Thomas A. Edison Papers

A SELECTIVE MICROFILM EDITION

PART I
(1850-1878)

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26

START

A Note on the Sources

THE REDUCTION RATIO FOR THIS REEL IS 16:1

Menlo Park Scrapbook, Cat. 1041

No. 27. "Submarine and Subterranean Telegraph - Cable Apparatus"

This scrapbook covers the years 1873-1882 and contains clippings about submarine and subterranean telegraph cables. There are 132 numbered pages.

Blank pages not filmed: 2-3.

1041

Sub marine & Subterranean Telegraph

Cable apparatus Torpedo

27

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LITHOGRAPH CHECKS, BONDS, NOTES, &c.

1

4

5

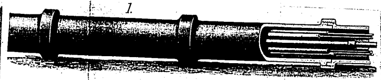
Scientific American.

APRIL 1, 1882.

IMPROVED INSULATOR AND PROTECTOR FOR UNDERGROUND LINES.

The great problem in telegraphy and telephony seems to be the disposition of the wires. Looking up from many of our New York streets, one can but wonder that the multitude of wires extending in every direction perform their function with so little interference one with another. Still

1.

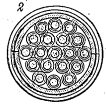


FRENCH'S INSULATOR AND PROTECTOR FOR UNDERGROUND LINES.

the trouble caused by "crosses," breakages during storms, and by the excursions of line men in building and repairing lines, is very great, and daily increasing, and a remedy is demanded. Clearly some system of underground lines is preferable to any arrangement of overhead wires. We give an engraving of one of the latest, and apparently a very practicable device for insulating and protecting underground telegraph and telephone wires, the invention of Mr. William A. French, of Camden, N. J.

The protector or outer casing consists of a tube of hard rubber made in ten-foot lengths and of a diameter suited to the number of wires to be used. The ends of the tubes are united by a water-tight joint. Short connecting tubes, made

2



SECTION OF INSULATOR AND PROTECTOR.

in halves, join the longer lengths and admit of being removed to insert or remove the conductor.

The lengths of large tubing are filled up with smaller tubes of soft rubber, which project a short distance from the ends of the large tube into the connecting tubes, where they meet the ends of the corresponding tubes of the adjacent section, and are connected by a short coupling of hard rubber.

The small tubes are of such size as to admit of readily inserting and removing the telegraph wire. In some cases the inventor covers the wire with a protective coat of insulating material before placing it in the small tubes.

In applying the invention to practical use the telegraph wires are passed through the small soft rubber tubes of a number of hard rubber tubes, which are placed at such a distance apart that the ends of the soft rubber tubes will meet. The ends of the corresponding tubes are then connected by the small hard rubber couplings. The divided connecting tubes are then applied to the adjacent ends of the hard rubber tubes, and the coupling bands are screwed on the collar, the joints being made tight by cement or packing.

The soft rubber tubes can be made of any desired length, and can be inserted in the hard rubber tubes before or after the hard rubber tubes have been put in position, and that the half section tubes can be dispensed with, in whole or in part.

6

Electrician Feb 14 1880

ANGLO-AMERICAN TELEGRAPH COMPANY (LIMITED).

The ordinary general half-yearly meeting of the above Company was held at the City Terminus Hotel on the 6th inst., under the presidency of Viscount Monck, the chairman.

The SECRETARY (Mr. John Grant) read the advertisement convening the meeting, and the minutes of the last ordinary general meeting, which were confirmed by the present meeting, and signed as correct by the chairman.

The report of the directors, the salient features of which appeared in *The Electrician* of last week, was taken as read.

The CHAIRMAN, in moving the adoption of the report and accounts, and the payment of the dividend in accordance therewith, said: The natural division of the subjects which he had to bring before them coincided with that which prevailed in a larger and more important annual meeting in which he took some concern on the previous day—namely, to divide itself into their domestic and foreign relations. With regard to their home work, the report, he thought, had made it pretty plain that he had nothing to tell them that was not eminently satisfactory. Their property was in good condition, and their cables were working with their usual efficiency; while their income had, as they would observe, very largely increased within the last half year as compared either with the preceding half year or the corresponding six months of 1878. They proposed, as they stated at the last half-yearly meeting, to lay down a new cable this year between Ireland and America, and they had the pleasure to tell the proprietors that they were in a position to do that without asking them or the public for one shilling of the money. They proposed in addition to that to lay down or renew, as they would observe by the report, other portions of their system, which had either worn out or become inefficient—he referred to the short cables connecting the island of Newfoundland with the continental portion of America, and that was a work which was absolutely necessary to be done in order to the efficiency of their system. They proposed to do that also out of money in hand. There was some doubt expressed at their last meeting, he thought, about the propriety of laying down a new cable between Ireland and America this year. The argument used, as he recollected it, was that when a cable got to the bottom of the sea it more or less deteriorated in quality, and, therefore, the longer, consistently with the efficient performance of their work, they could put off laying down a new cable the better. Well, no one was more ready than he to admit the general soundness of that argument; but it must be taken with certain qualifications. In the first instance, the enormous increase in their traffic had rendered it absolutely necessary that they should keep at least three cables in full work. Their three cables were working, each performing its full share of the work; but they must remember that one of those cables was very nearly eleven years old, and, without any disparagement to its condition, they must be prepared for contingencies—he would go no further than that. There was another view of the matter. He had not yet alluded—and his allusion would be very short—to their foreign relations, and by that he meant to express what they were all aware of, the cable which had been laid down by the new French company. The result of that would be a competition, and competition, as he understood, and as they had already announced, could only be carried on by a very considerable reduction of tariff, and a very considerable reduction of tariff meant nothing more than a very considerble increase of traffic; and in order to carry that increase of traffic with a reduced tariff as efficiently as they had done hitherto, they must be prepared with additional instruments for the working of that traffic. There was another view of the matter. They were not fools; they did not mean to go on competing and fighting for ever. Sooner or later they must come to an arrangement, and their share of profit arising out of that arrangement would depend very materially on the number of efficient cables they would have when it was made. He thought he need not trouble them further on that point, because he was satisfied, from the tokens of assent from all parts of the room, that the proprietors were convinced that the Board ought at once to exercise the powers they had of laying down the new cable. They had made arrangements, or arrangements were in progress, for a new survey of the bed of the Atlantic, so as to obtain, if possible, a better resting place for their new cable than had been afforded to those which had preceded it. It had been suggested that they should make experiments as to the coating of their cables. Well, that was a matter on which they had been engaged, and they were in great hopes, from the turn things had taken, and the result of the experiments made, that they would be able to get a class of cable which would more effectually resist the deterioration of whatever influences might be brought to bear on it under the water than any yet which had been laid down. He might say at once with respect to this new cable that they were doing everything they could to secure an intrinsic superiority in the cable itself, and the best possible bed for it in the bottom of the Atlantic. He did not know that there was anything else connected with their home relations to which he need refer, but he might anticipate some objections which might be made with respect to the expenditure of the last half year. They would see by abstract A—expenses at the head office in London—that there was a considerable reduction, a reduction of £850 odd in expenses at the head office during the last year. There was a considerable increase in the expenses at the out stations, but he thought if any gentleman would take the trouble of running his eye down that column and see the points in which the principal increase had taken place, he would at once recognise that it was attributable to the enormously increased traffic, and that it was only a very small per centage they paid for their increased gains. They could not do double the work without getting double assistance for it; and if they had double assistance they must pay for it. That was really the whole explanation. There were certain large items. For instance, there was the item of maintenance of land lines, instruments, and instrument stores, which they could not avoid—things would wear out and they must replace them. Then, repairs and furniture—that came under the same denomination. They had also been obliged to put up additional buildings at Valencia for their increased staff there, and in order to replace the building worn out. There was also an increase in the expenses for use of patents. They had duplexed all their Irish and Newfoundland cables, which were working most admirably, but for which they must pay. So far for their home work. He had alluded, incidentally, to the French company. The French company had laid down their cable to America, and they had been expecting that the competition would begin, but up to that time the French company had not interfered with them in the slightest degree, though they had announced that they were open. They were told a year or a year and a half ago, when that operation was first started, that one of the first motives of those patriotic individuals who set it to work was to gratify the *amour propre* of the French people, and it appeared that that was not only incidentally their object, but it appeared to be their only object. It appeared that they were quite satisfied to have laid the cable without working it. How long that was to continue they did not know, but he did not care how long it lasted, having regard to the proprietors' interests, for every day the French company acted on that principle of self-abnegation was worth thousands to this Company. At the same time, if they offered this Company terms which they considered reasonable, he they were not averse to work at amity with them. His belief was that there was room for them all. With these observations he would ask them to place the same confidence in their directors which the latter had so often experienced at their hands, and to leave the negotiations with them to deal with as they thought best. He considered that the state of their affairs proved that the directors were entitled to their confidence. He thought that the gloomy anticipations which for several years past had been made with regard to the future of the Company had not—at all events up to the present—been realised; and his thorough conviction was that as they had gone on for the last ten years, so they would go on in the future, managing their affairs with prudence and determination, realising for them a fair revenue on their outlay, and maintaining their property in good and serviceable condition.

Sir DANIEL GOOCH, Bart., M.P., one of the directors, seconded the motion.

Mr. GREENWOOD wished to ask a question, but not to oppose the motion in any way. He observed, however, in the report the following paragraph: —"The directors, under the powers conferred upon them by the articles of association, have, before declaring the net profits, set apart the sum of £140,000 to the renewal fund." That was a very enormous amount, representing, if set aside every half year, £280,000 a year. He was not, however, finding fault with the amount. He thought in present circumstances that it was most judicious to set aside a large amount; but he wished to know what were the exact powers of the directors in the matter. What was the limit? Or could the directors go on putting such an amount aside for as long as they thought proper?

Mr. JACKSON wished to ask a question as to the paragraph in the report which referred to the abandonment of two of the cables. He desired to know the cost of replacing them, as he thought it would be satisfactory to the shareholders to know. He thought, with regard to the report itself, that the impression on the shareholders must be twofold; first, that of serious depression that two more cables—though, it was true, they were not deep-sea cables—were actually abandoned by the Company. That, however, was a perfect evidence of the judiciousness and the necessity of the directors in providing such a large reserve fund for these matters, but he thought the fact of such abandonment was a subject for regret. A matter of unmixed satisfaction was that their receipts for 1879 had exceeded those of 1878 by £116,000, though they were not permitted to divide it. There was one satisfactory feature in connection with what the chairman had said as to the French company and dividing the profits on the basis of the number of cables on the ground. It should, however, be remembered that the new company, with its new cable, had to work its way, as this Company had done, through trials and difficulties, before it realised a moderate result; but even supposing, in any arrangement being come to, it did get its proportion of the profits, it would receive only one-sixth, which would come within the amount of the increased profit this Company had made in the past year. He mentioned that because he thought it might be satisfactory to those shareholders who might not have gone into the figures to know that even if they were deprived of one-sixth they would still have what would give them their present dividend, which he thought was very satisfactory, particularly to those who had bought their shares at present prices. He was very gratified to hear the chairman's remarks as to the experiments which had been made for securing an improved outer covering for their cables, and to believe, as he gathered from those remarks, that they had accomplished satisfactory results as to sheathing the cable with such a substance as would make it more durable. If they could see a fair chance of looking to fifteen or twenty years as the "life" of a cable, a quarter, or half, at the most, of their present reserves would suffice for the purpose. He knew that their manager liked to be "square," and give the shareholders plain facts and the plain truth, but he hoped that gentleman might be able to confirm the aspirations which he (the speaker) had expressed.

Mr. SEELEY asked the reason of the Board for abandoning the daily publication of the returns of the traffic. He was very much surprised to hear that the French company had not commenced to work. He thought that they had, and that they were in competition. He also asked a question with regard to the item in the renewal fund of "cash not yet invested," £115,000, and the item on the credit side of the balance-sheet of deposit and ordinary cash balances, £46,000.

Mr. J. NEWTON said he was surprised and disappointed to hear the chairman say that they had entered into negotiations with the new French company. From the number of meetings he had attended of this Company, he thought they had determined to fight for the monopolies which were granted to this Company when it first started—monopolies which he believed no company that was ever formed in the world more righteously deserved. This Company, at its own expense, proved to the world that it was possible to lay a submarine cable in deep water. For that great work they obtained the monopoly and privilege of having the traffic throughout all England, most of the traffic of North Germany, the traffic of all France, and practically, the command of the traffic for the whole of Europe, for the great work the Company had done. He thought that, with the strong position they occupied, negotiations should not have been entered into with the new French company so early. It appeared that they had been over here, and had had negotiations with the Board, and the result had been known, or presumed to be known, on the Stock Exchange, and the shares had been going up and down as a consequence.

The CHAIRMAN: Up, not down.

Mr. NEWTON thought, seeing that this cable was not required, that it was not a cable called into existence by money provided by shareholders, but the result of the jobbing work of a set of cable manufacturers, who were the enemies of all those who had invested money in these companies, that what the chairman had said was matter for surprise. There had been something like £20,000,000 laid out for the purpose of providing the world and civilisation with this great work, and because it had been done so well, and it was just possible that some other company might like to get some of the plums of the work, these jobbers made cables before they were wanted, and then came to companies like this and wished to negotiate. He was perfectly surprised to hear that a compromise would be based on the number of effective cables they possessed. He remembered the competition threatened on a former occasion; but after the amalgamation of this Company with the French Atlantic Company, and in view of it he sent a proposition to the directors, indirectly suggesting that instead of the scheme of preferred and deferred stocks they should, under the amalgamation, adopt the system of preferred and deferred messages, the Anglo carrying the deferred, and the original French Atlantic Company the preferred messages, the former to be carried at rates which would command nearly all the traffic from Europe to America, and the preferred messages, the most important ones, to be charged a higher tariff. He believed it was said at the time that that could not be done legally, owing to the amalgamation; but it might be done now, the Anglo taking the deferred and the Direct the preferred messages. He thought, with the strong position now occupied by the Anglo Company, that by going down to sixpence or threepence a word they could take every message sent from Europe to America, unless specially directed to go by the now competing French company. This Company must have the messages—there was no power to prevent it if they had the same rates as the French company. They would then be able to dictate terms to the new competing jobbing cable. With this Company's monopolies they could put that company in such a position that their receipts would bring them to an arrangement on a much lower level than on the basis of having one cable against five; they were, therefore, entitled to one-sixth of the total receipts. He maintained that if they would fight the French company for a little longer they would buy them up on the same terms as they did, practically, on a former occasion, when they took over another jobbing company. He thought the Board appeared somewhat as if they had been caving in.

The CHAIRMAN said he would try and answer as well as he could the several questions put to him. Mr. Greenwood had asked what were the powers of the directors to add to the renewal fund. The powers were unlimited by the articles of association, but he might at once explain that they had no intention of maintaining the contribution to the renewal fund to the same extent as they had done this half year. It was a purely exceptional case. They had had very large receipts, and they would have very large outgoings this or next year, and they had laid aside this extraordinary sum, about £65,000 more than they would have done otherwise, to enable them, as he stated before, to do all the permanent work they would be called on to do this year without calling on the proprietors for any further capital. Mr. Jackson had asked a question as to the inter-island cables. Those were very old cables; they were not laid by this Company, but by the Newfoundland company, and Mr. Jackson, who was perfectly conversant with all the changes that had taken place, would recognise how old they must be. They were ten or twelve years old, and they must be renewed.

Mr. JACKSON said he had asked as to their cost.

The CHAIRMAN: The expense would, probably, be about £100,000. As to the publication of the returns of their traffic, they were, more or less at that moment, in a state of war with the French company, and the abandonment of the publication of their daily returns was somewhat equivalent to what was known on the Continent as a declaration of a state of siege. They did not want, while they were contesting or fighting with that company, to let them see their hands, and to show them what effect the diminution of traffic had on their income, and that was why they kept this information to themselves. He might tell them, as a matter of fact, that the traffic for January amounted to a very tidy sum, and he could assure them that they need not be the least alarmed. There was another question asked with regard to the balance at their banker's at the close of the year. The fact was that that balance consisted of bills not already due, and items of that description, which had probably all been received and paid away since. They must remember that it was then six weeks since the end of the year, and they were obliged to make their balances with their bankers; they debited their bankers with all bills lodged for collection and not yet matured. With regard to the bellicose observations of the gentleman who sat opposite [referring to Mr. Newton], he thought that before he sat down he would satisfy the meeting that that gentleman had not the slightest foundation for the oration he had made on that occasion. Mr. Newton, in the first place, said they ought to fight for their monopolies. Well, he was a free trader, and as such was opposed to monopolies, but, on the other hand, if they had a monopoly which was advantageous to this Company he should be very much inclined to put his free trade principles into his breeches pocket; but, unfortunately, they had never had a monopoly. The only thing they had approaching to a monopoly was that they had an undertaking from the British Post Office, and a concession from the French Government, giving to the Company any messages which might be sent through their wires, not directed to go by another cable. And so with North Germany. That monopoly was not interfered with in the least degree, if it were a monopoly. Well, that took away, as it appeared to him, the main foundation for the speech they had heard from Mr. Newton. But that gentleman went on to say that they had a partner, the Direct company, and three cables of their own, and asked why they did not make use of the advantages which that state of things gave them — why did they not carry at very low rates, and let their partner carry special messages at a higher rate? Perhaps it would surprise that gentleman very much to know that that was precisely the arrangement they had made. Therefore, all that magnificent eloquence in favour of defending their rights [expressions of dissent, and interruption]—he was speaking in the most good-humoured disposition, but Mr. Newton had made a speech in favour of what they had done, and what he meant was that they had done precisely what Mr. Newton had suggested should be done. He must say that the speech was made in a rather criticising manner; and when it amounted to saying that they ought to do what they had done he thought he had disposed of the speech. Mr. Newton further said that they ought to fight and not to cave in. He begged to say that as far as any utility could be got from fighting, he was as ready to fight as any man, but the caving in was not of their seeking. The other company came to them and offered them certain terms, and asked them if they would accept them. As he said at the beginning of the meeting, those negotiations were still in progress, and, as he heard a very distinguished statesman say on the previous night, nothing could be more mischievous to the result of negotiations than questions put when they were in progress. He must, therefore, adopt the same observation, but as to saying that they had caved in, he assured Mr. Newton and the meeting that if it were possible, without prejudice to the interest of the Company, to put them in possession of all that had taken place, they would find, so far from caving in, they were as stiff as they could be. He assured them that they would look after the interests of the proprietors in this competition, and act to the best of their ability. They had had some dark periods in their history before, and without arrogating any undue credit to themselves, he thought they had pulled them through pretty well. He, therefore, hoped that without further reference to competition and fighting, they would adopt the resolution, and leave the conduct of this matter in the hands of the directors.

Mr. NEWTON desired to remind the chairman that he had not asked a single question. He had the utmost confidence in them, knowing that they would preserve the rights of the proprietors. He had it, however, on the official paper of the Company, that the monopolies to which he had referred were monopolies. He had that among his private papers, and under the signature of one of the gentlemen sitting at the Board.

The CHAIRMAN then put the motion, which was carried unanimously. He next moved the re-election as a director of Mr. Francis A. Bevan.

Sir JAMES ANDERSON seconded the motion, which was carried unanimously.

On the motion of the CHAIRMAN, seconded by the Hon. ROBERT GRIMSTON, the other retiring director, Mr. L. M. Rate, was also re-elected.

Mr. JACKSON then moved the re-election of the retiring auditors, Mr. Joshua Dear and Mr. Francis Glass. He expressed his pleasure at submitting the resolution, and hoped the auditors would make any suggestion they properly could which would give the shareholders a slight increase to their moderate dividend.

Mr. SEELEY seconded the motion, and it was carried unanimously.

Mr. NEWTON then moved a vote of thanks to the chairman and directors. They knew how they were treated at some of the meetings of these companies, and he believed they would all agree with him that Viscount Monck bore off the palm among chairmen, for even when his lordship had anything unpleasant to say he said it in such a manner as to leave no feeling of irritation behind.

Mr. SEELEY seconded the motion, which was carried unanimously.

The CHAIRMAN, in acknowledging the vote, returned his sincere thanks to the meeting for the confidence they had reposed in their Board, and to Mr. Newton for the expression of his opinion of his (the chairman's) urbanity. He felt very much indebted to them, but he would ask them to include in the resolution the officers of the Company.

Mr. NEWTON requested that he might be allowed to include the officers, and threw out the suggestion whether some pecuniary recognition of their services could not be made, observing that it would go to pay the income tax of those gentlemen. He had spoken on some occasions in favour of economy, but he did not think economy should be exercised towards those who worked for them.

The CHAIRMAN again thanked the meeting, and the proceedings then terminated.

8

Tel. Jour. Feb. 1 1877

Tel Jour. Feb. 1. 1877

The laying of cables between Halle-Leipzic, Halle-Cassel-Frankfort-Mayence, Berlin-Hamburg and Hamburg-Kiel, is to be commenced, we learn from the *Magdeburg Zeitung*, as soon as the ground is free of frost. The firms of Siemens and Halske, in Berlin, and Felten and Guillaume, in Cologne, are engaged in preparation of the cables. The laying will proceed much more easily than in the case of the Halle-Berlin cable. Dr. Siemens has devised a machine which makes the trench, and deposits the cable, and it is only necessary that a gang of workmen follow to fill in the trench. Siemens' machine will be used on those stretches of road where the making of the trench is not hindered by underground rock; in the latter case dynamite blasts are necessary. The cables are to lie one metre deep; the bottom of the trench must be of equal depth throughout, that the cable may be secure, and this is effected by the machine. The laying will be easiest between Berlin, Hamburg, and Kiel, the ground being here uniformly sandy and clayey. The Cassel-Mayence stretch will require much more labour and be more costly. The cost, however, has been carefully estimated. As the work of laying is to begin at several points at the same time, the work may be completed by the beginning of the hot season; it is anticipated, at least, that all the cables will be at work by September. The Halle-Berlin cable is giving every satisfaction, and the experience with it has materially conduced to an extension of the system.

Tel Jour. Mar 15 77

Trial of Direct Communication between London and Malta, with Brown and Allan's Relay. By M. Grammaccini.

This experiment was made at Marseilles. The relay named is a Siemens' relay improved by addition of a contact-rod, giving much more rapid action. One translation, worked by hand, was arranged at Bona, another at Marseilles; there were besides, the ordinary translations of Paris and Beachey Head. The average of transmission did not exceed nine or ten words per minute; and the transmission was generally defective, the *employés* not being used to this kind of work; hence loss of time in rectification. Thus direct translation through a long land-line connected with a long submarine cable is shown to be possible; but the author doubts if it has real practical interest. There would be economy in *employés* and a single translation; but, on the other hand, the work is first less rapid, and the translation must be suspended from time to time to permit the sending of local telegrams. Supposing no local traffic, the transmission would still be disadvantageous, for the cable is a capital which should produce as many telegrams hourly. It is thus important to have the maximum production, and this is at present obtained by use of the Thomson mirror apparatus or the recorder. With the Morse, the cable without translation can hardly give more than 20 telegrams an hour, or 480 in twenty-four hours; with translation, it will give only 15 or 380; but the land-line is generally interrupted four or five hours in the twenty-four, which reduces the work produced to about 300 telegrams, while the land-line alone could produce an average of 25 telegrams hourly, or 600 in twenty-four hours, that is, even failing the lost hours for working the cable.

Tel. Jour. Sept-15 1877

Tel Jour Sept 15. 1877

UNDERGROUND TELEGRAPH LINES IN GERMANY.

By EDOUARD RAU.

On the 23rd of July last there was submerged in the Rhine, near Mayence, the cable completing the one of the two great subterranean lines—that of Berlin-Mayence (Metz)—to establish which the German Parliament voted a sum last year.

Germany is, then, the first power which, after long hesitation it is true, established subterranean lines on a large scale.

The amalgamation of the postal and the telegraph administrations has powerfully contributed to accelerate this important reform. The unsuccessful attempts which took place some eleven years ago under the special direction of M. Chauvin, the then director of telegraphs for the Prussian Government at Cologne, had greatly tended to confirm the doubt of the practicability of underground telegraphs. Later on financial difficulties prevented further experiments. This difficulty now ceases to exist, in consequence of the union of the postal and telegraph services, a union which allowed of the reduction from 2,000 to 50 of the number of independent telegraph offices, and which, in consequence, reduced considerably the working expenses.

The excessive increase and continuation of the number of faults which occurred on the aerial wires led to the reopening of the question of underground wires. The following official returns will give an idea of the number of faults which have occurred. In 1874 there were 350 poles broken, 875 breaks in the wires, 2,826 interruptions from contact or earth. In 1875 there were 506 poles broken, 1,405 breaks in the wires, 4,076 interruptions from earth or contact. In 1876 the numbers were: breaks in poles, 1,708; breaks in the wires, 3,284; and 4,415 faults from earth or contact.

This increase in the number of accidents was out of all proportion to the number of lines. In 1874 the length of line in use was 31,035 kilometres, representing a mileage of wire equal to 107,645 kilometres. In 1875 there was 34,141 kilometres of line and 123,455 kilometres of wire; and in 1876, 37,264 kilometres of line and 138,891 kilometres of wire.

There were, then, in 1874, for 10 kilometres, 0·11 pole-breaks, 0·08 wire-breaks, and 0·26 earths or contacts; in 1875, 0·15 pole-breaks, 0·12 wire-breaks, and 0·33 earths or contacts; and in 1876, 0·46 pole-breaks, 0·24 wire-breaks, and 0·32 earths or contacts.

All, except during the year 1876, during which the telegraph system had suffered from a hurricane on March 12 and 13, and from storms on November 12 and 13, showed from 1874 to 1875 an increase of faults in the proportion of one to two, whilst the increase in the mileage of line was only in the proportion of 10 to 11, and the increase in the mileage of wire in the proportion of 7 to 8. This disproportion leads naturally to the belief that the financial difficulties had scarcely time to be put straight when they reappeared in consequence of the increase in the number of accidents caused by the aerial lines. It is true that one cannot yet say

9

THOMSON AND JENKIN'S AUTOMATIC CURB-SENDER.

Simultaneously with his invention of the mirror galvanometer in 1857, Sir William Thomson directed his attention to the problem of how to send signals through submarine cables in such a way as to diminish as far as possible the retarding effect due to the electro-static capacity of the line, the theory of which he had investigated two years before. He pointed out that the sending of currents through cables should be effected so as to make the current attain as soon as possible a strength at the receiving end sufficient to move the indicator there, and that after this the charge remaining in the cable should be removed without delay—the removal of the residual charge being effected by the application at the sending end of an electro-motive force opposite in kind to that by which the signal had been produced. This system of using two currents, one to produce the signal and the other, of opposite name and somewhat shorter duration to neutralize (as nearly as possible) the residual effect of the first, is what is known as Curb-Sending. Its object is, of course,

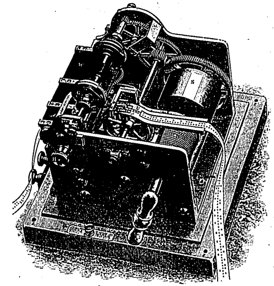


Fig. 1.

to increase the speed of signalling, and it does so by giving each signal a sharp definition, and an independence of the signals that precede and follow, which is unattainable when, as in ordinary working, each signal enters a cable already in a complicated state of charge. Simple as the principle of curb-sending is, its practical application has been found to present many difficulties. Trials have been made, but without success, to send curb-signals by means of a hand-key, the failure being no doubt due to the fact that a greater perfection of spacing is necessary than hand-sending can give. The problem has now, however, been solved, and the introduction during the past year of the Automatic Curb-Sender, under the joint patent of Sir. W. Thomson and Professor Fleeming Jenkin, is certainly one of the most important recent advances in submarine telegraphy.

Fig. 1 gives a general view of this instrument, the actual dimensions of which are about double those in the figure. The message to be transmitted is prepared beforehand by being punched on a strip of paper in right and left-hand holes corresponding to dot and dash. The paper-strip enters in front (the left-hand side in the figure)

10

Tel Jour
Tel Jour Nov 1. 77

We have lately seen some interesting trials of the articulating telephone through Dr. Muirhead's artificial cable. It is well known that this artificial line offers the closest approximation to the electrical conditions of an actual cable that has been hitherto attained; in fact these conditions are practically realised in this artificial line, and hence its success in submarine duplex working. Any mere distribution of separate condensers along a resistance circuit, as in Varley's artificial line, is at best but a very crude approximation to an actual cable; but in Muirhead's artificial line capacity and resistance are mutually blended throughout in the same manner and to the same extent as in the actual cable, of which the artificial one is an imitation. The experiments in question were made through a length of artificial cable of the type of the Direct United States Cable. The artificial cable is so constructed that the capacity can be added to the circuit or taken away from it at will. When the capacity is taken off, the circuit is of course a mere resistance circuit and comparable to a length of land-line; but when the capacity is put on, the circuit is equivalent to a length of submarine cable. In speaking by telephone through a hundred miles of this artificial D. U. S. Cable, the words were comparatively loud and distinct; in short, were the usual telephonic utterances, reminding one of the small voice of pigmies and other fabulous elves; but the instant the capacity was put on, the voice lost both power and distinctness in a remarkable degree. It appeared only half as loud as before, and dull in tone, as if the elf had receded into the distance, or had caught a severe cold and been muffled up in thistledown. To use a homlier simile it was like speaking from under a blanket. With a hundred and fifty miles of the artificial cable, while the voice was apparently as strong as ever through the resistance circuit alone, it was completely silenced by putting on the capacity. One hundred and fifty miles must not be taken, however, as the limit of the telephone's power on submarine cables; something depends on the quality of the telephone applied. But even with the best of those at present constructed, the extreme limit of articulation cannot be much beyond a hundred and fifty miles, and certainly under two hundred. Experiments have been made, we are told, at Glasgow University, through two hundred miles of Sir William Thomson's artificial cable, with successful results; but this cable is one of Varley's "test circuits," combining condensers and resistance coils, and is by no means a close approximation to an actual cable. Theory points out, and experiment verifies the fact that if the voice is allowed to dwell on a note for a sufficient time to establish, despite induction, a regular succession of the electric waves in the cable, a faint sound will be audible. Thus, singing can be heard, indistinctly it is true, but still heard, through a greater length of cable, than talking. In articulation the changes of voice are so hurried that time is not given the cable to establish the regular series of waves necessary to reproduce sound, so nothing is heard at all.

Tel Jour June 15. 75

BLASTING BY ELECTRICITY.—The Aberdeen *Free Press* says that an experiment was made with electricity as a means of firing blasting charges in Mr. Fife's quarries at Kemnay. A huge breast of rock, calculated to weigh about 2000 tons, was bored in eleven places, charged, and fired almost simultaneously by a current of electricity, from a battery which was under the care of Mr. David Wright, electrician, Aberdeen. The huge mass was started with little noise from the report, but with a rumbling sound like that of distant thunder. A second blasting was fired the next day, and though the ground was covered with snow, and a heavy snowstorm was falling, wires extending 1500 feet in length being laid, and a current of electricity being put on, in an instant a tremendous explosion was heard, which shook the ground like an earthquake. Great masses of granite were upheaved in the air, and about 5000 tons were displaced. It is the largest blast which has ever been witnessed in these quarries, effected by means of electricity applied by a new apparatus, most ingeniously constructed.

Tel Jour June 15. 75

NEW TELEGRAPH SHIP.—In the *Telegraphic Journal* for February 15, we announced that the directors of Hooper's Telegraph Works had ordered a steamer to be built expressly for the purpose of reducing the expense and lessening the risk of submerging telegraph cables. On Wednesday, the 11th inst., a party of scientific gentlemen assembled at Millwall Docks to inspect this new vessel. She is 350 feet in length, 55 feet beam, and 36 feet in depth, and of 5000 tons gross register, with engines of 400 nominal horse-power working up to 2000, and realises, though not intended for speed, 10½ knots an hour. Being the first vessel ever constructed entirely for telegraphic purposes, her tanks, which are only three in number—huge cylinders, 30 feet deep and 53 feet wide—so far from being a source of weakness, really strengthen the hull; while the paying-out machinery and the appliances for picking up a lost or damaged cable embrace every improvement which experience up to the present time has suggested. The vessel is now taking in 1500 miles of cable directly from the Hooper works at Millwall, belonging to the Western Telegraph Company, which is about to lay 2500 miles of cable along the east coast of South America. The work will be performed in three sections, the first, that which is now about to be despatched on board the *Hooper*, being laid from Pernambuco to Rio de Janeiro, the second from Pernambuco to St. Thomas's, and the third from Rio to Monte Video, taking in all the intervening South American ports. After inspecting the works of Hooper's Telegraph Company, the party adjourned to the vessel—a noble, though somewhat unsightly, craft—much interest being felt in the perfect electrical testing cabin, fitted up at the suggestion of Sir Wm. Thomson, who, with Mr. Latimer Clark, represented science on the occasion, and showed the means by which signalling and testing for insulation can be carried on at the same time.

Tel Jour Nov 1. 1878

TOMMASI'S RELAY.—We recently gave an abstract of some experiments made by M. Tommasi on the Atlantic Cable taken from the *Comptes Rendus* (bulletin of the French Academy of Sciences), an authority which ought to be trustworthy. These results did not appear to us to form any practical test of the apparatus, but we gave them for what they were worth. Mr. Weaver, General Manager of the Anglo-American Telegraph Company, however, informs us that these results are erroneous, and that the relay was a complete failure. We are not surprised at this, for it ignores the essential fact of a varying zero in submarine telegraphy, and its much vaunted sensitiveness is only exhibited through resistance—induction being absent. We have condemned this relay before, and are now not sorry to be able to expose the hollowness of its pretensions for practical submarine work.

11

THE TELEGRAPHIC JOURNAL.
VOL. V.—No. 100.

UNDERGROUND TELEGRAPHS.

THE two valuable practical papers—"Underground Telegraphs," by Mr. Willoughby Smith, and "Underground Telegraphs in France," by Mr. John Aylmer, C.E., of Paris—which were read before the Society of Telegraph Engineers at their last meeting, on the 28th ult., has served to bring again into prominence the subject of covered telegraph lines.

Taking up a statement of Mr. Prescott's which appeared in the American *Journal of the Telegraph* some six or eight months ago, that the "use of underground telegraph lines had thus far been attended with very unsatisfactory results," Mr. Willoughby Smith sought to establish, and undoubtedly succeeded in establishing, the fact that underground telegraph lines need be attended with no greater risk than open lines—nay, that were the proper material only employed, and due care taken in the execution of the work, there is no reason why covered lines should not be made as safe and durable as need be desired. The most interesting feature, however, of Mr. Willoughby Smith's communication was the argument which he brought forward against the employment of tar on gutta-percha covered wire. A covering of tarred tape is, as is well known, all but universally adopted at present as the final protective covering. This, it is alleged, is a grave mistake; for by reason of its use the insulation resistance is materially diminished, and the germs of decay which in time lead to the complete destruction of the coating are implanted in the gutta-percha. The tar ought to be abandoned, and in its place tannen, whose employment was stated to have been highly satisfactory, ought to be adopted. In the valuable address delivered some time since by Professor Abel, at the Society's opening meeting, this same subject was dealt with, and the state of our knowledge with reference to the causes of decay in gutta-percha was shown to be crude in the extreme.

Granting, however, that tar is an objectionable feature in the manufacture of gutta-percha covered wire, was there not some point in what was remarked by one of the speakers in the animated discussion which followed, that surely then Chatterton's Compound was not altogether an unmixed advantage? Chatterton's Compound consists of one part of Stockholm tar to one of resin and three of gutta-percha, and has long been regarded as the panacea for every evil that could befal gutta-percha covered wires. No coating can be considered complete, it is said, no two can be welded homogeneously together without Chatterton's Compound; and if tar is the *bête noir* it is now stated to be, what becomes of the influence of Chatterton's Compound? It is all very well to be told, as Mr. Willoughby Smith told us the other evening, that "in the Compound the sting of the tar was taken out." It is a pity that the same process of sting-abstraction could not be applied with equal success to the tar in the tape. No, we shall wait for a few further data and a few additional experiments before condemning the tar wholesale and making it accountable for all the mischief; and we will be content to look for the deterioration of the gutta-percha, to a very great extent, at least, in the cheap and consequently indifferent material which has never been properly tested, and hasty manufacture over which no efficient check has yet been introduced.

No one will now attempt to call in question the possibility of manufacturing really good covered wires: the battle of india-rubber and gutta-percha need not be fought over again, for the improvements effected in the latter have been so decided of recent years, that its position is well-nigh unassailable by its old rival. If danger is to be anticipated from any quarter, paraffine and the products of paraffine will probably show it the most dangerous front. Meanwhile, every one will admit that covered wires as good as need be looked for in the existing state of our knowledge can without difficulty be manufactured, and no one will deny that their laying is a matter which requires nothing more than care to be attended with success. When, therefore, the need for underground telegraphs on a more extended scale than at present does arise either from the crowded state of the open lines on every available route or from an alternative channel being thought desirable, we may rest perfectly satisfied that our telegraph engineers and electricians will be quite equal to the occasion; and if the day when that need does arise is even but a short way off, they may as likely as not turn round and regard our manner of doing things in much the same light as we regard the now antiquated attempts of but a few years back in the matter of covered lines.

We have no space at our command to go into Mr. Aylmer's paper at present, but we shall again return to it. His communication was one of great practical value, bringing forward many new and striking facts as to how these things are done in Paris.

Tel Jour Jan 76

TELEGRAPH STATIONS IN MID-OCEAN.—Several foreign naval powers are directing their attention to the practicability of establishing telegraph stations in mid-ocean, by which messages can be sent from any part of the sea along the line of the cable to the terminal points on shore, and *vice versa*, so that communication with ironclads, mail steamers and other vessels when out at sea, may be established. The invention consists of a hollow sectional column, with a base plate attached by ball and socket joint, which column is lowered into the water, and anchored rigidly to the ground. The branch cable is coupled to the main cable, and carried along the column to the surface of the water, to be there connected with instruments on board the vessels. By this invention it is proposed to control naval and strategical movements, whilst a ship in distress could communicate her exact position, the nature of disasters, and thus procure assistance.

12

THE TELEGRAPHIC JOURNAL.
Vol. IV.—No. 82.

REPAIRING SHIPS.

We have once or twice alluded to the necessity of Submarine Telegraph Companies possessing properly fitted steamers for the repair and maintenance of their lines. Yet we can hardly find fault with private companies for not having cable ships of their own, when our own Government sets the example of false economy by remaining entirely dependent on the casual hire of a steamer for the repair and maintenance of their cables.

The Electric Telegraph Company, whose lines formed the greater portion of the system transferred to the Post-office, had a repairing ship of their own, and this ship was made over to the Government, but, being worn out, was condemned, and has never been replaced; and although designs for a new ship have been made and approved, and tenders sent out some three times, the Lords of the Treasury have each time repented of their step so far, and have retreated with buttoned-up pockets. The consequence has been that, under pressure of broken-down communications, a fully fitted ship has to be hired, and the expense that has been incurred by chartering ships for each repairing expedition, as compared with the cost of buying and maintaining one, must be very great, and would form an interesting subject for a question in the House of Commons. The ships hired are generally larger than necessary for the work; indeed, for some work, their size is a positive disadvantage. But, besides this, the hiring of a ship must always be preceded by negociations which, even between companies or firms, must take time. With all the encumbrance of government official correspondence this must still be greater, and during this period communication is stopped. Moveover, the case might easily occur that no fully fitted cable ship was disposable, as they are not so very numerous, and thus the government would have to hire a steamer and fit her out, an operation that would occupy several weeks.

Nearly all companies and administrations having submarine cables have learnt, sooner or later, by their own experience, when they have ignored the experience of others, the absolute necessity of having at their constant disposal a ship ready to repair and maintain their lines, and the Government have simply gone a step backwards from the preceding owners of the telegraphs in thus neglecting to supply the place of the *Monarch*.

The "*Monarch*"—the "*old Monarch*," or "poor old *Monarch*," as she was at last affectionately called, was *the* first permanent repairing ship. She was a paddle-wheel wooden steamer of 427 gross tonnage, built in 1830, and bought by the International Telegraph Company in 1853, and from her were laid the first cables between England and Holland. In 1854, she was fitted with the first drum "Picking-up" gear, and in her the first systematic operations connected with the repair of cables were executed. She continued to be employed at this work until the transfer of the telegraphs to the Government, and soon after was condemned. The Submarine Telegraph Company, who for some time employed Liverpool tugs, at last built the *Lady Carmichael*, paddle-wheel steamer. The Indian Government, in 1863, bought the *Charente*, a small screw-steamer, re-named her the *Amberwitch*, and fitted her as a repairing ship for the Persian gulf cable, where she has been employed ever since. The Anglo-American Company bought the *Robert Lowe*, since wrecked, which was followed by the *Minia*, their present repairing ship. The Eastern Company possess the *Chiltern* and the *Hawk*. The Eastern Extension Company have now the *Agnes* and the *Edinburgh*. The Great Northern Company possess the *Œrsted*; the Western Brazilian Company the *Norseman*; and the West India and Panama, the *Investigator*. The American International Ocean Company possess the *Professor Morse* (formerly the *Suffolk*), and the French Government had for some time a small steamer, called the *Ampère*, which has since been replaced by a larger vessel called the *Charente*. The Direct United States Company have no repairing ship of their own, but employ the *Faraday*, and the Anglo-American Company, besides their permanent ship the *Minia*, are now employing the *Hibernia*.

It will be seen, therefore, that the necessity for repairing ships has become generally acknowledged. Indeed, with the exception of the Brazilian Submarine Company, our own Government are the only important administration possessing cables without the means of dispatching a ship to repair a fault within a few hours after the interruption of a cable.

For a perfect repairing ship, many qualities are required, but, perhaps, the most important is that of being capable of turning without "way" through the water. Disconnecting paddles effect this, but if there are only a pair of engines, there is the disadvantage of the dead point, besides the cumbrous nature of the disconnecting gear if the ship is large. A pair of engines to each wheel overcomes the dead point question, but this increases the machinery. The plan adopted by Mr. Siemens, in the *Faraday*, of twin screws, the shafts of which converge towards a point astern of the ship, is

13

with Panama, on the Pacific coast, by a submarine cable, has, after protracted negotiations, been abandoned by mutual consent, it having been found impracticable to obtain the necessary landing rights at Panama, except on terms which the Company could not with advantage accept. The working agreement that existed between this Company and Mr. Henley, of North Woolwich, and which lapsed through the suspension of Mr. Henley, has been renewed with a Company formed for the purpose of carrying on his extensive works, on terms which, it is believed, will be advantageous to both parties."

CHINA.

Shortly after the establishment of the Torpedo College at Foochow, His Excellency Li Hung Chang, Viceroy of Cheli, First Guardian of the Emperor, &c., &c., sent an official request that Mr. J. A. Betts, the director of the college, should proceed to Tientsin with the whole of the torpedo apparatus just received from England, to carry out a series of experiments before His Excellency.

The *Chi-Ngan*, one of the Chinese gunboats, was ordered to convey Mr. Betts, and the stores, to the latter port, and during the month of October last a lengthened and very successful series of experiments in telegraphy and torpedo warfare were carried out in His Excellency's presence.

Telegraphic circuits were established, and a complete system of torpedo defence fully illustrated by the explosion of numerous torpedoes in the Pei-ho, near Tientsin. Further experiments with heavy charges were shown at the Takn Forts. His excellency lent his own steam launch for these trials, and expressed himself much pleased. The electro-contact torpedoes excited great interest and were much admired.

Mr. Betts exhibited the Royal Engineers' system of telegraphing by "Walker's Lime-light" on the city walls of Tientsin; this seemed to create a deal of astonishment among the Chinese, and although at a late hour of the night, and bitterly cold, caused an immense crowd to assemble.

Mr. Betts will return to Tientsin in the spring, when he will, at once commence drawing up a system of torpedo defence for the Takn and Peh-tung Forts, which are also to be connected by a line of telegraphs.

M. Duchemin has found that nickel, deposited by electricity on the magnets of compasses, preserves them from oxidation. He deposited in this way a layer of nickel on several rings of one of his circular compasses, keeping two concentric circles free from the operation. This compass was put on board a vessel which went round the world. The rings covered with nickel preserved their polish, but the others were completely rusty. The magnetic power of the nickelized rings had been exerted with difficulty, no doubt on account of the magnetic property of the nickel.—*Comptes Rendus de l'Academie des Sciences, Nov.* 15, 1875.

Proceedings of Societies.

THE SOCIETY OF TELEGRAPH ENGINEERS.

Contributions to the Theory of Submerging and Testing Submarine Telegraphs.

By Dr. WERNER SIEMENS.

The starting point of submarine telegraphy is to be found in the subterranean lines constructed in Prussia during the years 1847—1852. Before that time, it is true, attempts had been made to insulate wires with glass tubes, caoutchouc, &c., for use as underground lines. Experiments on a somewhat extensive scale by Jacobi* at St. Petersburg in the year 1842 deserve mention; but these attempts failed.

In the year 1846 the author suggested to the Prussian government the use of gutta-percha as insulating material, this gum having then recently become known in Europe. Its remarkable plasticity and insulating property appeared to render it very suitable to the purpose in question, but neither the experiments made at Berlin, nor those carried out simultaneously in England, were attended with satisfactory results; for the joints of the gutta-percha (which was rolled round the wire), gave way after a short time. At last, in the year 1847, the problem found its solution in a covering machine, constructed and used by the author and Mr. Halske, by means of which the gutta-percha, rendered plastic by heat, is pressed round the wire without any seaming.

During the subsequent years an extensive network of underground lines, insulated with gutta-percha pressed round the conducting wires, was somewhat too hastily and inconsiderately introduced in North Germany and Russia; although those lines were far from durable (particularly because the conducting wires, to save expense, were imbedded in the ground without external protection, and at too small a depth), they afforded opportunity of gaining practical knowledge for the construction and maintenance of such insulated conductors, and of studying their physical properties. But it was reserved for English enterprise to convert the knowledge and experience thus gained to practical account in a sphere where there was no competition with cheaper overground lines, that is to say, to submarine telegraphy.

As early as 1850, Mr. Brett laid a single gutta-percha-covered copper wire across the Channel between Dover and Calais. As might be expected, this became useless; but in 1851, Mr. Brett substituted a conducting wire insulated with gutta-percha, and protected externally by a sheathing of iron wires. This was the first practical submarine cable.

No great difficulties were encountered in laying these cables in the comparatively shallow waters of the Channel. But when later Mr. Brett endeavoured to lay such cables in seas of greater depth he failed, because the forces brought into play in laying deep sea cables were not yet recognised, and, consequently, the necessary precautions had not been taken. The laying of the first successful deep sea cable between Cagliari and Bona, in the year 1857, in which the author

* *Pogg. Annalen*, vol. xxviii. p. 403.

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Tel. Jour. July 15 1876

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The new joint for gutta-percha covered wires, devised by Mr. Willoughby Smith, is formed by removing the coatings from the two ends to be united, and joining the cleaned wires by what is technically known as the "bell-hanger's twist." No solder is necessary. The twist is then warmed slightly, and covered with a rough coating of insulating "compound," somewhat thicker than the original diameter of the wire. The joint, while warm, is placed in the lower half of a small wooden block, about three inches long and one inch wide, fitted internally with a groove for the wire, widening in the middle into a niche, about an inch and a half in length, for the reception of the compound-covered joint. While the compound is yet warm, the upper half of the mould—in shape corresponding exactly with the lower one—is placed on the top, and by means of a clamp, screwed down until the two wooden surfaces are pressed firmly together. While in this position they are permanently fixed by half-a-dozen ordinary brass screws, and, the compound having hardened, the clamp is removed and the joint complete. The principal advantage claimed for the new joint is its simplicity, as it can be readily made by comparatively experienced hands in about ten minutes. The cost is reduced to a very low figure, and, by means of the wooden cover, all danger of leakage or separation of the wires through bending is obviated.

Tel Jour. Apr 15 1877

Tel Jour Apl 15 1877

A paper on "Underground Telegraphs" was then read by the author, Mr. Willoughby Smith, a *resumé* of which is appended:—

Underground Telegraphs.

In the *Journal of the Telegraph*, dated September 1, 1876, under the heading of "An Interesting Statement," after recapitulating what had been done in England in 1852-3, appeared the following statement: "The most experienced telegraph engineers and electricians of all countries in which underground wires have been used, are united in the opinion that thus far at least their use has been attended with very unsatisfactory results, and that no method of construction yet devised has maintained underground wires in working order for any length of time."

Mr. Smith was of opinion that that statement, emanating, as he believed it to have done, from an American gentleman of high authority, ought not to pass unchallenged. True it was that the failure which followed the laying down of the system of underground wires in England during the above-mentioned years gave a blow to the prospects of subterranean lines, from which they have never yet recovered; but, on the other hand, when we take into consideration the manner in which the wires were then made and the system carried out, we can feel no surprise at their early failure, and our only wonder can be that they lasted so long as they did.

In 1853 four of the then largest telegraph companies were engaged in the manufacture of the wire, which they subsequently laid in the later part of the year between London and most of the large towns in England. In June of the same year part of the factory of one company which supplied most of the wires was destroyed by fire, which did not help matters, inasmuch as each company, in their anxiety to complete their respective lines, allowed a laxity of supervision which would not otherwise have existed. Coal-tar, naphtha, and other solvents of gutta-percha were applied between the coatings to effect adhesion, but which evidently exercised a deleterious action upon the gutta-percha.

In 1857 Mr. Smith introduced an adhesive mixture for this purpose, consisting of 60 per cent. of Stockholm tar, 20 per cent. of resin, and 20 per cent. of gutta-percha, at present known as Chatterton's compound, and this has been almost unexceptionally employed since that date, and with every success.

The conductor employed was a solid copper wire, weighing 63 lb. to the mile, and of very inferior conducting power; some lengths have since been found to possess only 18 per cent. of the conductivity of pure copper.

The system of testing employed was very rough. The wire was immersed in water at no specified temperature, one end left free, and the other connected to one terminal of a sand battery of 360 cells, and with what would now be considered a very dull vertical galvanometer; if the deflections so obtained were not high, the coil was considered good, and delivery soon followed. When subsequently faults were discovered, the pernicious system of pricking the wires was resorted to.

The manner of laying the wire was equally detrimental to its longevity. One company laid part of their wire without any protection whatever in the six-foot of a railway, and the remainder were laid in square *creosoted* wooden blocks, from six to ten feet in length, with a groove of sufficient size to contain them. Boards of the same material were then *nailed* on after the wire had been laid, and the trench in which the whole had been placed was then filled in. The nails penetrated the gutta-percha in many places, and so numerous were faults of this nature that nails had to be abandoned, and the troughs were bound with wire instead.

Another company laid their wires just as they received them from the manufactory, in a somewhat similar manner, after having passed them through a bath of *hot coal-tar*, and then allowed them to dry in the sun, suspended from bars of wood.

In 1861 Mr. Smith introduced a great improvement upon the tarring process, viz., that known as the "wet serving." He advocated the use of an external conducting serving in the form of tanned hemp, inasmuch as tar, being an insulator, possesses the property of temporarily concealing the presence of a fault which must ultimately develop itself. Another and still greater argument against the use of tar is the prejudicial effect exercised by it on the durability of any gutta-percha covered wire, especially when exposed to atmospheric influences. Since that date the use of tar in connection with submarine cables ceased, though it still continues to be employed in the case of subterranean lines, and it was with a view to induce its discontinuance in the latter also that Mr. Smith undertook the following experiments:—

Three separate samples of what was said to be pure Stockholm tar were procured from three different sources, and three lengths, 1,000 yards each, of core, containing 107 lb. of copper and 140 lb. of gutta-percha per nautical mile, were immersed, one length in each sample. In the coil marked No. 1, the tar was kept at a uniform temperature of 90° Fahr. while the coil was immersed in it. Daily tests of the resistance of the gutta-percha were taken, and the results carefully noted. The fall in its resistance

15

decreased daily. From June 8 to November 21 the resistance had fallen from 62 to 1·25 megohms per knot. The coil was then cleansed from the tar and immersed in water, which was kept at 90°. From November 27 until March 5 the resistance gradually *increased* from 1·257 to 26·96 megohms per knot, and then gradually began to fall, and on May 20 its resistance was 2·237 megohms per knot. For three years this core remained immersed in water at no regular temperature. The water was then kept at 75° Fahr. for twenty-four hours, and the resistance was then found to be *nil*. The coil was then divided into four equal lengths, and each length gave the same result, showing that the resistance was destroyed by no local fault, but was general throughout the entire length.

Coil marked No. 2. In this experiment the conditions were precisely the same as in the previous one, with the exception that the tar was not kept at an uniform temperature, but varied during the experiment, the minimum being 60° and the maximum 68° Fahr. During four years the resistance gradually decreased from 13·98 to 4·76 megohms per knot. After being cleansed from the tar, and immersed in water at a temperature of 75° degrees for twenty-four hours, the resistance increased to 11·43 megohms per knot. This coil was divided also into four equal lengths, and the result showed a depreciation throughout the coil.

Coil marked No. 3. This experiment was conducted precisely the same as with coil marked No. 1. From June 12 to November 21 the resistance gradually fell from 74·4 to 0·587 megohms per knot. It was then thoroughly cleansed from the tar and immersed in water. From November 27 to December 22 the resistance gradually increased to 3·55 megohms per knot, and then began to decrease, and at the end of one month its resistance was *nil*. The depreciation was uniform throughout the entire length. When one end of the conductor was connected to one terminal of an induction coil, and a wire from the other terminal to which was attached a piece of moist sponge was passed near the surface of the gutta-percha, it was instructive to see the current, in the form of a luminous brush, passing freely through the gutta-percha; and at distances varying from seven to nine inches the current broke through the gutta-percha with force, leaving a hole resembling a puncture made by a small blunt instrument. No such effects were produced on a length of the same core which had not been in tar, but kept at the same temperature in water, when subjected to precisely the same treatment. It will be seen that the action of the tar on the electrical qualities of the gutta-percha was more rapid on coil 3 than on coil 1. Although the tar used with coil 3 was said to be from Stockholm, it was much inferior in quality to the other two samples. It will also be seen that the higher the temperature the quicker the effect on the gutta-percha. Coal-tar has a much quicker effect than Stockholm-tar, and coal-tar naphtha very quickly destroys its insulating properties, and disintegrates the gutta-percha, causing it to "crumble like old putty."

At the close of the last session Mr. Smith brought forward a new form of joint of which he had great hopes, and from which he had already succeeded in getting very high insulation; but he had at that time only two months' experience of its mechanical and electrical properties. Since that time, however, it had been regularly submitted to severe tests, and he could now speak of it with more confidence. He had at first advocated the use of Chatterton's Compound in the formation of that joint; but however suited that compound may be for the purposes for which it is employed, he preferred at present to use a compound of gutta-percha and resin alone. Mr. Smith also exhibited several lengths of wire containing joints, and stated the insulation resistance of each length in megohms; also two test boxes—one to contain twenty and the other over a hundred joints.

Mr. Smith also proposed that the size of the wire at present in use should be increased comparatively, as the thin coating of gutta-percha causes the wire to be in danger of receiving mechanical injury when handled.

In conclusion, Mr. Willoughby Smith expressed his opinion that if proper care were taken in the testing of the wire and its subsequent mechanical protection, we possess no data which point to failure; on the contrary, as subterranean wires come more and more into favour, all the evidence which we can at the present gather points unmistakably to success in this direction.

An interesting paper was then read upon "The Underground Telegraphs in France" by Mr. John Aylmer, the Society's Local Honorary Secretary in that country. We are prevented from entering to any extent into the ingenious contrivances mentioned in this paper beyond the fact that in Paris the underground system is chiefly placed in an extensive network of sewers beneath the streets of that city; a cable is made the size depending upon the number of wires required, and laid in leaden piping supported along the walls of these sewers.

When the piping is completed a carrier, to which is attached a light cord, is sent through by pneumatic pressure. When the carrier arrives at the distant end of the section it is removed, and the cord which it has brought through used to pull in a wire, which in its turn pulls in the cable.

The discussion on these papers was taken up by Messrs. Schramm, Truman, and Treuenfeld, Mr. W. H. Preece, Sir Charles Bright, the President, and Mr. Willoughby Smith.

Mr. Schramm described the form of subterranean line employed by the German government.

Mr. Truman asked why it was that if tar was so injurious to the durability, the compound mentioned by Mr. Smith, in which tar existed to the extent of 60 per cent., was not also injurious, and expressed his opinion that it was so, and that he thought the time was not far distant when cable-core would be formed by a copper strand covered by a single coating of gutta-percha, inasmuch as the difficulties which presented themselves in the early days of cable manufacture, and which necessitated the building up of the core, have long since been obviated.

Mr. W. H. Preece gave an entertaining history of tar in connection with gutta-percha covered wires, mentioning that the chief inducement offered by the use of tar, which ended in its subsequent employment, was the fact of its filling up any fissures in the gutta-percha with an insulating fluid.

Mr. Treuenfeld remarked that it would be interesting to know whether tar formed any known chemical reaction in the presence of gutta-percha.

Sir Charles Bright gave an interesting historical account of some of the lines mentioned in Mr. Willoughby Smith's paper which he himself laid down.

The President then stated that, with reference to the question raised by Mr. Treuenfeld, the actual chemical action which takes place when tar and gutta-percha are in contact are somewhat difficult to determine, since tar itself is not a simple chemical substance but a mixture of substances, all possessing more or less a solvent action on the percha, and also that no two samples of tar are chemically alike.

Mr. Willoughby Smith, having replied to his paper, a vote of thanks was unanimously accorded on the motion of the president to the authors for their valuable papers.

The meeting then adjourned.

We understand that Mr. Sivewright is about to proceed to the Cape Colony to investigate the working of the telegraph system at that place. From his experience in the Home Postal Telegraph Service, Mr. Sivewright is eminently fitted for such a task.

10 16

and Manchester have been eradicated in the present work; and the main causes of failure in the British Company's road wires will, it is hoped, be also avoided. This is a question which time alone can solve. This is, the author believes, the first time any severe and searching system of testing has been adopted in any such work. The line selected for laying down a series of underground wires was from Liverpool to Manchester. The survey for the route was made by Lieutenant Ramsay, of the Royal Engineers, under whose charge also the pipes were laid. The new work commenced where the street work in Liverpool ceased, and proceeded along the main road in iron pipes for some distance,—thence to Warrington by earthenware pipes, and thence in a mixture of earthenware pipes and iron pipes to Manchester. About seven miles from Liverpool the ground generally lies very low, and that part of the country is celebrated for its rainfall. On a considerable proportion of the route the water lies in the pipes even in summer. A more favourable situation for gutta-percha covered wires can not well be imagined. The various forms of cables hitherto used for underground work have differed in the size of the wires, but very little in their construction. Of the previous cables there may be said to be two forms, the general form being the straight wire cables consisting of a number of single wires covered with tarred tapes and bound together, forming a "cable" so called. The second, the form used by Mr. Henley in the works carried out by him, consisted of a number of plain gutta-percha covered wires laid parallel to each other, and being of the same length, and served over with tarred tape or some other preparation. The cables used in the present work were made by the Gutta-Percha Company, and were entirely different in their construction. They were of the true cable pattern. The core itself consisted of gutta-percha wire No. 7 gauge; copper wire No. 18 gauge, 39 lbs. to the mile; gutta-percha 46 lbs. per mile. It was manufactured in the ordinary way, being covered with two coats of compound, alternating with two coats of gutta-percha wrapping. The total weight was 85 lbs. per statute mile. The core, as it was manufactured, was cut off into special lengths as the cable required. The wires so cut off were wound on bobbins. The cables which were made up were subsequently passed through a bath of cold Stockholm tar in which was a quantity of fine cork-dust, to give the tar more solidity. After receiving this tar, the cable received two servings of tarred tape laid on in opposite directions. The tape was specially manufactured for the purpose. The cables, when ready for drawing in, were placed upon drums revolving on a stout frame, and at a convenient distance from the mouth of the pipe to avoid friction against the various points. Close to the mouth of the pipe was placed a wooden roller so as to prevent any friction against the edges of the pipe. After the cables had been drawn, and the wires numbered, the several ends were opened out, cleaned, and properly prepared for the jointers, who followed on as soon as they had completed the preceding set of joints. Each jointer had an assistant. The men employed at this work were more intelligent than the ordinary labourers. It was necessary that, as the work extended over open roads, a travelling testing-van should be constructed for the purpose not only of carrying the instruments and battery, but of affording accommodation for more than one person, and, indeed, acting as an office and travelling-carriage. A van admirably adapted for this service was designed by the author, and used in the work. The electrical apparatus consisted of 100 No. 3 Leclanché cells specially mounted on well-insulated tops. As the tests of the cable were to be almost identical with the ordinary tests of the submarine cable, the insulation of batteries and instruments was carefully secured. It being necessary to test the various joints throughout the work, a special joint-prop, with ebonite feet, was made for the purpose of placing inside the joint-boxes. For carrying out the tests, it was necessary to "make earth" wherever the van stopped. For this purpose a copper plate was used for places where water was at hand; and a long iron tube pointed at the bottom end, and with a screw connection for the earth wire at the top. This was driven into the ground at the dampest places, and answered admirably. The proper method of testing the joints was a question of some difficulty. After a great deal of consideration, and the abandonment of several plans, the author succeeded in devising a system which, he believes, will be found the best for adoption in all future underground works. The cables were tested in sections, and, immediately afterwards, all the joints of that section. The peculiarity of this plan is in so dividing the cables into sections varying in length, and in so looping the wires at the two ends, that a continuous circuit is formed. Any wire, therefore, in a joint-box will at once present the two ends of this continuous circuit, and render any tests of whatever kind perfectly easy. Condemned joints were replaced, and, as a proof of the improved insulation obtained by cutting out the bad joints, a statement may be given of the insulation resistance of the loops of two sections before and after the joints were cut out. In one section, the mean insulation-resistance before the joints were cut out was 111; afterwards, 481. In the other section, the mean of the fourteen wires throughout the section was 110. After the condemned joints had been cut out and replaced by good joints, the mean grew to 480. After a section had been passed, it was perfectly joined on to the next, and so on; but no section was added until the previous one had been found to be still in good condition. Of the various operations connected with practical telegraphy, there is scarcely one so important, or requiring so much practice and experience, as the making of the joints in a gutta-percha covered wire; and this operation was the most difficult throughout the work. Joints had to be condemned wholesale. Of the causes tending to bad joints, one is dissimilarity in the materials employed. Another cause was physical unfitness on the part of the workman. A greasy sweat sometimes issues from the pores of the hand, and it is easy to see that, as the joint requires frequent handling, this fact will tend towards bad jointing. The inclemency of the weather will sometimes interfere with the operation. And, lastly, the absence of cleanliness is one of the most serious defects a jointer can possess, and one which, more than anything else, is the cause of bad joints. The faults which beginners usually exhibit are simply the result of a want of experience, and this want practice alone can meet.

The Chairman said that the paper was one which would be sure to elicit a warm discussion, but the remarks must necessarily be somewhat curtailed, as a special meeting for altering the rules of the society was to take place after the present proceedings. He then invited Mr. Graves to open the discussion, he having had a great deal of experience as to the causes of failure on the Great Northern and North Eastern lines.

Mr. Graves said that perhaps the causes of failure were, throughout, the same—simply the neglect of the conditions which Mr. Preece had stated to be essential to the manufacture of a good joint. The joints, some years ago, were made without the slightest consideration of the conditions that were necessary to produce anything like a perfect result. To begin with, attempts were made to unite thick pieces of gutta-percha, simply by bringing together two portions of the material, very often imperfectly heated, and in a different state of temperature in relation to each other, and also frequently consisting of different manufactures.

17

The President said the first subject on the agenda was the adjourned discussion on "*Underground Telegraphs.*"

Major Webber said the very interesting paper read at a previous meeting by Mr. George Preece gave a most complete account of probably the most perfect underground telegraph line that had ever been laid down in this country, but he said very little of the history of the past maintenance of underground telegraphs and the experience of those connected with their construction. He (Major Webber) then ventured to remark that the history of underground telegraphs, so far as they know, was not such as to make it desirable to perpetuate the use of covered wires carried underground; but he only did so in order that perhaps others who had had experience of it in other countries would tell them something about it. Seeing that the paper for the evening was likely to be of so much greater interest to the meeting than anything he was likely to say on the subject of underground telegraphs, he would not take up their time, but hoped that the subject would be again brought forward on some future occasion.

Mr. R. S. Culley said the great difficulty with underground telegraphs, so far as he knew, had been in the joints. Mr. Preece took especial care with his joints, and they appeared to stand very well indeed; but it was almost impossible to afford the time that was necessary to make the joints in the perfect manner that Mr. Preece had done. There were 250 or 280 gutta-percha wires running through the Holborn viaduct, and 280 wires jointed on Mr. Preece's system would take very likely 280 half days to complete. They were consequently obliged to use a much rougher mode of making the joints, which, in competent hands, was generally fairly successful. But still, though they tried to teach the men to joint, they found that their wires were constantly giving more or less trouble at the joints, not so much in London as in the country. In London the joints stood tolerably well, because they had men who had been making joints, some of them, for these 20 years. If any one could invent a method of jointing gutta-percha wire that could be done more quickly than the kneading method, and yet would give a fair joint that would stand, and a fair amount of insulation, say ten millions, it would be a very great advantage.

Mr. Trueman said he believed he was in a position to say that such a joint could be made,—a joint of perfectly solid gutta-percha, without any appreciable loss of insulation,—and that such a joint could be made in the course of perhaps 20 minutes. He had some experience in the use of gutta-percha, and for many years it had been his hobby to use all the knowledge he had for the purpose of advancing its use for telegraph purposes, one of his main objects being to improve the joint. The great impediment in the way of a perfect joint was the compound, for they could not manipulate the gutta-percha properly when they had another substance intervening between the layers. He believed that a solid gutta-percha covering without any compound was what they wanted, and at some future period he should be happy to lay before the Society any knowledge he might have upon the subject.

Mr. R. S. Culley read a paper on "*Duplex Telegraphy.*" He stated that the details of the system are too minute to be dealt with successfully in a paper before an audience. The first questions which are asked are, How do the currents pass one another in line wire? and if they do pass, how is it they do not interfere one with the other? Telegraphists are too well aware that when two stations dispute for the possession of a circuit, the signals of each station are affected by those of the other, and neither station can read a word. In the case of the single needle, it is found that when the direction of the two currents is the same, the needle moves more strongly than when the current is simply from its own battery; and when the direction of the two currents differs, the needle scarcely moves at all. As the effect of this is entire confusion of signals, they must see whether it would not be posible to unravel this confusion, and if so, they would resolve the problem of the duplex. Suppose, first, that each sending-clerk knows the force with which his needle ought to strike the stops by the action of his own current, so that it is just possible for him to see when the distant station, B, sends a current in the same direction as he is doing at A, because at that moment A's needle strikes the stops more strongly than usual. Let A read that movement as a signal sent by B in the same direction as his own. Secondly, if B tries to move A's needle in the opposite direction, it will strike the stops less strongly, or perhaps will only move half-way to the stops. Let A read this as a movement in the opposite direction to his own. If it were possible, then, to have two clerks, one standing by the key and watching the way the sender moved his hand, and at the same time watching the movement of the needle and the strength of the deflection, it would be possible for him to know what signal the distant station sent. The author does not mean to say that, practically, anyone could read in this way, but it is just possible the direction of signals sent by the distant station might be distinguished. Thus it would be seen that, if by any means they could arrange so that a station's outgoing current could not affect his own needle, it would leave his dial free to show only the effect produced by the incoming current, and then the signals sent by the two stations would be separate one from the other. How then can each instrument be so connected that another sender shall affect his own needle, and yet so that his coil shall always remain in circuit to receive the current of the distant station? The author proceeds in his paper to consider what occurs in testing a line wire simultaneously between two stations for resistance with a differential galvanometer. He shows by actual experiment that so long as the resistance of the rheostat at each end remains equal to that of the circuit tested, each station will see the current sent by the other, although neither of them can see his own current. The reason is this; the current sent by each station is divided equally between the line wire and the rheostat. The two resistances being equal, the currents in the two coils are equal, and, therefore, the outgoing current does not move the sending station signal. The two currents do not pass one another as has been imagined; but when both stations signal at the same time, the current sent by either station acts upon the distant instrument by determining, for the moment, whether the line or the rheostat shall offer the easier path for the current originating there. In studying the effects produced by the varying positions of the key at each end of the circuit, the author states that it is better to take the case of a single instrument working by a single current, such as a Sanger or a Morse. In working one of these instruments the batteries are generally connected, so that when both keys are pressed at the same time, the currents flow in the same direction and assist one another, and when either station signals separately the currents are divided. But if the distant station depresses his key, he puts a zinc current on the line that assists the current in the line, but does not assist the current in the rheostat; therefore the strength of the current in the line is much greater, perhaps double that in the rheostat, and the needle of the distant instrument moves because the resistance of the line is virtually decreased, or the effect is the same as that of decreasing the resistance of the line. In the case of the single needle, if A sends a positive current, while B sends a negative current, the two are in the same

Tel. Jour. Dec 1, 1876

Tel Jour Dec 1. 1876

Submarine Key of M. Sommati.

THE object is to neutralise, at each emission of the current, the effects of charge of the cable. (M. Sommati applies the principle of it, also, to Siemens relays, employed in translations, and Hughes apparatus, working on long lines.) A reversing battery is, by means of an auxiliary lever, made to act momentarily when the key is returning to the state of rest, and before it has reached it. The editor considers the arrangement will probably work well on short submarine cables, not on long ones. The idea of the small auxiliary lever bringing into action a reversing battery is not new.

Tel Jour Sept 1. 1878

A SUBMERGED TORPEDO BOAT.—The Rev. G. W. Garrett, Manchester, has invented a torpedo-boat which is capable of sailing under water and fixing torpedoes to a ship's hull. It can be propelled by the men on board, by compressed air, or other motive power, and is lighted by electricity. Electric beams can also be directed in any direction under water. The supply of air taken in for the use of the men is purified by a very ingenious process, which is also applicable to diving bells, and enables the men to remain several hours submerged. A successful trial of this boat was made recently at the Birkenhead docks. While on this subject we may mention that a new and very devastating torpedo has been invented by Mr. Ericcson.

Tel Jour Dec 1. 78

759. "Telegraph Cables." F. LAMBERT. Dated February 23, 1878. 6d. This consists in protecting cables from toredo ravages or rusting, by sheathing it in the material called mineral wool, slag wool, or silicate cotton, with a suitable agglutinating material such as pitch, tar, oils, india-rubber, &c., capable of resisting the action of water. The protection is applied either as an outer coating, or as a tape wound spirally round the core, or as serving in lieu of the ordinary hemp serving.

Tel Jour Aug 15. 73

THE INTERCOLONIAL CABLE.—An agreement for the construction of a cable from New Zealand to New South Wales, and from Normantown to Singapore, has been signed by the conference representatives of New South Wales, Queensland, and New Zealand. The agreement is to the effect that these colonies shall guarantee five per cent upon one million pounds for thirty-five years, on condition that the cables are constructed for that sum. Receipts of over twelve thousand pounds go to reduce the guarantee. The arrangement will effect a reduction of thirty per cent on the rates charged for messages *via* Singapore, as compared with the Java cable rates. Mr. Audley Coote, agent for the Indo-European, Atlantic, and other leading telegraphic companies interested in the construction of the cable, has been instructed to accept the proposals of the delegates for the construction of the line. The tariff of charges is as follows:—From New Zealand to New South Wales, not to exceed 15s. for twenty words, and 9d. for each additional word; from Normantown to Singapore, 40s. for twenty words, and 2s. for each additional word.

Tel Jour Jan 15. 76

UNDERGROUND TELEGRAPHS.—STREET WORK OF LONDON.†

By C. FLEETWOOD.

THE following is an abstract of this paper:—From the original five wires used by Cooke and Wheatstone in July, 1837, to test their five-needle telegraph, the system has increased latterly with rapid strides, 750 wires at the present time entering the central station, St. Martin's-le-Grand, alone, with a total mileage of over 3,500 miles of wire.

On the successful issue of the Cooke and Wheatstone Telegraph, five wires were placed underground in lead pipes between Paddington and Drayton, but became defective in 1841, and were replaced by overground wires on posts.

In 1846, on the incorporation of the Electric and International Company, the lines erected by Mr. Cooke were led by wires in iron pipes to the first office in London, 345, Strand. In the following year the system was extended underground to the new central station, Founder's Court, Lothbury. The total system of the Company at that time reached 1,500 miles, less than one-half of the present street work in London alone.

The length of pipes underground now is 110 miles, consisting of five trunk lines, radiating from the central station, St. Martin's-le-Grand, to the following points:—Hounslow, Clapham Common, New Cross, Maryland Point, Stratford, Bayley's Lane, Stamford Hill, East End, Finchley, north end of Primrose Hill Tunnel, and Harrow Road.

At the central station the whole 700 wires are carried up the interior of the building, and terminate on a test box, where each wire is numbered. Provision has been made on this box for 500 wires from the west, and a corresponding number from the east, a total of 1,000 in all.

A 4-inch pipe will hold 100 wires, and a 3-inch 72. The pipes are 9 feet long, and previous to being laid, are well cleansed inside.

The socket joints are made same as in gas or water-pipe joint.

In marking out the route, the footpath is generally chosen; the pipes are laid under the pavement, it being more accessible than the roadway.

Flush boxes, 2 feet 6 inches long, 11 inches wide, and 1 foot deep, are fixed 50 and, in some cases 100 yards apart. As the pipes are laid an iron wire is threaded, by which the cables are hauled through.

The cables are sent out in lengths of 400 yards. On arrival at the place where it is to be used about 6 inches of 'percha is trimmed off the end of each wire, and the whole passed through a loop in the iron leading in wire and secured, a piece of canvas is then wrapped round and fastened with string.

An iron frame with two wooden rollers fitted is then fixed in the flush-box, the cable is made to pass over one roller and under the other, the latter is so arranged that the cable enters the pipe with a clear lead and without being chafed against its edges.

After a few sections have been drawn in, the jointers follow, numbering the wires and making permanent joints.

Within the last five years nearly the whole of the underground wires in London have been relaid. The work has been effected with comparatively little or no interruption of the working circuit, and by less than is experienced from removals on railways or road lines.

The wires are tested periodically from the central station by means of a Wheatstone bridge and Thompson's galvanometer. To prevent stopping the circuits two wires (where available) are used between St. Martin's and the points to which the wires are to be tested, one joined to an instrument for speaking, and the other for substituting the working wire during the time it is being tested. The average insulation is about twelve megohms per mile.

The position of faults are determined by a loop test, and as a rule is very correct. It seldom happens that a joint is found defective, but generally something within the pipes, probably caused by lightning.

If this view is correct, it would be well to have means of fixing lightning protectors at the ends of each underground route.

A few years ago it was customary to cut or prick wires when one was wanted at a point where numbers had not been attached. This was a very dangerous practice, and frequently led to interruptions of working owing to the cuts or pricks not being made permanently good. At the present time, by means of a quantity current and a horizontal galvanometer, a wire can be found at any point of the London street work without any difficulty, by merely placing each wire over the galvanometer.

Elect News Aug 5. 75

Improvements in Grapnels for Raising Submarine Cables.—Walter Claude Johnson, civil engineer, 38, Old Broad Street, London. December 10, 1874.—No. 4253. The object of this invention is to cut the cable and to raise one end only. The shank is similar in form and size to that of a grapnel ordinarily used for recovering cables. At the base of the shank are formed strong deep tapering jaws, preferably two in number; in each of these jaws is placed a hinged clip capable of receiving the bight of the cable, the inner surfaces of which are roughened or grooved so as firmly to grip the interposed cable. A bolt of lead or other suitable material is placed under the clip so as to keep it in the best position for receiving the cable, and a steel spring keeps the sides of the clip pressed firmly against the cheeks of tapering jaws. The prongs are made wide at their base so as to guide the cable into the before mentioned clip. Near one end of this clip is situated a V knife, which is similar in construction to that in ordinary cutting grapnels.

Subterranean Telegraph Line.—M. Holtzmann.—A line of this kind, forty miles in length, is laid in the neighbourhood of Amsterdam. A cast-iron trough is placed in the bottom of a trench, and filled with an insulating mixture, liquid pitch still in the warm state. The gutta-percha covered wire is then put in the liquid, the trough is closed with a lid, and the trench filled up.

Tel Jour July 15. 73

THE HOOPER CABLE SHIP.—This vessel has been built specially for the Hooper Company, and is fitted with three iron cable tanks built into, and with the ship, thus rendering them an element of strength instead of a source of weakness, as instances on record. The largest tank is 53 feet in diameter, and each one is 30 feet deep. The *Hooper* is propelled by a double-bladed screw, driven by compound surface-condensing engines, the high-pressure cylinder being 52 inches in diameter, with a 48-inch stroke, and the low pressure cylinder 92 inches in diameter, the piston rods being carried up through the cylinder covers. The engines are placed well aft, and take steam from four circular multitubular boilers. Besides the ordinary screw propeller, the *Hooper* is fitted with a transverse screw, placed a short distance inwards from the propelling screw along the keel, and driven by a pair of powerful engines in a deck house. The object of this screw is for manœuvring the vessel whilst laying the cable when it is expedient to remain on one spot. The arrangement has been tried, and proves to be quite satisfactory; when the main engines are stopped, and the transverse screw started, the vessel can either be kept stationary or hovering about one particular point. The vessel is not without appliances for saving labour, both on deck and below; water is laid on throughout the vessel, and her saloon and cabin accommodation is excellent. She was built by Messrs. C. Mitchell and Co., of Newcastle-on-Tyne, in seven months. The engines were built by Messrs. Thomas Clark and Co., and the paying-out and picking-up apparatus are by the Vulcan Foundry Company. The *Hooper* has a speed of 8½ knots, although when laying the cable she will not be required to run at more than 5 knots per hour. When loaded with 5000 tons, and drawing 23 feet of water, she displaces 1500 tons of water. She will take 1200 tons of coal on board for an average trip. She carries many thousand fathoms of grappling rope, composed of seven strands, each consisting of seven wires, separately covered with Manilla yarn, likewise grapnels, buoys, and necessary adjuncts for grappling or buoying the cable, should such a contingency as a break occur. A fine wire apparatus for sounding has been devised by Mr. Hooper, and answer well for great depths. In paying-out, the cable is led from each tank in succession to a series of five grooved pullies, which it passes over and under alternately, each pulley being fitted with a strap break. The cable then passes round a drum 6 feet in diameter, fitted with a powerful strap break, and thence over the paying-out wheel, 4 feet in diameter, and placed at the stern, a dynamometer being used to indicate continuously the strain on the cable. The picking-up apparatus is situated near the bows of the vessel, and is worked by a powerful double-cylinder engine carried on the same framing as the winding apparatus. The electrician's room is placed below deck between the main and after tanks, whilst there is a small house on the deck for jointing and similar operations. The batteries are upon Sir William Thomson's improved principle, the bluestone liquor being contained in long-necked bulbs, whose openings are loosely stopped with tow, and the necks inserted in the charged cells, the exudation of the liquor being by capillary action. These are stated to be both economic and satisfactory. The apparatus is so arranged that signals can be transmitted through the cable, and insulation readings taken at the same time. Signalling apparatus is fitted throughout the vessel to facilitate instant communication from one department to another.

20

Tel Jour July 15.73

Revue Hebdomadaire de Chimie, Vol. iv., No. 22.

New Method of Firing Mines, Dynamite, &c.—By M. Toselli.—The principle by which M. Toselli proposes to supersede the present method of firing mines by electricity, is the transmission of pressure in a liquid. The inventor employs a metallic tube of about one centimetre in diameter laid from the firing station to the mine. At one of its extremities, the tube is in connection with a very feeble pressure pump, and at the other is fitted with a piston which is attached to the trigger of a pistol or to a fuse. By the slight motion caused by pressure of the water, the trigger is moved, and sets fire to the powder or other explosive material.

Electrician Sept-14.78

THE BLOWING UP OF HELL GATE AT NEW YORK.—*La Nature*, in the issue of Sept. 7, gives details of the use of electricity in this gigantic operation. The electricity for the purpose of igniting the dynamite cartridges, containing 50,000 kilogrammes of dynamite, was obtained from a bichromate of potash battery, consisting of forty-eight cells, each containing ten elements. The zincs and carbons were arranged so that they could be raised from or lowered into the exciting fluid at pleasure. To obtain the exciting fluid, 80 kilogrammes of bichromate of potash were dissolved in 650 litres of water and 130 litres of strong sulphuric acid. The cells were thus grouped:—Seven batteries of 44 elements each, four of 43 elements, and twelve of 40 elements, and each battery was expected to explode eight groups of 20 cartridges. The cartridges were connected by conducting wires to little cups filled with mercury. Above these cups a metallic plate, connected with the battery and held by a rope, was placed, so that when it fell contact was immediately made. The rope held a cartridge, connected through a key with a cell. At a certain time the carbons and zincs were lowered into the exciting fluid. The daughter of General Newton pressed the key, the cartridge connected with the rope exploded, the rope was broken, and the contact plate descended, making the mine contact, and the dynamite exploded. The success, as we all know, was complete, and we only refer to the affair to show the part played by electricity.

Elect News Sept-23.75

165,535. *Underground Telegraph Lines.* David Brooks, Philadelphia, Pa. Filed June 2, 1875.—1. An underground telegraph wire or cable clothed with absorbent material, covered with insulating substance, and contained within a pipe, in combination with a liquid insulating medium maintained under pressure within the said pipe, all substantially as set forth. 2. An underground telegraph wire or cable surrounded by pipes arranged in sections, each section being bent upward at the ends, as set forth, and terminating in a box or receptacle, B, for the purpose specified.

Tel Jour Nov 15 77

SEA SOUNDING.—Sir William Thomson has recently patented an ingenious method of sounding, which can be put in practice without reducing a ship's speed. The pianoforte wire sounding apparatus of the same inventor was a great improvement on the old fashioned lead-line, and has done good service in the American navy and on cable-ships, notably the s.s. *Hooper* and *Faraday*. By the wire-sounding apparatus a great deal of time is saved, owing to the small amount of friction of the sea water on the wire in sinking and in hauling in, as compared with the friction on the rough hemp surface of the lead-line. Owing to the speedy execution of a wire sounding, it was also possible in shallow water to take a series of flying soundings from a ship without slackening her speed as she approached the coast,—a great advantage to a mail steamer in thick weather. One objection to flying soundings by the wire exclusively, lay in having to take the great slant of wire paid out as a measure from which to deduce the depth, since owing to the ship's motion, it was impossible for the wire to drop vertically down to the bottom. The new invention of Sir William Thomson measures the depth independently of the wire paid out, which, however, may serve as a check on the other result. The pressure of the sea-water at the depth to which the lead sinks is made the means of registering the depth, in the following way. A glass tube closed at one end and open at the other, is lined inside with a colouring matter such as aniline blue, red prussiate of potash, or, better still, chromate of silver, which will be acted upon chemically, and discoloured by sea water. This tube, suitably guarded in a brass guard-tube against accidents, is lowered with the lead-line into the sea. The sea water, forcing its way into the tube by the open end, compresses the air-column therein, and mounts up the tube to a height corresponding to the pressure, and discolours the lining of the tube in its passage. The discolouration in the tube marks the height to which the sea-water has penetrated, and this becomes a measure of the water pressure, and consequently, by employing a suitable scale, of the depth in fathoms to which the lead was sunk. A chromate of silver lining of the tube is turned from orange yellow to white by the action of the sea-water. Instead of discolouring the lining by sea-water alone, the sea-water itself may be tinctured by a dye as it enters the tube; or it can be arranged by proper valves simply to trap the water in the tube, and retain it there until it can be brought to the surface and its height read off. The indicator tube and lead-line are used in conjunction with the pianoforte-wire apparatus. Recent trials of this new apparatus on board H.M.S. *Minotaur* have proved highly satisfactory.

21

plied, that some action should be taken and the pirates hunted down.

Since the 13th of February all the offices of the Spanish provinces of Gerona, Barcelona, Lerida, Tarragona, Castellon, and Ternel, which had been closed through the Civil War, have been re-opened for work. The international service has also been re-established by the Franco-Spanish frontier of Perpignan Junquières. This will, no doubt, affect the receipts on the Barcelona and Marseilles cable belonging to the Direct Spanish Company, but to what extent remains to be seen. The cable has been well-worked, and has had an excellent and well-deserved traffic, and may yet be able to compete with the French and Spanish land lines. On the other hand, the receipts on the Santander line to England will, as soon as commerce is re-established at Bilbao in its old state, increase considerably.

In our last we mentioned that the Direct Spanish cable had been repaired in the s.s. *International*, Capt. Hayward. The work has been carried out by Mr. Benest, who was second Engineer on the laying of this cable, and has had considerable experience in cable work. The work was near a dangerous coast with a heavy Atlantic swell rolling in on it, and as another cable, belonging to the Spanish Government, between Santander and Bilbao runs parallel with and close to the cable repaired, the successful repair of the cable, without injury to the Government cable, does great credit to those engaged in the work at this time of the year.

The cable between Calais and Denmark has been for some weeks broken down, and the steamer *Caroline* is working at the repairs. Why this cable was ever laid seems difficult to imagine, as it runs parallel to the coast of countries in which numerous inland telegraph lines between France and Denmark exist. It must cross, at right angles, some eight or ten telegraph cables between this country and the continent, and all crossings of cables are objectionable, as if the crossed cables have to be raised, it would be difficult to do so without breaking or cutting one of the cables.

The Australian and New Zealand cable has been laid successfully by the Telegraph Construction Company. This cable is of a novel pattern. Instead of an outer sheathing of iron wires touching one another, as in the pattern of the Mediterranean deep sea cables, or of wires covered each separately with hemp, as in the Atlantic cables, we have alternately a wire and a hemp strand. This makes the cable cheaper at first cost, but we doubt whether it will be cheaper in the end to the company for whom it has been laid.

The steamship *Edinburgh*, which laid a portion of the cable, has been purchased by the "Eastern Extension and Australian Company" for £15,000 from the Telegraph Construction Company, and will remain out as a permanent cable repairing ship. Permanent repairing ships are a step in the right direction, but we cannot say that in this case the buying Company have been judicious in the selection of a ship, notwithstanding that they have a ship of 2,315 gross tonnage for £15,000. She is not a spar deck ship, and yet for a cable ship, a spar deck, so as to give plenty of room below, is almost a necessity. If she is a sound ship with compound engines and fully fitted with tanks and machinery she should be worth at least three times the price. The jump the company have made from the miserable little *Agnes*, the ship they have hitherto had for their former lines, to a ship of 2,315 tons is extreme, and there is something suspiciously small about the amount of money paid for the *Edinburgh*, which savours of getting rid of a broken down old horse for a song. We believe the selection of this ship as a repairing ship was in no way due to the engineers of the Extension Company. Most likely it was a matter arranged entirely between the Chairman and Managing Directors of the Companies with the advice, no doubt, of some "intelligent boatswain

The Direct United States Company's Torbay, New Hampshire, section is repaired. The cable was found cut with a hatchet. It is nothing new to find cables in shallow seas cut to clear nets and anchors; but the depth of one hundred fathoms, in which this was found cut, is greater, we believe, than any previous experience has shown.

The *Faraday* is to be kept out for the present as a repairing ship until the Company get one of their own. It is most strange that it should only now be dawning on the directors of the Direct United States Company that a repairing ship is necessary. With their opportunity of profiting from the experience of other companies they might have built the most perfect repairing ship by this time, and saved a considerable sum of money.

The Brazilian Submarine is another company without a repairing ship. These two companies are the only large companies without repairing ships. We suppose both companies will keep putting off the evil day until, under pressure of a break-down, in a hurry they buy some imperfectly arranged old tub, with the machinery crowded, not enough tanks and separate coiling spaces, and no room for the extra crew and stores.

A permanent repairing ship or cable ship should have plenty of room between decks for crew, stores, and men to work at splices, &c., and have

The Telegraph Construction Company have commenced the manufacture of the cable for duplicating the Eastern Company's system between Suez and Bombay.

22

Tel Jour ape 15 76

In our last we mentioned that the Committee appointed by the Admiralty, the Board of Trade, and the Trinity House, to consider the rules of the road at sea, had issued their report. Amongst the alterations proposed, is the following relating to telegraph cable ships:—"Art. 5. The following ships, viz.—A steamship laying or picking up a telegraph cable; a steamship which, in consequence of accident to her machinery or steering gear, or for any other reasons, is not under command, shall, by day, carry in a vertical line, one over the other, not less than three feet apart, in front of but not lower than her foremast head, three black balls or shapes, each two feet in diameter; and shall at night carry, in place of her masthead light, three red lights in globular lanterns, each not less than 10 inches in diameter, in a vertical line, one over the other, not less than three feet apart. These shapes and lights are to be taken by approaching ships as signals that the ship using them is not under command, and cannot therefore get out of the way. The above ships, when not making way through the water, shall not carry the side lights, but when making way shall carry them."

These proposed regulations have been submitted through the Foreign Office to all the countries which have adopted the existing International Regulations, and of course must be endorsed by them before they can become law.

It was certainly time that something was done as regards the lights of telegraph ships. In 1862 Sir S. Canning called the attention of the Admiralty to the subject, and in August of that year the Admiralty issued an order compelling all ships laying cables to carry two red lights at night in addition to the side lights and masthead lights, and two black balls at the foremast head by day. The order was not sufficiently published, and the late Shipping Act ignoring it altogether, it was no longer legal to carry these lights.

The present proposal does not seem a good one, as the same lights are to be used by steamers that are broken down as by a telegraph steamer. The consequence will be that every telegraph steamer will be taken for a broken down steamer, and consequently ships will bear down on them to see if they require assistance. It was greatly to prevent this that special lights for telegraph ships were required, as ships often come ranging alongside a telegraph ship at night, thinking she is a disabled ship and adrift like themselves, to ask if they want assistance; whereas the telegraph ship is perhaps moored by the cable she is picking up, and thus there is danger of the other ship drifting on to her. It will also be seen that if this proposal is made law every ship will have to carry on board three red lights and three balls so as to have them ready in case she breaks down.

Tel Jour Dec 1, 78

Proceedings of Societies.

THE SOCIETY OF TELEGRAPH ENGINEERS.

At the ordinary general meeting of this Society, Nov. 16th, Mr. Andrew Jamieson, C.E., read a Paper on "Cable Grappling and Cable Lifting." After reviewing the various kinds of accidents which produce faults in submarine cables, and classifying them into faults by abrasion, anchors, teredo, deterioration of core, lightning, Mr. Jamieson described the process of grappling and lifting cables. He pointed out that the present mode of stoppering a cable when it has been raised up to the bows on the grapnel is unsatisfactory: a man having to be lowered to cut it with a saw: and also suggested that improvements might be made in lighting mark buoys. At present these buoys are lit by a lamp attached to the pole of the buoy by a boat's crew, a clumsy, and in rough weather, a dangerous mode. Captain Collison's buoy, which is lit by gas compressed to 10 atmospheres within the buoy itself, has been recently tried during gales at sea; and had kept alight for twenty-two days and nights; the light being visible four miles by the glass, and two by the naked eye. This buoy, Mr. Jamieson thought, was worthy of trial. It may be mentioned that in the discussion which followed the paper, Mr. W. H. Preece related that he had seen a buoy off Sandy Hook which compressed air as it rose and sank on the swell, and gave out a powerful whistle. Mr. Jamieson then came to the subject of grapnels, and after describing the ordinary grapnel, the centipede and Lambert grapnels, he gave a detailed account of the grapnel with hinged flukes, invented by himself and Mr. W. F. King. The

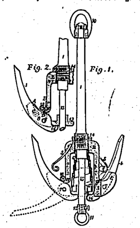


Fig. 2. Fig. 1.

special advantage of this grapnel is that in moving over the bottom should the prongs or flukes encounter a rock, they will not be broken off as in the case of the ordinary and centipede grapnels, but will bend backward until they relieve themselves from the obstruction, when the grapnel is freed. On the other hand, should the cable be caught it will fall into the hollow between the stem and shorter flukes, where it will be retained. The figure represents a section through this form of grapnel, where 1 is the stem and 10 is the shackle; 2 is a hollow cast iron box, containing a stout spiral spring 6; 4, 4, are the moveable flukes, long and pointed, turning round pivots 7, 7; 8, 8 are the shorter flukes which retain the cable 18, when it is caught, although the longer flukes 4, 4, may be bent back. The flukes 4, 4,

23

ing, and, if need be, undermining the cable. From a note that each wire should be the core of a rope line well saturated with boiled tar, and that the lines should finally be made into a rope treated in the same manner, one can form some idea of the nature of the cable which was contemplated. The scheme of connecting France and England expanded in the following year, 1841, into one for connecting Portpatrick and Donaghadee, and laying a cable across Portsmouth harbour from Portsmouth to Gosport. The Channel telegraph still, however, retained the uppermost position in his mind, and with this object in view a preliminary experiment was carried out in September, 1844, with some insulated wires submerged in Swansea Bay. The communication was preserved with the Mumblehead Lighthouse, and it is interesting to note that the old lighthouse-keeper, who had been an assistant in some department to Sir William Snow Harris, exhibited the keenest possible anxiety as to the result of what was going on, and rendered all the assistance in his power by reading the signals and communicating with those who were out in the boat. A letter from Wheatstone to Captain Beaufort, R.N., of the Admiralty, written in September, 1845, shows that the Channel project was still prominent in his mind, and from the pointed inquiries which it contains give evidences of the shrewdness and far-sightedness of the man. In these inquiry is made as to the action of sea-water upon lead, from which it would appear that he had some idea of employing this metal as the protective covering. As early as 1845 it would appear that Sir Charles Wheatstone intended to employ guttapercha in connection with his cable, although in what capacity is not clear. In that year he endeavoured to obtain some, but failed, owing to the fact that the last parcel had been bought by Mr. Hancock, of Charing-cross, and

credit of Mr. Newall that what was used by him at the birth, so to speak, of submarine telegraphy, should be taken up and all but universally employed even now, with all the accumulated experience of later times. With reference to the historical portion of the subject, the Spezzia-Corsica cable was the first one in deep water, laid by Mr. Brett along with Mr. Thompson, one of Mr. Newall's head assistants. In some places the depth was as much as 500 fathoms, and as the cable weighed about 7 tons to the mile, extra precautions had to be taken with the break power. Two ordinary drum breaks, each with double straps and five turns round each drum, were employed and answered the purpose. The same machinery failed in the following year with a 6-wire cable. After two starts from the land about eighty miles of cable were brought back, whilst sixty miles were picked up afterwards by Mr. Liddell and Mr. Webb in the *Elba*. This was the first heavy cable picked up from deep water.

In the case of the Bona-Cagliari cable mention is made of water-tight tanks having been used. That is hardly the case; they were iron tanks, but never intended to be water-tight. There is one historical fact in connection with this cable which deserves to be mentioned. It was the first cable on which a dynamometer was made use of. Its employment was first recommended by Dr. Werner Siemens, and adopted by Mr. Newall. Mr. Webb then entered into a minute description of this dynamometer, and the various improvements which have since been effected in it.

Mr. Webb confessed himself unable to answer the question put in the paper as to whether the formulæ of Messrs. Longridge and Brooks are correct or not. Considering, however, the number of cables whose submergence has been based upon the calculations of Messrs. Longridge and Brooks,

Sept 4 1880

The Telephone and Submarine Cables.—It is sometimes necessary to grapple and lift a faulty ocean telegraphic cable, and if it lies in the water along with other cables of similar external make, it has hitherto been impossible to decide, without cutting it apart, on the indentity of the grappled portion. To avoid the evil of having to cut and splice the cable unnecessarily, it is now suggested to employ the telephone on an auxiliary parallel wire in which the induction may be sufficiently strong to enable the electricians in charge to read the signals which may be sent into the cable, and so identify it.

Proceedings of Societies.

THE SOCIETY OF TELEGRAPH ENGINEERS.

(Concluded from page 106.)

The secretary then proceeded to read a very interesting communication which had been received from Mr. Sabine with reference to Sir Charles Wheatstone's early ideas of a submarine telegraph. This was accompanied by carefully executed drawings, to illustrate the type of cable to be employed and the mode of submergence to be adopted between France and England. From the letters in Mr. Sabine's possession it is found that as early as 1837 this was a subject in which Sir Charles Wheatstone was taking the greatest interest. It was when under examination before a Select Committee of the House of Commons some years later—the 6th of February, 1840—that he gave the reply which has now become historical, as to the practicability of establishing electrical communication by means of a cable between Dover and Calais. Towards the close of 1840 the drawings, which were exhibited, were executed. One of these shows very clearly the method of insulating and manufacturing the cable, as well as the means to be adopted for shipping it; the other shows the route to be taken and the methods of laying, join-

NOTES RELATING TO ELECTRIC FUZES.*

By F. A. ABEL, F.R.S., Treas. C.S.

THE earliest practical application of electricity to the explosion of submerged charges of gunpowder was made by Sir Charles Pasley, who, in the course of operations which he was carrying on for removing the wreck of the *Royal George* at Spithead, consulted the late Professor Daniell and Sir Charles Wheatstone, at King's College, on the subject, the result being the employment by him of a form of Daniell's Battery for the purpose of heating to redness a platinum wire surrounded by gunpowder.

In 1856 the subject of the application of electricity to the explosion of gunpowder was referred for experimental investigation to the Ordnance Select Committee, of which Colonel Bainbridge, R.E., Sir Charles Wheatstone, and I were then members. The investigations had reference to the further development of the application of high tension currents, as obtained with electro-magnetic induction coils and frictional machines (including Armstrong's hydro-electric machine), to the explosion of mines, and especially to the utilisation of magneto-electric induction apparatus in the same direction. The production of a highly sensitive and otherwise efficient fuze for employment with such instruments, as well as with other high tension apparatus, was made the subject of special investigation by me, in which I received most valuable assistance from Mr. E. O. Brown. After applying gun-cotton and various other highly sensitive compounds and preparations as priming (or vehicles for ignition) of such fuzes, the ultimate result was the production of the high tension phosphide of copper fuze, through the agency of which even small voltaic piles and so-called galvanic chains, as well as the simple forms of magneto-electric machines manufactured for medical purposes, became available for the explosion of mines. A very efficient magneto-electric exploding machine was also devised, by Sir C. Wheatstone, by means of which a large number of those fuzes could be exploded in divided circuit with such rapidity as to have the practical effect of simultaneous explosions in operations *on land*, and which served as the foundation for the construction of other instruments of the same class. Although the highly sensitive character of the phosphide of copper fuze has rendered it very valuable and superior to other fuzes of similar nature as a means of exploding mines and groups of mines, both land and submarine, its very sensitiveness became an obstacle to its employment with confidence in *submarine* mines. I was therefore recently led to devise a modification of the high tension fuze, specially designed for use in submarine mines, and which, while possessing the requisite sensitiveness to ignition, has been proved by ample experiments to sustain with absolute safety the transmission of any test-currents to which it may be necessary or desirable to submit them.

This fuze dispensed with the necessity for employing cumbrous and troublesome batteries, and rendered the success of exploding operations independent of distance and of good metallic connections. These high tension fuzes met with varying success. One chief objection arose from their deterioration whenever they became moist, and to which accident they were very liable. A very substantial objection to their use in submarine mines was, however, the liability to considerable alterations in conductivity by being frequently, or for long periods, submitted to even feeble test-currents, and the possibility of its accidental ignition by passing through them such comparatively powerful test- or signal-currents as it may be found necessary to

employ in conjunction with an efficient system of submarine mines. The new tension fuze, specially devised by me for use in submarine mines, is, as already stated, quite free from the latter defect, and, though its conductivity is by no means unaffected by the long-continued transmission of test-currents through it, the changes to which it is liable in this respect have been found, so far as present experience goes, not to affect its efficiency. Owing to the great liability which high tension fuzes have of exploding accidentally from induced currents a lighting discharge will probably decide whether it is desirable to replace them with low tension or wire fuzes.

The highly permanent character of platinum, combined with the comparatively great resistance which it opposes to the passage of an electric current, has led to its being almost exclusively used until quite recently as the material for the construction of the bridge or the source of heat in low tension fuzes. The wire of this material hitherto used in the production of fuzes for military purposes has varied somewhat in diameter, and the resistance offered by it is not very high. Its average diameter is about 0·003", and its weight 1·65 grains per yard; its resistance is equal to about 31 ohms per yard, so that the length of the wire which has generally been introduced into the construction of a fuze has offered a resistance of about 0·2 ohm. Several very full experiments were made to ascertain how far the sensitiveness of low tension fuzes could be increased by employing thinner wires than 0·003" inch, and it was found that the conductivity of such *fine* platinum wires as are employed in the construction of electric fuzes is but slightly affected by physical differences in the metal from which they are produced, and that the considerable variations observed in the electric resistances of commercial samples of fine wires are ascribable to variations in chemical quality or degree of purity of the metal.

In the course of these experiments it was brought to my notice by Lieut. Bucknill, R.E., that Mr. Farmer, of the United States, has recently devoted much attention to the improvement of wi[illegible] for the explosion of mines, and had applied G[illegible] silver wire to the construction of low tension fuzes with very promising results; also that Commander J. Fisher, R.N., had entertained the idea of using an alloy of about 33 parts of platinum with 66 of silver, adopted by Matthiessen for the reproduction of the standard of electrical resistance. With the view of ascertaining whether wires of either of these alloys presented decided advantages over fine platinum wire, I obtained some from Messrs. Johnson and Matthey, which were submitted to experiments. The conclusions arrived at are as follows:—

1. Both the German silver and the platinum-silver alloy are greatly superior to platinum in regard to the resistance opposed to the passage of a current, and the heat consequently developed in giving lengths of wires of a particular diameter.

2. German silver is, in its turn, superior in this respect to the platinum-silver alloy, as is especially apparent in the finest wires. This superiority, though very marked in considerable lengths of wires of the same diameter, is, however, only trifling in short lengths; the comparatively ready fusibility of the platinum-silver wire contributes, with other physical peculiarities of the two alloys, to reduce the fine German silver wire to about a level with it, and sometimes even to a somewhat lower level, as regards the thermal effects produced. Some slight influence in this direction may perhaps also have been exerted in these particular experiments, by the greater cooling power exerted, by the brass supports between which the wires were fixed, upon the German silver wire of comparatively low specific gravity.

In selecting a wire for the construction of low tension fuzes, its power to resist corrosion when in intimate contact with gunpowder or other substance employed as the igniting medium in such fuzes, especially if some moisture should be accidentally absorbed by them, possesses an important bearing upon its permanent efficiency. In Matthiessen's report on the application of platinum-silver wire to the preparation of standard resistance coils it is stated not to oxidise by exposure to air; it has, however, been observed to do so gradually, to the extent of becoming tarnished, and as, with extremely fine wires, a very superficial oxidation might appreciably affect the resistances of fuzes constructed with them, it was thought desirable to ascertain by actual experiment of a somewhat severe nature the power of such wires to resist corrosion in comparison with German silver wire. It was, of course, unnecessary to experiment with platinum wire in this direction. Wires of the two alloys, about 8 inches long, were enclosed in glass tubes, and each wire was surrounded closely by gunpowder and gun-cotton in the ordinary air-dry condition; one of each being also simply enclosed in air for purposes of comparison. In addition, a length of about 2 inches of each kind of wire was buried in wet gunpowder, the extremities being allowed to protrude sufficiently for testing purposes. Slight fluctuations were exhibited in two or three instances in the resistance-measurements of the fine and comparatively light German silver wire in the foregoing observations, and are no doubt ascribable to the effects of fluctuations of temperature, which did not influence the readings obtained with the platinum-silver wire, its conductivity being less affected by changes of temperature than that of any alloy experimented upon by Matthiessen. In all three experiments with the German silver wires enclosed in tubes there were indications of very slight superficial oxidation, as demonstrated by the permanent, though small, increase in the resistance of these wires, which, in the case of its exposure to contact with gun-cotton, continued very gradually up to the forty-first day, when it [illegible]nary. The resistance of the platinum-silver w[illegible] in glass tubes remained constant throughout.

The exposure of the wires to contact with *wet* gunpowder has afforded very marked evidence of the greater liability of the German silver wire to corrosion; at the same time it must be borne in mind that this test far exceeds in severity any conditions under which fuzes constructed with wire bridges would be likely to be preserved in actual practice. It will be seen that the platinum-silver wire remained unaffected by this test for thirty-two days after the continuity of the German silver wire had been destroyed by corrosion. The great influence of the charcoal in the gunpowder in promoting corrosion in its capacity as an electrolyte is interestingly demonstrated by the fact that the German silver wire remained buried for twenty-two days in wet saltpetre without undergoing great oxidation (which oxidation did not progress after that time), while the wire which was buried in wet gunpowder was destroyed by corrosion within six days.

The foregoing comparative experiments appear to warrant the conclusion that a wire consisting of the alloy, composed of about 66 parts of silver and 33 of platinum, is not only superior to a platinum wire of considerably smaller diameter as regards the resistance it offers to the passage of an electric current, but that it is also, practically, quite equal in this respect to a German silver wire of the same diameter, and is at the same time greatly superior to the latter in its power to resist corrosion.

In selecting the platinum-silver alloy as the material for the reproduction of standards of electrical re-

APHIC JOURNAL.
II.—No. 39.

ILLUSTRATIONS OF
'S LAW.*

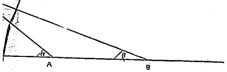
C. FOSTER, F.R.S.

sistance and the *electromotive*
out the use of tables.

ngent galvanometer.

up of a battery, tangent gal-
esistance coils. On making
ter needle is deflected through
sistance R is added, and the
value β. Take a point A in
ke angle $DAC = \alpha$. Make
$BC = \beta$. Let fall $CD + DB$.

Fig. 1.



ginal resistance of the cir-
omotive force, because—

= 1st current,

= 2nd current.

galvanometer.

$DBC = \beta$. Produce BC
ting ECA. With centre

. 2.

C and CE. The radius
electromotive force, and
the internal resistance.

circle $= DF'$,

$\frac{DF'}{DB} = \sin\beta$.

strating Ohm's law to a class in
by Prof. G. Cary Foster at the
ociation, and communicated to

ON THE
USE OF ELECTRO-MAGNETIC INDUCTION IN CABLE SIGNALLING.

By G. K. WINTER, F.R.A.S.
Telegraph Engineer, Madras Railway.

IT will doubtless be remembered by most telegraph engineers that at the Brighton meeting of the British Association I brought forward a subject connected with signalling on submarine cables that I thought had not received the attention it deserved. This subject was the use of an induction coil at the receiving end of a cable, the current from the cable being made to pass through the primary wire, and the currents generated in the secondary wire being used for working the receiving instrument.

There was one point connected with my experiments, and passed over as a matter of course in my paper, which seems, nevertheless, to have been misunderstood. I refer to the fact that, having a primary wire adapted as to its length and resistance for making the most of the received current, you may fill up the space to be occupied by the secondary wire with wire of any diameter, so long as you use a galvanometer or other receiving instrument of an appropriate resistance; in other words, the secondary coil must be treated as a distinct rheomotor, and, therefore, according to a well-known law, the resistance of the galvanometer should be equal to that of the secondary coil.

The resistance of my primary wire was about 2500 units, and, as explained in my paper, the resistances of the secondary coil and the galvanometer were about 2·5 units each. It is manifest that signals even from a strong battery, if passed through, say, 20,000 units, would scarcely affect such a galvanometer; whereas, if the same signals were passed through the primary wire of the above-mentioned induction coil, this same galvanometer would be specially adapted to show the currents generated in the thick secondary wire. A galvanometer, however, of the same dimensions, wound with 2500 units of fine wire, would be far more strongly affected by the direct signals than the thick wire galvanometer would be, even when joined to the secondary wire of the induction coil.

The induction coil is not therefore able to increase the *obtainable* strength of signals, but, if wound as mine was, it is able to convert signals that require a high-resistance instrument to show them into others that are best shown by one with low resistance. There are some instruments that are essentially low-resistance instruments, and which cannot be modified in this respect as galvanometers can. Such instruments would, of course, be useless as direct receiving instruments from long circuits,

pole of a Daniell, the zinc of the Daniell is put in communication with β, the zinc of the Leclanché with α. The mercury moves out of the field. One turns the handle v till the mercury is brought back to zero; the manometer marks 270·5 m.m. of mercury. The electromotive force inscribed opposite this number in the table is $e=0{\cdot}450$: hence 1 Leclanché = 1·450 Daniell.

ON THE THEORY OF CONSTRUCTION OF ELECTRIC FUSES.*

The name *induction fuse*, given to fuses that are inflamed by a current from an induction apparatus, seems to have been applied prematurely. Considering that the currents produced, whether by discharges or by chemical actions, are ruled by the same laws, and vary only in their effects, we think the name of *tension fuse* may be much more rationally applied to fuses in which the platinum wire is replaced by a powder, whose conductivity may vary within certain limits, but which has a great resistance, capable of being overcome only by a current of high tension. To distinguish, however, the fuses, which are only inflamed by ordinary induction apparatus, and those which may be exploded either thus or by a battery current (40 to 150 piles in tension) we shall designate the former *induction fuses*, and the latter by the more general name of *tension fuses*. The induction fuse, of which that of Ebner is a type, is more easy of construction than these latter. For, in tension fuses, the conductivity, the compression (*tassement*), and the separation of the wires play a very important part, and if the conditions in these respects be not strictly fulfilled, the sensitiveness to inflammation decreases till the number of piles required puts such fuses beyond possibility of use.

In what follows we have assimilated the currents of static and dynamic electricity . . . We assume that the electric spark is only a particular case of the electricity of batteries of high tension.

We have observed that:—

I. With the same conducting powder, compression of it, and separation of the wires, the greater the section of wire the more is the galvanometer deflected. The cylinder of powder between the two sections of wires may be compared to a resistant conductor the conductivity of which increases with the section. We know that the conductivity of a wire is in direct ratio of its section.

We have determined empirically a constant diameter of wire, corresponding to a given sensitiveness of inflammation (with the same compression), verified by the deflection of the galvanometer. It may be easily conceived, that if we change the diameter of the wire, all other conditions remaining the same, the fuse will no longer have the same resistance, and to obtain the previous effect it will be necessary to alter the conductivity, and consequently the compression, with the result of presenting a greater or less number of conducting molecules to the action of the current.

II. If while diminishing the diameter of the wires we increase the compression so as to have the same deflection in the galvanometer, the fuse will be less sensitive to inflammation. In fact, suppose the powder cylinder between the sections of wires to represent a bundle of platinum wires, very fine, and therefore very resistant; to compress the powder is to bring close together the molecules forming it, or, in one comparison, to diminish the distance separating the platinum wires so as at length to form a single wire, of section equal to the sum of the partial sections. The resistance of the platinum wire to the current will not have changed, but as the heating of a wire traversed by an electric current varies in inverse proportion to the fourth power of the wire, it follows

* Abstract of portion of memoir by MM. Champion, Pellet, and Grenier, in *Annales de Chimie et de Physique*.

The employment of tension fuses seems capable of obviating this inconvenience, the electric current necessary to their explosion having but an excessively weak tension proportionally to that of induction currents.

Riess has observed that a wire near that which allows the discharge to pass may retard the latter when it is a less good conductor. For the effect to be sensible the discharge wire must be wound in a spiral, as also the other, so that considerable lengths of the wires are in presence of each other. The two ends of the wire independent of the battery must also be joined so as to form a closed circuit. There is evidently an induction effect in the circuit the electricity of which reacts on that which passes in the discharge wire. The retardation is more pronounced the less conducting the induced wire.

It is evident, *a priori*, that we may prepare powders for induction, and tension fuses with a great quantity of substances, provided the mixture has a suitable conducting power. In this respect we believe we can rectify, *en passant*, some errors about certain bodies such as picrate of potash and nitro-glycerine.

Picrate of potash, even with chlorate of potash added, which much increases its facility of explosion, does not undergo any alteration in presence of ozone contained in the air; and they are mistaken who have supposed accidents, through explosion of the picrate, to have been produced by this cause; besides, no experimental fact can confirm this opinion.

As to pure and perfectly neutral nitro-glycerine, its fixity cannot be doubted since the labours of Nobel. This engineer has kept nitro-glycerine for more than ten years without observing any alteration, and our personal experiments on nitro-glycerine subjected to various temperatures fully confirm this fact. Certain spontaneous alterations of dynamite, sometimes remarked, have arisen from an incomplete neutralisation of the nitro-glycerine in consequence of defective manufacture.

Several foreign naval Powers are directing their attention to the practicability of establishing telegraph stations in mid-ocean, by which messages can be sent from any part of the sea along the line of the cable to the terminal points on shore, and *vice versa*, so that communication with ironclads, mail steamers, and other vessels when out at sea, may be established. One invention for carrying out this scheme consists of a hollow sectional column with a base plate attached by ball and socket joint, which column is lowered into the water, and anchored rigidly to the ground. The branch cable is coupled to the main cable, and carried along the column to the surface of the water, to be there connected with instruments on board the vessels. By this invention it is proposed to control naval and strategical movements, whilst a ship in distress could communicate her exact position, the nature of her disasters, and thus procure assistance.

"Bridge" which bears his name. The object of the first-named instrument, we need hardly say, is to measure the current strength by the interposition of a wire which produces a known resistance; then, by varying the length of this wire by a definite amount, causing an equality in the galvanometric effect produced by any two currents, which may thus separately be compared, and the relative strength of one to the other thereby estimated. Under various forms this instrument still remains indispensable in the cabinet of the physicist.

But it is by "Wheatstone's bridge" that the subject of our memoir is, perhaps, most widely and gratefully remembered by physicists generally. The object of this instrument is too well known by every electrician to render it needful for us to describe it, further than to say it is essentially a differential instrument depending on the law of derived circuits, which Wheatstone was the first to apply to electrical measurement. Upon the same law he also describes, in the paper to which we have referred, the now universally-used "shunt," and shows how a delicate galvanometer can thus be employed to measure any current strength, giving, too, the necessary formula to be used when the "reducing wire"—as he terms it—is introduced. But our space is more than exhausted, though we have by no means exhausted the benefits Wheatstone has conferred to both pure and applied science.

It only remains for us to notice the personal loss this Journal has sustained by the death of Sir Charles Wheatstone. When the first number of the Electrical News appeared, Sir Charles expressed to its present editor the liveliest interest in its future prosperity, and had, moreover, several communications with us respecting the means for increasing its usefulness and securing its ultimate success. Not only did he promise his invaluable aid, but even in the midst of feeble health he collected a number of hitherto unpublished notes, and it was arranged that a short-hand writer should—by taking down his thoughts—save him the trouble of writing. Unfortunately for ourselves, and we may add for Science also, Death laid its hand upon him ere his kind intentions could be carried out. It is to be hoped that the world will not lose the benefit of his unpublished papers, for we believe it is no secret that he had obtained latterly some new results which he esteemed of great value, and upon which he had promised us an early communication.

As we have regarded Sir Charles Wheatstone only from a scientific standpoint, leaving others to speak of him in his kindly home life, we cannot do better than conclude this hasty and imperfect notice in the words which Faraday uttered, nearly twenty years ago, as the lesson to be drawn from the career of one who did perhaps more than any single individual to increase the material and intellectual prosperity of mankind. Faraday says:—

> "Wheatstone's life is an argument in favour of a large public recognition of scientific education, because in Wheatstone we find a man both of science and practice, and his career is a strong illustration of the effects which a general scientific education may be expected to produce. . . . Such an education teaches us to be *neglectful* of nothing; not to despise the small beginnings, for they precede of necessity all great things in the knowledge of Science, either pure or applied. It teaches a continual comparison of *small and great*, and that under differences almost approaching the infinite; thus the mind becomes comprehensive. It teaches us to deduce *principles* carefully, to hold them firmly, or to suspend the judgment; to discover and obey *law*, and by it to be bold in applying to the greatest what we know of the smallest. It teaches us first, by tuition and books, to learn that which is already known to others, and then by the light and methods of Science to learn for ourselves and for others,—so making a fruitful return to man in the future for that which we have obtained from man in the past."*

Such faithful words cannot be too often pressed upon the attention of the nation.

SIR WILLIAM THOMSON'S REPORT TO MESSRS. SIEMENS BROTHERS ON TESTS OF DIRECT UNITED STATES CABLE,

Taken at Ballinskelligs Bay Station, September 16 and 17, 1875.

On Wednesday evening, September 15th, I arrived at Waterville, and proceeded thence to the cable station at Ballinskelligs Bay. There your electrician, Mr. Ebel, met me, and showed me the instruments which he was ready to put at my disposal for the tests; and Mr. Gavey, the Company's superintendent, obligingly lent me a number of additional condensers which I desired for measuring the electrostatic capacity of the line. Having made preliminary arrangements, and learned that, by orders from London, the line was to be at my disposal from 7 till 10 next morning, I returned to Waterville for the night, appointing to meet Mr. Ebel at the station in the morning at 7 o'clock.

About 8 a.m. on the 16th, after some preliminary trials of the instruments in connection with the cable, which showed strong earth-currents, I commenced testing for insulation with a battery of 20 cells, having its two poles constantly joined through a resistance of 20,000 Siemens units, but found so great disturbance by the earth-currents that it was impossible to

* Faraday, Lecture on Wheatstone's Electric Telegraph in relation to Science; Royal Institution, January 11, 1858.

Electrical News, August 5, 1875.

SIR WILLIAM THOMSON'S METHOD OF DEEP SEA SOUNDING BY PIANOFORTE WIRE.

On the 22nd of April, 1874, Sir William Thomson delivered a lecture before the Society of Telegraph Engineers, on his new method of deep-sea sounding by means of pianoforte wire. In that admirable lecture Sir William showed that the great merit of wires compared with rope is the smallness of the area and the smoothness of the surface which the wire presents, as compared with the greatness of the surface and its roughness when rope is used with a comparable degree of strength. Pianoforte wire, of the Birmingham gauge No. 22 has been found most suitable: it weighs about 14½ lbs. to the nautical mile, and bears from 230 to 240 lbs. pull without breaking. Messrs. Johnson produced a length of 3 miles, in one piece of crucible steel, capable of bearing a strain of about 230 lbs. One of the greatest difficulties to be overcome was the splicing of the wire. Experiment showed that a splice of 2 feet long was sufficient, but 3 feet may be safer. The two pieces of wire to be spliced are laid together, and held between finger and thumb at the middle of the portions thus overlapping. Then the free foot and a half of wire on one side is bent close along the other in a long spiral, with a lay of about one turn per inch, and the same is done for the free foot and a half on the other side. The wire has been previously coated with marine glue, just to increase a little the surface friction. The wires are found to cohere perfectly when splices are made in that way, all that is necessary to make the splice permanent being to cover the ends over for about an inch with a serving of twine just to keep the ends firm down.

The sounding apparatus as it is now finished and sent out by Mr. White, of Glasgow, and as it has been used by the screw-steamer *Faraday* on the Direct United States Cable Expedition, is represented in the accompanying figure, for which, with the description, we are indebted to the editor of *Engineering*. It consists of a large light drum, A, of galvanised sheet iron, on which the wire is carefully coiled. The free end of this wire terminates in a stout galvanised iron ring, *b*, and to this ring the sinker *c* is attached by a hemp line, *d*, several fathoms long. The interposition of the line between the wire and sinker prevents the wire from reaching the bottom, and the ring is heavy enough to keep the wire tight: thus kinking of the wire is avoided. The circumference of the drum is 1 fathom, and an indicator *e* is fixed to the axle to indicate the number of revolutions of the drum. A slight correction, due to the thickness of wire on the drum, has therefore only to be applied to the indicated number of turns in order to give the amount of wire paid out, or depth of the sounding in fathoms.

In order to stop the drum immediately on the sinker reaching the bottom, the brake F F is employed: it consists of a friction-cord attached at one end to the framework of the apparatus, and passing over a secondary groove on the circumference of the drum A, the other end being weighted at *g*. By means of this brake the increased pull on the wire due to the amount of it paid out is to be more than counteracted, so that the drum will revolve by a pull on the wire due to something less than the weight of the sinker; for, in this case, when the sinker is supported by the bottom there will be a friction on the drum bringing it to rest. The weights *g* have, therefore, to be applied gradually, as the wire runs out. The rule adopted in practice is to apply resistance always exceeding by 10 lbs. the weight of the wire out. Then, the sinker being 34 lbs., we have 24 lbs. weight left for the moving force: that is found amply sufficient to give a very rapid descent —a descent so rapid that in the course of half an hour or fifty minutes the bottom will be reached at a depth of 2000 or 3000 fathoms. The person in charge watches a counter (the indicator *e*), and for every 250 fathoms (that is, every 250 turns of the wheel) he adds such weight to

hung on a couple of fathoms of cord, but a greater length would have been better. I believe that 5 fathoms ought to have been used. Then the wheel was simply let go with a resistance of about 8 lbs., or, perhaps, an actual resistance of not more than 6 lbs. on the circumference of the wheel. When the ship was running at the rate of 4½ knots an hour, the cable was paying out at the rate of 6 knots; and after, perhaps, 150 fathoms had run out—in some cases 175 fathoms—suddenly the wheel would get so much slower that it almost stopped. In half a turn it was obvious that there was a difference. The moment that difference was perceived, the man standing by laid hold of the rim of the wheel and stopped it. Thus we achieved flying soundings in depths of 150 fathoms with the ship going at the rate of 6 miles; and we obtained information of the greatest possible value with reference to the depth of the water and the course to be followed by the cable. I think this is of such great importance that I never would like to go to lay a cable without an apparatus for flying soundings to be regularly practised, say every two hours at the least."

THE GOVERNMENT TELEGRAPHS.

A report, dated July 17, 1875, of the Committee appointed by the Treasury to investigate the causes of the increased cost of the Telegraph Service since the acquisition of the telegraphs by the State, has just been presented to Parliament. It bears the names of Alfred Austin, H. Weaver, and W. G. Anderson.

The points which received the attention of the Committee were:—

(1). The causes of the very serious discrepancies between the estimates of telegraph expenditure, year after year, and the actual outlay.

(2). The general expenses of the service as compared with those of the telegraph companies.

(*a*). As to the conduct of the business, and the staff employed for the transmission of messages.

(*b*). As to the cost of maintenance and extension.

(3). The extent to which offices and services are maintained which are not required by public convenience, and are not paying their expenses.

The following is an abstract of the result of the inquiries into these several points:—

Comparative statement of the expenditure on Telegraph Services, as compared with the grants for the different years since the transfer of the telegraphs to the Post Office, taken from the appropriation accounts rendered by that department to the Comptroller and Auditor-General—

Year.	Grant.	Expenditure.	Surplus.	Deficit.
	£	£ s. d.	£ s. d.	£ s. d.
1869-70 (2 months)	90,000	62,273 11 5½	27,726 8 6½	—
1870-71	360,000	409,493 8 8	—	49,493 8 8
1871-72	420,000	551,521 11 10	—	131,521 11 10
1872-73	669,990	871,915 17 8	—	201,925 17 8
1873-74	858,000	967,917 18 2	—	109,917 18 2

The Post Office asked for a grant of £90,000 for the three months ending March 31, 1870, but the transfer of the telegraphs to the Government having been postponed to January 29, 1870, the grant taken for the expenses of the entire quarter exceeded by £27,726 8s. 6½d. the expenditure of the months of February and March.

It appears from a Parliamentary return of August, 1870, only six months after the date of the transfer, that there were at that time employed in the telegraph branch no less than 4913 clerks, &c., instead of 1528 as proposed, and 3116 messengers, instead of 1283; so that the staff of the telegraph branch as compared with that of the companies was more than doubled. This fact alone will

UNDERGROUND TELEGRAPH WIRES.

A Pioneer Line Between the Fire Department and Police Headquarters.

Underground telegraph wires are being laid from the Fire Department Headquarters on Mercer street up to Houston street, thence to Mulberry street and to Police Headquarters. The wires are being laid by the United States Underground Telegraph Company by arrangement with the Fire and Police Departments. Sixty telegraph wires and six telephone wires run from the Fire Department building. Seventy-two wires are being laid under ground, so that there will be six extra wires. At the corner of Houston street thirty-four wires will be connected with the above-ground system of the Fire Department. Thirty-two wires will be carried underground to the corner of Houston street and Broadway, where they will be connected with the above-ground wires of the department. Six wires will be laid the whole distance between the Fire Department Headquarters and the Police Headquarters on Mulberry street. The entire length is between 1,500 and 1,600 feet, and it will be the largest underground line yet laid in this country.

In laying the wires an excavation is made to the depth of about two feet. A wooden trough is laid down, and in this the wires are placed, immersed in a composition which, it is claimed, perfectly insulates them. This composition is a mixture of powdered glass, paraffine wax, resin, and linseed oil. It is melted and poured in hot, and when it solidifies it is a tough, hard composition, impervious to moisture, and unaffected by changes of temperature. It will bend without breaking, and cannot be broken by the shifting of the earth or settling of the street bed. The wooden trough is simply a mould, which may rot away without affecting the efficiency of the cable. Instead of the ordinary galvanized iron wires of above-ground telegraphy, the wires used in the underground system are of copper, with two coverings of cotton fabric, soaked in paraffine wax. In placing the wires, a half-inch layer of the insulating composition is first put in the trench; then eight wires are put down, three-eighths of an inch apart; then come another half inch of the composition and eight more wires; and so on until the seventy-two are enclosed in a rectangular cable 6¼ inches wide and 3½ inches thick.

Mr. A. T. Woodward, who is in charge of the work, speaks enthusiastically of the qualities of this species of underground cable, and thinks that it will eventually supersede all above-ground wires, and that it will secure the department against storms or accidents.

He said: "Before beginning this work an experimental line was laid in Prospect Park, Brooklyn. It was a quarter of a mile long, with four wires giving a circuit of a mile. It was laid down last fall, in a shallow trench. The ground was frozen hard all winter, and was like mush in the spring, but the working of the wires was at no time effected. During the great winter storms, when there was a loss of four-fifths of battery power in the ordinary lines, there was no loss of power at all in the underground line."

Talking of underground cable laying in general, Mr. Woodward said: "The difficulty always has been to maintain the insulation of the wires. In London the underground system has been adopted, and the method there employed is to lay the wires in a packing of gutta percha or vulcanized rubber enclosed by iron or earthen pipes. The cables are laid in sections of 400 yards each, with test boxes between each section so as to locate breaks. There is an underground line of this kind between London and Manchester, thirty-six miles, but the cost is between $7,000 and $8,000 a mile, and frequent renewals of sections are required. In Paris telegraph wires are laid underground by means of cables carried through the sewers. The sewers are so large and well ventilated that workmen can go in and out without trouble, but it is a plan that with such a sewer system as we have here could not be imitated. In Berlin, also, the telegraph wires are laid underground, but they are made like ocean cables, with costly gutta percha and rubber packing and covering, making them cost upward of $2 a foot. In this city the only underground wires are the Western Union ~~lines connecting with the North River~~ cables. These are laid in gutta percha, enclosed by iron piping. Experiments have been made in the use of paraffine oil inside iron pipes, but it has been found that the oil gradually oxydizes and loses its non-conductivity.

~~It is claimed for the underground wires now~~ being laid that the cost is much less than any of the foreign systems, and that while it is greater than the ordinary above-ground wires, yet the system is much cheaper from its saving in cost of repairs and maintenance. The average life of the ordinary pole and line telegraph is eight years, and the cost of repairs and maintenance takes up one-fourth of the receipts. When the underground wires are properly laid it is claimed that the cost of maintenance is inconsiderable. Moreover, the workings of the wires will be unaffected by the storms which now sometimes destroy all telegraphic communication between cities for a time.

Ironmonger June 18 1881.

UNDERGROUND TELEGRAPH WIRES.

The reply of Mr. Fawcett, Postmaster-General, to a question recently asked in the House of Commons by Sir Henry Tyler will be received with feelings of general satisfaction. This feeling will be especially notable in the metropolis, which has suffered more, even in proportion to its size, from the dangers of overhead wires than any of the large towns and cities of the country. With the extension and development of the telegraphic and telephonic systems the plan of suspending the wires overhead has become an intolerable nuisance, a source of great danger, and a decided eyesore. Some of the streets of the City are literally cobwebbed with wires crossed and recrossed in every conceivable direction, so that in high winds or during extremely low temperatures the danger to pedestrians and others is a very grave matter. Mr. Fawcett now explains that the Post Office authorities are reducing the extent of the overhead wires in favour of the underground plan, and that they are endeavouring to diminish the mileage under the old system as rapidly as possible. The efforts hitherto made have been largely successful, seeing that in 1877 there were 1720 miles within a radius of four miles of the General Post Office, whereas now the mileage is only 500, and the underground wires have increased from 3,350 miles to 4,308 miles in the same period. This is satisfactory so far at it goes, but the extension of the telephonic wires is a matter which requires prompt and vigorous action on the part of those concerned. It has been proved to demonstration in Germany, New York, and elsewhere that underground wires can be successfully insulated and maintained, so that there need be no obstacle whatever in the universal adoption of the system—the carrying out of which would not only be a gain to the public, but would be an especial benefit to our tube manufacturers, founders, and others engaged in various branches of some of the industries represented by this journal.

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the value of this important improvement, which speaks for itself, and, as seen from the above, is very fast gaining in favor with the building trade.

Wm Radde's Patent

Underground Telegraph Lines.

The continually increasing objectionable features of the common clumsy and unsightly manner of carrying telegraph wires above ground on high poles, is calling attention more and more to the investigation of the best system of underground conductors for the subtle agent, electricity, at present one of the most indispensable servants which the ingenuity of man has succeeded in training for the use and benefit of modern society.

Every observing person is satisfied of the defects of the present system in use in this country, and we need only mention some of them, without wasting any space, to demonstrate the reality of these defects. The most striking are: 1st. Unsightliness of the poles and wires in cities, especially when many wires pass along the fronts of beautiful buildings. 2d. Danger to the public by the falling of poles and wires during a storm. 3d. The impediment they offer to the firemen in buildings situated behind many wires stretched in front.

These are the objections from the side of the public; but the telegraph companies who use the wires, also have objections, chief among which is the danger to which the conductors are exposed to damage, and thus lose their usefulness.

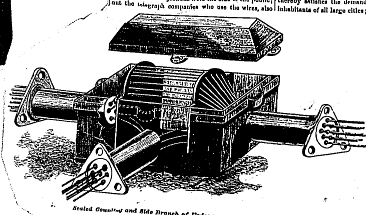
4th. Constant care and repair are required, as prostration by storm may interrupt the current by breakage or entanglement of the wires. 5th. Mischief can more easily cut a wire or throw down a pole than damage a well-made underground conductor. 6th. Rain and moist weather cause such losses of electricity as to make an increase of battery power necessary, and consequently an increase of expense. 7th. Thunderstorms and auroras may throw or induce so much electricity into atmospheric wires as to seriously impede the transmission of messages. 8th. It is easier to intercept a message by tapping an atmospheric wire than to do it with a subterranean wire.

These are only some objections, to which others may be added, and which do not exist in underground conductors. The only question is to make the latter so as to secure perfect isolation, to have them out of the way of harm, and still within reach so as to be at any time accessible for repairs and additions.

This difficult problem has been imperfectly solved in the European systems of underground telegraphs, and notwithstanding this, they are being more and more extensively substituted for the highly objectionable air lines. What then must be the future of a most perfect system of American invention, which is not only entirely free from all the above objections of the air lines, but also from the objections of the European underground lines? Being perfectly reliable under all circumstances, either for news messages or as a guard to life and property, and being composed entirely of inorganic substances, it is not subject to decay, and needs no repairs, like the gutta-percha covered wires and similar contrivances. It consists of a multiplicity of very small glass tubes, (from 3 to 18 and upward) put in an iron pipe. The naked copper wires are drawn through these glass tubes, which are held in the required position by paraffin wax.

For lateral connections, as well as convenience in laying the wires down, traps are used, into which the pipe is screwed, the wires passing over non-conducting bridges, thus allowing any wire to be taken out and replaced if desired, without interfering with the working of the others. The pipes are connected by a coupling, which, after being bolted together, is completely sealed with paraffin wax, the traps being closed and sealed in like manner. Such a trap is represented in the adjoined engraving, with the cover removed and the sides open to expose the interior.

It is clear that the advantages of wires so protected are that it does away with the telegraph poles, and thereby satisfies the demands of the authorities and inhabitants of all large cities; it saves the great cost of the constant care and repair of the wires suspended from the poles, and reduces the cost of transmitting messages. By this system we have no crossing of wires, no difficulty from atmospheric changes, no cutting of wires in cases of riot or for the purpose of defrauding, no imperiling of life and property by the breaking down of poles and wires by snow-storms or fires, (causing interruption of telegraphic communication,) but a perfectly reliable telegraphic connection under all circumstances. The advantage of the ingenious invention described, will be more evident still when we examine the underground system now in use in Europe. This is laid mostly in cables, coated with an organic material, which soon disintegrates, while all the wires become useless in case any of them need replacing. In this system any of the wires can be taken out and replaced without interfering with the others, each wire being exactly in the same position on one end of a line as it is on the other end.



Sealed Coupling and Side Branch of Underground Telegraph Line.

The system of an underground telegraph has been thoroughly tested, and has the indorsement of the best electricians in this country and in Europe. It has been publicly discussed before the Polytechnic Club of the American Institute of New York, and has been on exhibition and in operation at the fair of the American Institute in this city, receiving the diploma in 1875.

Mr. Wm. Radde, of 548 Pearl street, New York, has the patent, where further information may be obtained. Samples of the pipe and a working model of this system are on exhibition at the Centennial Exhibition at Philadelphia, in Machinery Hall, Siding 6, Class 566, Location B, 3, 20. This underground telegraph system has been laid between the Commissioners' and Finance buildings (72 wires) connecting these buildings, and registering all admissions to the Centennial Grounds by being connected with the turn-stiles at the entrance.

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occur in any other cables, and the fact that the high reward offered for the detection of any malicious cable breakers has failed to bring forth even an accusation, must be taken as strong evidence in favour of the correctness of our opinions. But, moreover, Mr M. I. Gaines, Superintendent of the Anglo-American Telegraph Company at Duxbury, in a letter to the *Boston Herald*, states that the Anglo-American cable from Duxbury to St. Pierre, laid in 1869, has been broken regularly every year since it was laid except in 1874, and that in 1875 it was broken three times during the year. He also states that this cable has been broken, curiously enough, on the 26th, 27th, and 29th days of May in different years, and that all the breakages with one exception have been within the space of fifty miles, while five of them have been within a space of ten miles. The owners and captains of the fishing-boats that broke the cable, have on several occasions been kind enough to report all the details of the accidents, which he proceeds to give as a conclusive demonstration that the breaking of the Direct Cable has been accidental, and not from malicious intentions or motives. Mr. Gaines gives the following example of the way the cables are broken. On the 4th of May, 1873, the cable was broken 66 miles from Duxbury by the fishing schooner, J. W. Bradley, of Rockport, Massachusetts. The facts in this case were that the day before the cable was caught it came on to blow severely. The schooner broke adrift just before night, and they had out about 180 fathoms of cable. In the morning when the schooner hove up they supposed the anchor had caught bottom. After about 80 fathoms had been hove in they found their anchor was hung, and continued to heave for six hours, getting only a turn on the windlass as the schooner pitched down as the sea rose and fell. At last they saw they had the cable, and while waiting to devise the best way to clear their anchor the cable parted. "This," Mr. Gaines says, "is the way it is done. It is always the same story with variations only of time and place. The skipper hooks the cable, heaves up his chain as far as he is able, putting a severe strain on the telegraph cable, and then swings to it, a heavy sea strikes him, or a tremendous ground swell throws him upwards like a cork, and something has got to go smash. That something is generally the cable, being the weakest." This account is much more in accordance with general experience than the opinion given by Sir W. Thomson and Mr. Bramwell in their report, viz., that "If a fishing vessel having hooked the cable accidentally brought it up to the surface and endeavoured to get the anchor on board, the cable could not be broken in the process," and we may safely assume that the Direct Company's cable has been broken in the same way that the Anglo-American Company's cables have been.

The Direct Company's cable has now happily had a long respite from these accidents, and has been working well, and it has been the turn of the Anglo-American Company's system to be interrupted, yet we do not find the Anglo-American Company insisting on any malicious breakage of their cables. Their Brest-St. Pierre cable—commonly called the French Atlantic—broke down on April 26, and the repairing ship Minia, which happened to be in the Thames, was despatched in a few days to the fault about 200 miles from Brest, a locality where the cable broke down in 1873. Unfortunately on May the 4th, before the repairs could be completed, the last of the cables between Placentia Bay, St. Pierre, and Cape Breton, broke down, thus completely stopping the communication between Newfoundland and New York. One of these was quickly repaired by a steamer hired for the purpose. But it was thought advisable to get another of the Placentia cables repaired, and the Minia was ordered to leave the French Atlantic cable and proceed on May the 18th to Newfoundland to effect this, which she has done. For the repair of the French Atlantic, the s.s. Hibernia, which has just returned from laying the Australia and New Zealand cable has been ~~hired from the Telegraph~~ Construction Company by the Anglo-American Company. She is fully fitted with machinery and tackle, and Mr. J. Laws, the experienced electrician, and Mr. London, one of the engineers of the Telegraph Construction Company, are entrusted with the work. The Hibernia left the Thames on the 18th, and we shall, therefore, no doubt soon hear of the repair of the French Atlantic cable.

With regard to the 1865 cable, which has been broken down since March, 1873, we believe no steps are to be taken this year as regards its repair. Indeed, it seems very probable that now it never will be repaired, for if the Anglo-American Company having now two repairing ships in their employ, cannot spare a ship to work at it, although it has been broken for three years, there will most probably be no better chance at any future date.

The coast cables, on the other side, seem to be the most troublesome to both companies, and in any future Atlantic cable it will be desirable to study very carefully the routes to be taken, and if no better than the present can be found, the cables must be of a heavier pattern, for the interruptions are too frequent for a single repairing ship to keep pace with. At the present moment Atlantic telegraphy is employing three repairing ships. Should an amalgamation take place between the companies, some of this expense might possibly be saved, for whilst the Anglo-American Company were in want of a repairing ship on the other side of the Atlantic, the Faraday was on that side and unemployed. In any case, the Anglo-American Company's system of cables from Placentia Bay to St. Pierre and Cape Breton, is not proportionate in safety from complete interruptions to their sections across the Atlantic, for whilst complete interruption has only occurred on the whole of the deep-sea cables once, and that when there were only two cables, and never since there have been more than two, the failure of the short cables has twice caused complete interruption on their system, and has not unfrequently caused them to be dependent on only one cable to carry on the messages from St. Pierre and Newfoundland, although these places were fed by four cables from Europe.

31

NEW ZEALAND TELEGRAPH.—Telegraphic communication with New Zealand has been successfully established. The New South Wales end of the cable was laid at Botany Bay on Saturday, February 5th, and the *Hibernia* and *Edinburgh*, the two steamers engaged in laying the submarine cable, then proceeded on their voyage to New Zealand. The work was performed in a very expeditious and successful manner, the whole work being completed within a fortnight. The New Zealand end of the cable was landed at Nelson. On the completion of the work congratulatory messages passed between the Governor of New Zealand and the Governors of the various Australian Colonies. The charge for sending messages from Melbourne to New Zealand is 10s. 6d. for ten words, and 1s. for every additional word.

SAN FRANCISCO CABLE.—The United States corvette *Tuscarora* has arrived at Brisbane. She has been taking deep-sea soundings from San Francisco to Honolulu, and thence to Moreton Bay in view of the proposed construction of a submarine cable between San Francisco and Queensland. It is understood that the route is considered particularly favourable for the projected cable. After coaling and provisioning, the *Tuscarora* will proceed *via* Sydney to Auckland, and run a line of soundings thence to Kandavu, to ascertain the feasibility of cable connection.

A telegraphic cable is about to be laid down between Havre and Honfleur. It will join the Normandy coast at a point between Honfleur and Trouville. The steamer Ampere, destined for the operation, can immerse a cable with a velocity of three miles an hour. A cable has just been laid between Marseilles and Bona in Algiers.

Aug 77

2 32

Eng **TELEGRAPHS.** Feb. 76

WE are glad to see that the Anglo-American Company are beginning to see that their cables cannot last for ever, and have, therefore, determined to create a renewal fund at the rate of 100,000*l*. per annum. They also state that the attempt to repair the 1865 cable in their repairing ship the Minia will be made this year. This at once shows that they now think it possible to repair the cable with a ship of only 2000 tons, although they were persuaded that no ship but the Great Eastern could repair it, and thus expended 70,000*l*. three years ago. It seems astonishing that the years 1874 and 1875 should be allowed to pass without any attempt at repairs. The chances of success must be much diminished by the time that has elapsed since the cable first failed three years ago.

The Direct Spanish Cable was announced as broken on the 4th instant. The rupture is near Santander. This cable originally started from Bilbao, but during the siege of that town in 1874 the cable was diverted by the company to Santander. It was cut at sea about 7 miles off Bilbao, and a cable run from Santander along the coast to the place where the line was cut and there spliced on to the part leading to England. This portion of cable, about 30 miles, lying parallel to the coast in shallow water, and being only deep-sea cable, except a short portion of shore end near Santander, will be always liable to interruptions, this being the second since it was laid. For cables to last when running parallel to the coast, they require to be of very substantial proportions. Of course this deviation could only be considered as a kind of temporary work. As soon as the Carlist War is over we presume the cable will again be diverted to Bilbao by splicing up the original cable. Possibly the deviation cable may also be run into Bilbao by an additional length of cable, so as to give the company a line between Santander and Bilbao, but as it is only a deep-sea line it would not last very long.

The Spanish Government last year had cables laid by Mr. Hurley from Santander to Bilbao and from thence to St. Sebastian. Thus there are three shore ends at present in Bilbao Bay. If the deviation cable is carried in also this will make a fourth. The bay is very narrow and there is much anchorage to keep clear of, while it is necessary to lead all the cables on one side of the bay. It seems very doubtful whether all these shore ends can be kept clear of one another, and if one ever has to be repaired the chances are that the others might be hooked or damaged when dredging. It is decided bad engineering to take four shore ends into so narrow a span. The Spanish Government are responsible for taking the second and third cables there. We notice that a Mr. Steenackers has been appointed by the Brazilian Government to put all the telegraphs in Brazil in order. Surely this cannot be the gentleman of that name who, as Minister of Telegraphs under the Government of National Defence in France, received a commission of 8000*l*.—according to evidence given in the case of Aspinall *versus* the India-Rubber, Gutta-Percha, and Telegraph Works Company—on the price of 88,000*l*. for a telegraph cable to be laid from Bordeaux to Dunkerque for war purposes during the war, thus drawing on the finances of his country at a time when his countrymen were bleeding by thousands in the field. At the trial one of the council called it a *douceur*. "Bribe" said Baron Bramwell. "It is a good Anglo-Saxon word." The last we heard of this worthy gentleman was that he had left his country and retired to Lisbon, and it appears almost improbable that it is the same person of whom we hear from Brazil. We cannot conceive what Brazil could want with his services. Dr. Capanima, the present director, is an able and scientific gentleman, and all the aid we should think he requires would be a few engineers practically acquainted with modern work and not addicted to receiving heavy commissions.

We learn by telegram that the Turkish Government has forbidden the transmission of telegrams in cipher over their telegraph lines.—*Railway News.*

In a circular issued by the directors of the Direct United States Cable Company, they mention the following particulars concerning their traffic during the interruption on the Anglo-American system:— June 1876

"The rush of traffic over the "Direct" cable practically lasted from the 4th to the 9th of May, inclusive, during which time 83,141 words were actually transmitted over the line. On the two heaviest days—viz., the 5th and the 9th of May—14,402 words and 15,906 words were sent over the line during each day, making an average speed for the whole of the 24 hours of 10 and 11 words respectively (the highest speed reached was 18 words per minute).

This speed, it must be borne in mind, was attained over the longest section of the system, viz., the main cable of 2,500 nautical miles.

On the shortest section of the line the speed was, of course, very much higher.

Considering the fact that the work usually performed by five cables was done during this time by one, it is a matter for congratulation that the maximum delay reached no more than about 15 hours, and that only at the time of the greatest pressure."

With regard to the interruptions in the Anglo-American system between Newfoundland and America, *The Telegrapher* of May 6th states: "This week all the other cables of the Anglo-American Telegraph Company are interrupted between the Island of St. Pierre and Placentia Bay, Newfoundland, which cuts off all communication between the cables which land at Heart's Content, N. F., and the connections this side, entirely suspending business.

"As the break is on the short section between Nova Scotia and Newfoundland, it will not probably take long to repair it. Unfortunately, the *Minia*, the regular repairing steamer of the Anglo-American Company, is at present on the other side of the ocean; but, another, a small boat, which has occasionally been engaged for repairing purposes, will be chartered, if possible, for the emergency."

The Telegrapher of May 13th, says: "The cable from Placentia Bay to Heart's Content, Newfoundland, is broken, and two of the cables connecting St. Pierre and Sydney, and four connecting Sydney and Placentia have been broken during the last two weeks, and now only one of them is in operation."

A NEW CABLE.—We learn from Madrid that a royal decree has been published authorising the Minister of the Colonies to accept proposals for laying a submarine cable between Manilla and Hong Kong. Dec 7 8

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[Journal of the Telegraph.]

THE PRESENT METHOD OF TELEGRAPHING THROUGH OCEAN CABLES.

THE peculiar conditions which are met with in the transmission of electricity through long submarine lines render it necessary to employ apparatus and methods for telegraphic correspondence which differ very materially from those used for land lines. The general principle, however, is that of the single needle telegraph of Cooke. In order to avoid any possibility of injury to the insulating coating of the cable, it is an essential condition that none but very weak currents should be employed, and for this reason the ordinary receiving instruments, which for the most part depend upon the action of electro-magnets, and require currents of considerable force to actuate them, are not available. It would occupy too much space to refer in detail to all the reasons which render it necessary to employ on long cables like those which have been laid across the Atlantic Ocean between Europe and America, the sensitive reflecting galvanometer of Thomson, but it is proposed in this article to describe the arrangement of the apparatus at the stations by which the effects of the phenomena of induction are overcome and the speed of signalling increased to the greatest practicable extent.

In Fig. 1 the manner in which the different parts of the apparatus are arranged at Valentia, Ireland, and Newfoundland, for operating the Atlantic cables, is shown in the form of the diagram. The condenser C consists of alternate sheets of tinfoil and paraffine paper, interleaved, and contains an aggregate inductive surface of 40,000 square feet. It occupies a space three feet long, two feet wide and five inches thick, and is inclosed in a box and surrounded on all sides by a thick body of paraffine. The switch *e r t* is a common three point switch, which serves to connect the cable K either with the transmitting keys T or the reflecting galvanometer G (which forms the receiving instrument) when sending or receiving. The double key T, in connection with the battery B, is arranged so that one key, *a*, sends a positive and the other, *b*, a negative current from the battery to line. W is a very large resistance, which connects the end of the cable K to the earth at the point where the former is attached to one side of the condenser C. The battery B usually consists of about five elements of the kind illustrated in Fig. 2.

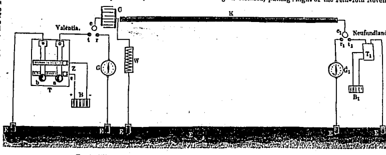

FIG. 1.—THE PRESENT MODE OF TELEGRAPHING THROUGH OCEAN CABLES.

If Valentia wishes to transmit to Newfoundland, the operator shifts the connection of the switch at *e* from *r* to *t*. When the key *a* or *b* is depressed, then one set of plates of the condenser C is charged either with positive or negative electricity, as the case may be. If, for example, the key *a* is depressed, then the + E of the battery flows by way of *e a t* and *e* to one set of plates of the condenser; hence the — E of the cable, in connection with the earth at Newfoundland, is attracted, and condensed on the other set of plates, which are connected with the cable, while the + E of the cable is at the same time repelled and driven towards Newfoundland. In this way there arises in the cable a positive current from Valentia towards Newfoundland, passing at the latter station by way of *e′* and *r′* to the receiving instrument or galvanometer G′, and thence to the earth, and by the deflection of the spot of light upon the scale produces a + indication. When the key *a* remains depressed but for a moment the flow of current through the cable is of short duration, for as soon as the key is released and touches the bar *z*, not only does the process of charging the condenser terminate, but its discharge as well as that of the cable itself immediately commences. The + E of one side of the condenser immediately begins to flow to earth by way of *e t a z* and *b*. This sets free the — E of the opposite side of the condenser, which flows off through the cable to Newfoundland. On the other hand, the + E still present in the cable, not having had time to escape to the earth at Newfoundland through the galvanometer G′, flows in the direction of Valentia, where the cable is in connection with the earth through the very large resistance W. Therefore there will be, under these circumstances, two simultaneous currents in the cable of about equal strength, but of opposite polarity or direction, which reciprocally neutralize each other, and thus destroy the inductive action which the original positive current had set up in the outer coating of the cable. By this means the cable becomes completely discharged.

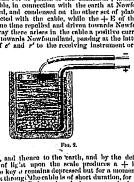

FIG. 2.

By making use of a similarly arranged condenser in Newfoundland, a communication may, in the same manner, be forwarded in the opposite direction; though it is stated that the Atlantic Telegraph Company, in order to avoid Varley's patent, have not adopted the system devised by him, but operate the cable by the use of a single condenser C at Valentia, which answers for transmission in both directions. With a single condenser the signals are sent from Newfoundland in the following manner:

When a key is depressed at T′, then the electricity, for example the + E, flows directly into the cable K, and arriving at Valentia, flows almost entirely into the side of the condenser C, which is attached to the cable, the resistance of W being so great that comparatively little of it goes to the earth. The accumulation of + E in one side of the condenser causes a like quantity of + E to be driven out of the opposite side of the condenser, passing through *e r* and G to the earth, giving a + signal upon the galvanometer. When the depressed key at Newfoundland is again released, putting the cable at that place to earth, then the + E stored up in the condenser flows back into the cable, producing a + current towards Newfoundland, which lasts for a certain time, partly because the discharge of the condenser is not instantaneous, and partly on account of the inductive action set up by the original current. At the same time the — E from the opposite side of the condenser flows through the galvanometer G to the earth, and produces a — signal. In consequence, however, of the great distance between the condenser and the battery, and the short time during which the keys are depressed in transmitting signals, the potential of the charge of the condenser is only about one per cent of that of the battery itself. For this reason the — E which flows from the opposite side of the condenser through the galvanometer to the earth produces a very weak pulsation, which has but little effect upon the needle other than to make it return more quickly to its position of rest, and does not in any way interfere with the regular signals.

It will be seen, therefore, that in this method of working the cable by means of a single condenser, the depression of the positive key at either terminal station produces exactly the same result—namely, the deflection of the needle towards the + side, and in like manner the depression of the negative key at either station gives a — signal. The combination of these two signs, so as to form letters and words, according to the Morse code, is precisely the same as in the single needle instruments, which the cable instruments in fact are.

The insertion of the shunt W, having a very high resistance, which may be considered almost infinitely large in comparison with that of the conductor of the cable, gives rise to only a small loss of current, while it keeps the cable in constant connection with the earth—a result in many respects advantageous. The advantages gained by working with condensers instead of a direct current from the battery, may be briefly stated as follows: The direct current can only affect the galvanometer by first charging the entire cable, while the flow of electricity from the condenser through the galvanometer to the earth commences at the same instant as the charging. When, therefore, the key is depressed, the indication upon the galvanometer follows much more quickly with the condenser than it would with a direct battery current. In addition to this, the period of deflection only lasts during the time of charging, for the moment the potential of the condenser equals that of the pole of the charging battery, the needle immediately returns to zero, even if the key remains depressed. The practical advantage of the method of working with condensers is so great, that a speed of from twelve to eighteen words per minute is reached on the cables between Valentia and Newfoundland.

LA COUR'S "MUSICAL" TELEGRAPH.

HAVING already given a description of the telephone, or musical telegraph, invented by Elisha Gray, of Chicago, Ill. (SUPPLEMENT No. 8), our readers may be interested in the somewhat similar system invented by M. Paul La Cour, the sub-director of the Copenhagen Meteorological Institution. The following is from the *Telegraphic Journal*: "In the electric telegraph, up to the present time, but two simple signals have been employed, and these have been formed either by currents in opposite directions, or by the prolongation, to a greater or lesser extent, of the duration of the current. The system which I devised on the 10th May last enables, however, a large number of simple signals to be made with a single conducting wire.

"When a vibrating body, at each of its vibrations, is made to close and open an electric circuit, the pulsations of the current will, of course, be isochronous with the vibrations of the sonorous body; and when such currents are, by means of electro-magnets, made to act upon a second sonorous body vibrating in unison with the first, the second body will vibrate, whilst another similar body giving a different sound will remain silent.

"The first experiment was successfully made on the 5th June, 1874, but it was feared that the vibrations might cease to be perceptible after traversing a long distance. I therefore made an experiment upon a telegraph line 390 kilometres in length (from Copenhagen to Fredericia and back), and, even with a rather weak current, the pulsations were easily perceptible. This experiment was made during the night of the 14th-15th November in the same year.

"To produce the intermittent currents and receive them at the further end, the sonorous bodies employed were tuning-forks. The apparatus is constructed in the following manner: The key or instrument which produces the intermittent current in the line is shown in Fig. 1.

"S S is a tuning-fork fixed by the shank in such a way that at each oscillation one of the prongs touches the contact, *c*, during a portion of the oscillation. The contact, *c*, can be adjusted by the screw, *k*, and, together with its support, is insulated from the tuning-fork by the insulating piece, J.

"When the shank of the tuning-fork is connected to one of the poles of a voltaic battery whose other pole is to earth, and when the contact piece is connected with the telegraph line and thence to earth, a blow given to one of the prongs of the fork will cause an intermittent current to be sent into the line, the pulsation of the current being in unison with those of the fork.

"It follows that, by keeping the fork in vibration, the same result will be obtained whenever the circuit is closed at any given point. It always follows that, by employing a contact upon the inside of the fork with a special battery for the same, the line can be charged with a succession of currents in opposite directions.

"The receiving apparatus is shown in Fig. 2, where P is a tuning-fork of soft iron, giving the same sound as that of the key. The prongs are inserted lengthwise in the coils, T T, which are surrounded by silk-covered copper wire; the prongs are so arranged as to vibrate freely within the centres of the coils. The intermittent current, on arriving at the station, passes through these two coils, and thence into the wire of an electro-magnet, M M, which is arranged so that its poles are placed in front of the opposed poles produced in the fork. It is evident that the current, in magnetizing the electro-magnet and the fork, produces an attraction which will open the prongs of the latter, but directly the current d, consequently, the attraction ceases to operate, the prongs will return to their position of equilibrium, and so on.

FIG. 1

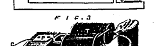

FIG. 2

LA COUR'S MUSICAL TELEGRAPH.

If then the pulsations of the current are in unison with those of the fork, the vibrations of the latter will soon attain a sufficient extent for one of the prongs, *n*, to touch the contact piece, D, closing the circuit, C C, of a local battery, and thereby manifesting the arrival of the current in the usual way, either directly or by means of a relay.

"I can not as yet, I admit, state the time required to produce in the fork of the receiving apparatus vibrations of a certain extent; it is a function of various factors, but experiment shows that the time which elapses before the local circuit is closed is so small a fraction of a second as to be hardly perceptible, even when the current is very weak. In the hope that this

34

The average time which messages for India, via Teheran, by the Indo-European Telegraph Company, have occupied in transit during the month of April, has been, from Calcutta 32 minutes, Bombay 33 minutes, and other places in India 53 minutes.

The following, from the *Journal of the Telegraph* gives further information regarding the repair of the Havana and Key West 1869 cable in the s.s. *Professor Morse.* This is, we believe, the first repair executed by an American staff in a sea cable, and appears to do them great credit.

The party reached Havana on April 4th, and left on the 5th, in small boats, for Cojimar, where the cable lands. Tests located the fault at 1.3 knots from the shore. Attempts were at once made to raise the cable by underrunning with the small boats, but it was not until the afternoon of the 6th that the junction of the shore end with the intermediate was brought on board. The cable was cut at this joint owing to its unfavourable appearance, but as the tests showed the wire shoreward to be in perfect condition, it was rejointed. To facilitate the work it was here deemed advisable to procure a light schooner, which having been done on the 8th, underrunning was resumed, and at 1 p.m., a galvanometer on shore indicated that the fault had been brought up. This fact was signalled to the working party. The cable was cut and found to be perfect westward by tests with Key West. On the 9th connection was made with new cable on the *Morse*, and the steamer payed out to the point where the cut was made on the 7th, where the final splice was made. After completing the repairs the entire cable was tested for conductivity and insulation, and found to be in excellent condition, as shown by the following figures. Copper resistance per knot, 11.28 ohms. Dielectric resistance, after one minute's electrification, 339.8 megohms per knot.

REMARKABLE CABLE TELEGRAPHING.

Ocean Cable Apr 1876

A suit has been brought by the city of Philadelphia to enjoin the Western Union Telegraph Company from placing poles in Tenth street, and to compel the company to run its wires underground. It was recently argued in the Court of Common Pleas No. 4, and affidavits from Mr. David Brooks and others showing the feasibility of operating subterranean lines were submitted. A question of fact arose as to whether underground wires in Europe had proved satisfactory. It was alleged on behalf of the defendant that such enterprises had almost invariably been abandoned, while on behalf of the city it was insisted that this was the method now in universal use in Great Britain and Continental Europe. The City Solicitor telegraphed to the post-office authorities in London early in the day, making inquiries in regard to the matter, and before noon a reply was received and read to the Court.

The following are the despatches referred to:

"PHILADELPHIA, March 6th, 1876. Charles T. Fleetwood, Chief Post Ofs. Telegraphs, Gen. Post Ofs. London, E.C.: Will you please inform me, by cable, whether the underground wires in London, referred to in your paper in the *Electrical Review* of January 15th, are in successful and perfect operation, and perform the same and as good service as if erected upon poles, and for how many years have they been performing such service satisfactorily?

"Are telegraph-poles in use in the principal streets of London or of any of the cities of Europe?

"In a case at this moment being argued between this city and the Western Union Telegraph Company, the latter contends that underground telegraphy has proved a failure in Europe. Is this so?

CHAS. H. T. COLLIS, City Solicitor."

LONDON, March 6th, 1876. Charles H. T. Collis, City Solicitor, Philadelphia: The underground wires in London, referred to in Mr. Fleetwood's recent paper, are in successful operation. It would not be possible to carry the same number of wires through London by overground work, nor would it be desirable, considering the atmosphere; but there are some overground wires which are carried over the housetops. There are no poles in the streets. All the important wires have been carried underground through London for the past twenty-five years.

"Pole and underground lines are in use in Continental cities.

"W. H. WINTER,

"Assistant Engineer in Chief, General Post Office, London, England."

The despatches were transmitted over the Atlantic and Pacific, and Direct Cable lines, and the time made was remarkable and the shortest ever made between Philadelphia and New-York. The despatch to London, which contained 126 words, was transmitted from Philadelphia to London, over land and cable lines, in twenty-three minutes; and the reply, which contained 108 words, was transmitted from London to Philadelphia in twenty-two minutes. The actual time in transmission of the despatch from London over the cable line was six minutes, the rest of the time being occupied in the transmission and repetitions over the land lines connecting with the cable.

In an underground telegraph system which is now in use at the Centennial Exhibition, connecting the Finance and Commissioners' Buildings, the naked copper wires are drawn through glass tubes, which are firmly held in position in the iron pipe by paraffine wax. For lateral connections, as well as convenience in laying, traps are used, into which the pipe is screwed, the wires passing over non-conducting bridges, thus allowing any wire to be taken out and replaced without interfering with the working of the others. The pipes are connected by a coupling which after being bolted together, is completely sealed; the traps being closed and sealed in like manner. By this system there is claimed to be no crossing of wires, no difficulty from atmospheric changes, no cutting of wires in cases of riot, no imperilling of life and property by the breaking down of poles and wires by snow storms or fires (causing interruption of telegraphic communication): but a perfectly reliable telegraphic connection under all circumstances.

July '76

— La « Direct cable Company » nous adresse une circulaire dont nous extrayons les renseignements suivants :

Il a été transmis par cette ligne, du 4 au 9 mai, 83,141 mots. Le 5 et le 9 mai, jour où le service a été le plus chargé, il a été expédié 14,402 et 15,906 mots, ce qui équivaut à une vitesse moyenne de 10 et 11 mots par minute. La plus grande vitesse obtenue a été de 18 mots par minute.

Il ne faut pas perdre de vue que cette vitesse a été atteinte sur la plus longue section du câble, soit 2,500 milles marins.

La vitesse, sur la plus courte section du câble, a été naturellement bien plus considérable.

Les recettes effectuées pendant les deux semaines, dans l'intervalle desquelles s'est produite l'interruption des câbles de la Compagnie anglo-américaine, ont dépassé 11,000 livres sterling, et, depuis lors, les recettes journalières sont bien plus élevées qu'elles ne l'étaient avant l'interruption.

June 76

The Peruvian exploring vessel *Chalaco* has been engaged in taking preliminary soundings between Chorrillos in Peru and Chaldera in Chili, with the view of laying the submarine cable between these two points. The route examined was on a line starting from Chorrillos and passing within four miles of the Island of San Gallan, forming here a slight deviation towards the coast, and then running parallel to it for about twenty miles, about eight or ten miles off. The depth of the sea as far as San Gallan is not great, not exceeding a maximum of one hundred fathoms, the bottom all along being a mixture of mud and gravel. From thence the soundings begin increasing as far as the Morro of Chala, where a depth of 600 fathoms was noted. The submarine exploration, so far as it goes, proved that no difficulties would be met with in laying the proposed cable. 77

35

with Panama, on the Pacific coast, by a submarine cable, has, after protracted negotiations, been abandoned by mutual consent, it having been found impracticable to obtain the necessary landing rights at Panama, except on terms which the Company could not with advantage accept. The working agreement that existed between this Company and Mr. Henley, of North Woolwich, and which lapsed through the suspension of Mr. Henley, has been renewed with a Company formed for the purpose of carrying on his extensive works, on terms which, it is believed, will be advantageous to both parties."

CHINA.

Shortly after the establishment of the Torpedo College at Foochow, His Excellency Li Hung Chang, Viceroy of Cheli, First Guardian of the Emperor, &c., &c., sent an official request that Mr. J. A. Betts, the director of the college, should proceed to Tientsin with the whole of the torpedo apparatus just received from England, to carry out a series of experiments before His Excellency.

The *Chi-Ngan*, one of the Chinese gunboats, was ordered to convey Mr. Betts, and the stores, to the latter port, and during the month of October last a lengthened and very successful series of experiments in telegraphy and torpedo warfare were carried out in His Excellency's presence.

Telegraphic circuits were established, and a complete system of torpedo defence fully illustrated by the explosion of numerous torpedoes in the Pei-ho, near Tientsin. Further experiments with heavy charges were shown at the Taku Forts. His excellency lent his own steam launch for these trials, and expressed himself much pleased. The electro-contact torpedoes excited great interest and were much admired.

Mr. Betts exhibited the Royal Engineers' system of telegraphing by "Walker's Lime-light" on the city walls of Tientsin; this seemed to create a deal of astonishment among the Chinese, and although at a late hour of the night, and bitterly cold, caused an immense crowd to assemble.

Mr. Betts will return to Tientsin in the spring, when he will at once commence drawing up a system of torpedo defence for the Taku and Peh-tung Forts, which are also to be connected by a line of telegraphs.

M. Duchemin has found that nickel, deposited by electricity on the magnets of compasses, preserves them from oxidation. He deposited in this way a layer of nickel on several rings of one of his circular compasses, keeping two concentric circles free from the operation. This compass was put on board a vessel which went round the world. The rings covered with nickel preserved their polish, but the others were completely rusty. The magnetic power of the nickelized rings had been exerted with difficulty, no doubt on account of the magnetic property of the nickel. — *Comptes Rendus de l'Académie des Sciences, Nov. 15, 1875.*

Proceedings of Societies.

THE SOCIETY OF TELEGRAPH ENGINEERS.

Contributions to the Theory of Submerging and Testing Submarine Telegraphs.

By Dr. WERNER SIEMENS.

The starting point of submarine telegraphy is to be found in the subterranean lines constructed in Prussia during the years 1847—1852. Before that time, it is true, attempts had been made to insulate wires with glass tubes, caoutchouc, &c., for use as underground lines. Experiments on a somewhat extensive scale by Jacobi* at St. Petersburg in the year 1842 deserve mention; but these attempts failed.

In the year 1846 the author suggested to the Prussian government the use of gutta-percha as insulating material, this gum having then recently become known in Europe. Its remarkable plasticity and insulating property appeared to render it very suitable to the purpose in question, but neither the experiments made at Berlin, nor those carried out simultaneously in England, were attended with satisfactory results; for the joints of the gutta-percha (which was rolled round the wire), gave way after a short time. At last, in the year 1847, the problem found its solution in a covering machine, constructed and used by the author and Mr. Halske, by means of which the gutta-percha, rendered plastic by heat, is pressed round the wire without any seaming.

During the subsequent years an extensive network of underground lines, insulated with gutta-percha pressed round the conducting wires, was somewhat too hastily and inconsiderately introduced in North Germany and Russia; although those lines were far from durable (particularly because the conducting wires, to save expense, were imbedded in the ground without external protection, and at too small a depth), they afforded opportunity of gaining practical knowledge for the construction and maintenance of such insulated conductors, and of studying their physical properties. But it was reserved for English enterprise to convert the knowledge and experience thus gained to practical account in a sphere where there was no competition with cheaper overground lines, that is to say, to submarine telegraphy.

As early as 1850, Mr. Brett laid a single gutta-percha-covered copper wire across the Channel between Dover and Calais. As might be expected, this became useless; but in 1851, Mr. Brett substituted a conducting wire insulated with gutta-percha, and protected externally by a sheathing of iron wires. This was the first practical submarine cable.

No great difficulties were encountered in laying these cables in the comparatively shallow waters of the Channel. But when later Mr. Brett endeavoured to lay such cables in seas of greater depth he failed, because the forces brought into play in laying deep sea cables were not yet recognised, and, consequently, the necessary precautions had not been taken. The laying of the first successful deep sea cable between Cagliari and Bona, in the year 1857, in which the author

* Pogg. Annalen, vol. xxviii. p. 40.

36

Subterranean Telegraph Joints.—At a meeting of the Society of Telegraph Engineers held last week in the rooms of the Institution of Civil Engineers, Mr. C. V. Walker, F.R.S., in the chair, a paper, by Mr. Willoughby Smith, was read, on "The Formation of Joints in Gutta percha Covered Wires for Subterranean and other Telegraph Lines." The author has given careful attention to the subject, and had at length succeeded in inventing what he had no doubt would prove a simple, cheap and efficient mode of dealing with one of the practical difficulties of subterranean telegraphy. The new joint is formed by removing the coatings from the two ends to be united and joining the cleaned wires by what is technically known as the "bell-hanger's twist"; no solder is necessary. The twist is then warmed slightly and covered with a rough coating of insulating "compound," somewhat thicker than the original diameter of the wire. The joint while warm is placed in the lower half of a small wooden block, about 3 inches long and 1 inch wide, fitted internally with a groove for the wire, widening in the middle into a niche about 1½ inches in length for the reception of the compound-covered joint. While the compound is yet warm the upper half of the mould — in shape corresponding exactly with the lower one—is placed on the top, and, by means of a clamp, screwed down until the two wooden surfaces are pressed firmly together. While in this position they are permanently fixed by half-a-dozen ordinary brass screws, and the compound having hardened, the clamp is removed and the joint complete. The cavity in the interior of the block in which the copper ends meet being completely filled with compound, the insulation is all that could be desired. Numerous experiments, carried out by the author, having satisfactorily tested the electrical qualities of the arrangement. The cost is thus reduced to a very low figure, and by means of the wooden covering all danger of "leakage" or separation of the wires through bending is obviated. The joint was not, of course, applicable—except in cases of emergency—to submarine cables, but as far as the author could judge, was all that could be desired for the purposes for which it had been designed. The adjourned discussion on Mr. Latimer Clark's paper on "Clamond's Thermo-electric Battery" was then resumed, occupying the remainder of the evening.

CUBA SUBMARINE TELEGRAPH.

The following is from the report of the directors for the half-year ending 30th June, presented at the general meeting on the 17th of August: 7

The accounts show that the gross receipts amount to £14,150, and the expenses to £2,848, leaving a sum of £11,302, out of which the directors have placed £3,155 to the credit of the reserve fund, increasing the fund to £5,000. The balance, after providing for the preference dividend, will admit of a dividend on the ordinary shares at the rate of six per cent. per annum, and leave the sum of £852 to be carried forward to the current half-year's account. They recommend that dividends be declared accordingly, payable 18th instant. In April last the new cable contracted for with Messrs. Hooper's Company was successfully laid from Cienfuegos to Santiago de Cuba, and has continued to work satisfactorily. At the same time, the old cable was cut and the ends landed at Cienfuegos, thereby establishing duplicate means of communication between Havana and Santiago, as contemplated by the directors' special report of 2d June, 1874. In the course of the half-year interruptions have occurred on the lines of contiguous companies, but, being short of duration, have not materially affected the revenue of the company. The last half-yearly meeting having been held so recently, there is little to report on this occasion. The business of the company, as will be seen, has made satisfactory progress during the half-year, and the directors have every reason to believe that such will continue.

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SUBMARINE CABLES AND INTERNATIONAL LAW.

ch 24/76 – Over 233

The ownership of property on land is often a difficult question even for our elaborate legal machinery, but the question of ownership at the bottom of the sea must some day arise to puzzle our most acute international lawyers. Millions of pounds worth of valuable property now lies at the bottom of the sea in the form of submarine cables, and stands in the names of various joint-stock companies, and of our own and foreign governments. As long as cables live and die a natural death, or are peaceably picked up by the representatives of those who paid for them, no legal questions arise. But cases have occurred where cables have been cut by fishermen to clear their nets, and by ships to clear their anchors, and even in one instance damaged by a ship dredging for one cable and hooking another. The fishermen have generally got off through not being detected, as they have generally operated far from land. Ships that have hooked cables with anchors have been known to hang on to a shore end for six tides, and defy those sent to them to ask them to let go, and if the fishermen could be detected, it is doubtful if they could be made liable. Cables have been damaged by ships breaking through them close to land in broad daylight. On January 5, 1858, the Dover and Calais and Dover and Ostend cables were both broken close to the South Foreland by a sailing ship that drove from the Downs. Since then the North Sea cables have often been broken by anchors, and under certain circumstances a few ships have had actions brought against them—we believe only when they have broken cables within the jurisdiction of the Crown. This it appears extends to three miles from the coast. Thus the secretary of the Commissioners of Woods and Forests, when writing to the Lords of the Treasury in 1858, after stating that the shores of the sea between high and low water belong to the Crown except where by grant or usage they may belong to subjects, goes on to state that "With respect to the bed of the sea from low-water mark, I apprehend the Crown title is indisputable, and that it cannot lawfully be permanently occupied by a subject without license from the Crown. As an illustration of the Crown's right to the bed of the sea, I beg leave to enclose a copy of the Cornwall Submarine Mines Act of last session, which declares that as between the Crown and the Duchy of Cornwall, mines between high and low-water marks belong to the Duchy, but that mines below low-water mark belong to Her Majesty "as part of the soil and territorial possessions of the Crown," and by the 42nd section of the Atlantic Telegraph Act, 1857, it is provided that it shall not be lawful for the company to execute any works whatsoever on the bed or shore of the sea, or of any navigable river so far as the tide flows, without consent in writing of one of the Commissioners of Woods."

So far, then, it seems clear Government claim authority over the ground within the three miles from shore—the old reputed distance of cannon-shot—but what about the sea beyond? Can a man if he negligently or even wilfully destroys a submarine cable be made amenable to law, and if so by what country is he to be prosecuted? Does the flag cover the deed and render the person liable to the Government under whose flag he sails. But without either negligence or malice civil cases may arise. Only last year a piece of cable belonging to the Direct Spanish Company which, although sealed up and ending in the sea, was never intended to be disturbed, was dredged up by accident by a ship at work on other cables, and those in charge supposing it to have been a piece of abandoned cable picked up some portion of it and brought it to England, and the case nearly led to solicitors' letters passing. The trial of such a case would have been very interesting and important. With the numerous cables now down, some lying parallel and not far from one another, it is quite possible that in dredging, a ship may catch a wrong cable, and the legal question that would arise in the case of a long interruption of communication on an important line, would, it appears to us, be very difficult to decide. May not a ship dredge where she likes in the search of a cable?

But another case may be put. Cables now cross one another at right angles. The Marseilles and Algiers cable crosses the Gibraltar and Malta. The Direct Spanish crosses the French Atlantic; and a cable from France to Denmark boldly runs over some half dozen North Sea cables. Now if the lower cable gets out of order near a crossing and has to be picked up, it would be almost impossible to pick it up without cutting it or cutting or breaking the other. The only safe process no doubt would be to pick up to within a short distance of the cross cable, cut and buoy, and then grapple for it again on

New Submarine Telegraph Cable.—A telegraph cable between Tenedos and Constantinople has been successfully laid. Aug 2 78

37

THE
TELEGRAPHIC JOURNAL.

Vol. IV. APRIL 1, 1876. No. 76.

UNDERGROUND AND OVERGROUND TELEGRAPHS.

Decidedly the question of underground versus overground wires is growing to a head. The severe test that our overburdened telegraph poles have been put to by the weather resulting in great gaps being made in important lines, the delay to the special train carrying the Empress of Austria on the Great Western, through the fall of telegraph poles across the permanent way, and finally the accidents in the metropolis, through the breaking of overhead wires, have all served to draw public attention to the matter. The press have frequently alluded to it, and even in the House of Commons the subject has cropped up, and Lord John Manners hinted, in answer to a question, that subterranean lines would be more employed in future than they hitherto had been.

We have been so long accustomed to considering overground wires, in the country at least, as the best and only way of constructing telegraphs, that the idea of subterranean wires only comes to the front now and then, when the question is prominently thrust before the public by the interruptions caused by the overground system failing seriously, in spite of the numerous routes which our great network of telegraphs gives between any two important towns. These great interruptions have, however, become more frequent, although they occur, we admit, at considerable intervals. But if we consider that fresh wires have constantly to be added to the poles, which, although scarfed and repaired at times, must on the whole be constantly growing weaker, it is certain that these interruptions must become more and more frequent. On some lines there are 18 or 20 wires on one set of poles, and on the Great Eastern line, near London, the wires nearly touch the railway embankment, from the number that have been placed on the poles. On many lines telegraph poles run on each side of the railway, and soon therefore, a third set of poles would have to be erected.

The telegraph lines on the railways are maintained by the railway companies at so much per mile for the Government. Who these lines belong to it is difficult to say. They were erected by the telegraph companies, and the Government paid the telegraph companies for them; but if the Government wished to remove them, we suppose they could not do so, even if they were worth taking down.

If the Government require more wires, they can obtain them by paying the railway companies, or they can go along the high roads. This they do to a great extent, but principally by overground lines. Now if overground wires are bad along railways, they are ten times more objectionable along high roads, at least in a mechanical and electrical point of view. A railway, with its straight lines and easy curves, is well adapted for overground lines; but our tortuous English lanes and roads, with trees and hedges, are excessively ill adapted for this purpose. Sharp turns at right angles have to be made, which the ordinary insulators that can be used on straight lines or easy curves cannot stand, and therefore shackles, giving less perfect insulation, have to be employed. Again, even the poles are subject to considerable strain, even with only one or two wires, at these sharp angles, and the staying of them is difficult, as the poles have to be kept clear of the road, and are thus thrust close to the hedges, whilst even to get a stay into a ploughed field the permission of some landowner has to be obtained. Trees have naturally to be avoided if possible, and when even to save great strain on the poles it is desirable to cut a corner off, a wire has to hang over private property. In the case of trees, permission has to be obtained to cut them; and even in cutting the corner off the landowner has to be applied to. Thus, what with permission for stays, cutting of trees, and cutting off corners, the number of permissions to be obtained is quite as formidable a work as erecting the telegraph; and, indeed, it was at one time so formidable, that an eminent novelist and popular writer, at that time in the Post Office service, was selected to go through a whole district to coax the country gentlemen into giving the necessary permission for erecting the Post Office telegraphs; so that in fact it may be said that Her Majestys's telegraph lines live out in lodgings on sufferance.

No amount of ingenuity or mechanical feeling can make a telegraph line along a crooked country road look either picturesque or mechanical, but very often there is not much mechanical feeling expended on it, and one pole bending one way and another leaning the other, with insulators starting

Le câble de Rio-Grande do Sul à Montevideo dont nous avons annoncé l'interruption dans notre dernier numéro est rétabli depuis le 10 de ce mois. Quant au câble de Madras à Penang, il est encore interrompu.

Pendant le mois qui vient s'écouler, il s'est produit, en outre, plusieurs interruptions importantes sur les lignes sous-marines. Ainsi, le câble de Banjoewangie, Java, à Port-Darvin, Australie, est interrompu depuis le 27 Avril et, pendant cette interruption, les dépêches ne peuvent parvenir en Australie qu'en empruntant à Pointe de Galles ou à Singapore les paquebots de la poste. Le câble d'Amoy à Shanghaï a subi également une interruption, mais de très-courte durée.

D'un autre côté, le câble de Brest à St-Pierre-Miquelon, dit câble transatlantique de 1869, est interrompu depuis le 26 Avril, et, en outre, tous les câbles de Terre-Neuve au Cap-Breton appartenant à la Compagnie anglo-américaine ont été interrompus du 4 au 9 de ce mois, en sorte que pendant ces cinq jours, toutes les communications directes avec les Etats-Unis et l'Amérique ont été réduites au câble de la Compagnie Direct United States Cable.

1876

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Le câble de Penang à Singapore interrompu dans les derniers jours du mois d'Août a été rétabli au commencement de Septembre; mais celui de Madras à Penang dont l'interruption remonte à la fin du mois de Mars n'a pas encore pu être réparé. Pour remédier aux inconvénients de cette interruption, la Compagnie a organisé à partir du 1er Septembre un service spécial de paquebots entre Rangoon et Penang. Les départs ont lieu tous les 4 ou 5 jours.

Le câble des îles Orkney et Shetland a été rétabli le 1er Septembre.

Les communications sous-marines et autres grandes lignes internationales ont encore subi dans le mois qui vient de s'écouler un assez grand nombre d'interruptions qui, la plupart heureusement, n'ont pas été de longue durée. Pour plus de clarté, nous reproduisons ci-dessous la liste de celles de ces communications qui sont actuellement interrompues ou dont la situation a subi des variations depuis la publication de notre dernier numéro.

	Dates des interruptions.	Dates des rétablissements ou situation actuelle.
Câble Demerara-Cayenne .	29 Décembre 1875	interruptions intermittentes.
» » »	22 Novembre 1876	interruption totale.
» Cayenne-Para . . .	29 Décembre 1875	interruptions intermittentes.
» Para-Pernambuco .	24 Février 1876	encore interrompu.
Lignes du Mexique . . .	24 Mars »	interruption provenant de troubles politiques.
Câble Bahia-Rio-de-Janeiro	21 Octobre »	9 Novembre 1876.
» » »	24 Novembre 1876	25 » »
Lignes ottomanes (voie Vallona)	22 Octobre »	fonctionnement irrégulier.
» Havane à Cienfuegos	21 » »	encore interrompu.
Câble Singapore-Batavia .	25 » »	dito.
Ligne de Sibérie (entre Blagowetschenck et Raddo .	26 Octobre 1876	27 Octobre
Câble Amoy-Shanghaï . .	2 Novemb. 1876	12 Novembre
» Madras-Penang . .	3 » »	5 »
» Santiago de Cuba-Jamaïque	6 » »	23 »
» Penang-Singapore .	8 » »	20 »
» Lisbonne-Madère . .	13 » »	23 »

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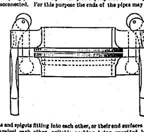
Ironmonger. June 25. 1881.

Pipe-joints.—5102.—December 7, 1880.—Nicolas Taland, of Boulevard Magenta 47, Paris, mechanician.—According to this patent the ends of pipes may be readily secured together, without the use of screw-bolts or screw-couplings, so that the joint may be rapidly and effectually connected and disconnected. For this purpose the ends of the pipes may either have



sockets and spigots fitting into each other, or their end surfaces may merely butt against each other, suitable packing being provided between the meeting surfaces to make a tight joint. The end of the one pipe has lateral lugs, to which are pivoted links, the free ends of which carry eccentrics or cams that can be turned by keys or levers. The end of the other pipe has projecting jaws, between which are introduced the links of the other pipe, whereupon the eccentrics or cams are turned by the keys, so as to press against the jaws with sufficient force to bring the two ends of the pipe tightly together, and thus make a perfectly tight joint. By turning the cams or eccentrics in the contrary direction the joint is readily disconnected again. The levers for actuating the eccentrics may be fixed thereto, in which case they are arranged to lie close against the sides of the pipe, after the joint is tightened up.

Nous reproduisons dans le tableau ci-dessous la liste des grandes communications internationales actuellement interrompues ou dont la situation a subi des modifications depuis notre dernier numéro :

	Dates des interruptions.	Dates des rétablissements ou situation actuelle.
Câble Demerara-Cayenne .	29 Décembre 1875 [1]	interruptions intermittentes.
» Cayenne-Para . . .	29 Décembre 1875	interruptions intermittentes.
» Para-Pernambuco .	24 Février 1876	encore interrompu.
Lignes du Mexique . . .	24 Mars »	interruption provenant des troubles politiques.
» ottomanes (voie Vallona)	22 Octobre »	6 Décembre 1876.
» Havane à Cienfuegos	24 » »	encore interrompu.
Câble Vigo-Lisbonne [2] .	8 Décembre »	»
» Falmouth-Lisbonne [2]	8 » »	»
» Bahia-Rio-de-Janeiro	15 » »	22 Décembre 1876.
» Penang-Singapore .	20 » »	22 » »

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La *deutsche allgemeine polytechnische Zeitung* annonce qu'outre les deux lignes souterraines de Berlin-Halle et de Berlin-Potsdam établies en 1876, l'Administration allemande se propose d'en établir quatre nouvelles et elle ne doute pas que les crédits nécessaires à cet effet ne soient autorisés par le Reichstag [3]. Ces quatre lignes seraient les suivantes, Berlin-Hambourg-Kiel, Berlin-Leipzig, Halle-Saale-Francfort s/M (par Cassel) et Berlin-Magdebourg. Cette dernière ne consisterait que dans la prolongation jusqu'à Magdebourg de la ligne Berlin-Potsdam. La construction de ces lignes souterraines serait confiée à la maison Siemens et Halske, qui ferait fabriquer les câbles nécessaires dans les usines qu'elle possède en Angleterre.

* * *

Les steamers la *Seine*, l'*Hibernia* et la *Kangoroo*, appartenant à la Telegraph Construction and Maintenance Company, sont actuellement occupés, les deux premiers à la pose, sur les deux sections Suez-Aden et Aden-Bombay, d'un second câble destiné à doubler les communications appartenant à la Compagnie Eastern entre l'Egypte et les Indes britanniques et le troisième à la pose d'un câble entre Rangoon et Penang qui a également pour but de doubler la communication Madras-Penang de la Compagnie Eastern Extension.

* * *

[1] L'interruption totale qui s'était produite le 22 Novembre dernier a cessé le 1er Décembre et le câble a repris sa situation antérieure, c'est-à-dire qu'il ne fonctionne qu'irrégulièrement et par intervalles.

[2] Les communications par cette voie sont rétablies au moyen d'un nouveau câble (voir la nouvelle précédente).

[3] Les crédits ont été effectivement demandés au Reichstag, sous forme de l'autorisation d'un emprunt de 8 millions de marks (fr. 10 millions). La question a été renvoyée à l'examen d'une Commission. *(Note du Bur. internat.)*.

Nous trouvons dans «The Telegraphist» du 1er Novembre sur la ligne souterraine qui relie Liverpool à Manchester quelques détails qui offrent d'autant plus d'intérêt que dans les améliorations et les réformes du service télégraphique la question de la substitution des lignes souterraines aux lignes aériennes est une de celles dont on s'est le plus occupé dans ces derniers temps.

La ligne souterraine de Liverpool à Manchester est une ligne de 14 fils; elle a été établie en 1871 et depuis cette époque aucun des fils n'a subi d'interruption. Le câble qui la compose a été fabriqué dans les ateliers de la Gutta-percha Cy, et sa composition diffère complètement de celle des câbles employés auparavant pour les lignes souterraines; elle ressemble beaucoup à l'âme d'un câble sous-marin qui aurait été cousue et tordue. L'âme se compose d'un toron de fils de cuivre recouvert de gutta-percha du N° 7 de la jauge de la Compagnie [1]. Après sa fabrication, il a été plongé dans un bain de vieux goudron de Suède mélangé avec de la poussière de liége pour plus de consistance. Ainsi enduit, il a été recouvert de deux couches, enroulées dans des directions opposées d'une étoupe goudronnée fabriquée ad hoc et pourvue d'une double bordure. Le câble ainsi formé a été placé dans des tuyaux en fer ou dans des tuyaux en terre. Sur les $36,_{124}$ milles ($58,_{160}$ kilom.) qui composent la longueur totale de la ligne, environ 10 milles (16 kil.) sont formés de tuyaux de fer neufs, 4 ($6,_{440}$ kil.) de tuyaux de fer vieux et 22 ($35,_{420}$ kil.) de tuyaux en terre. Toutefois, là où l'on pouvait craindre l'influence des eaux stagnantes le fer a été remplacé par du plomb. La route sous laquelle le câble a été enfoui traverse dans sa plus grande partie des terrains bas, où les pluies sont très-fréquentes, en sorte que l'eau pénètre dans les tuyaux et y reste d'une manière à peu près continue, même pendant les chaleurs de l'été. C'est là une circonstance particulièrement favorable à la conservation de la gutta-percha et au développement de ses propriétés isolantes. Pendant toute la durée de la pose, le câble a été soumis à des essais fréquents, faits avec le plus grand soins. D'après M. E. Grave, la dépense totale d'une ligne souterraine de ce genre serait le sextuple de celle d'une ligne aérienne.

[1] D'après les tableaux insérés dans le Handbook of practical telegraphy de M. Culley et qui lui ont été fournis par un agent de la Compagnie Gutta-percha, le fil N° 7 a un diamètre en pouces anglais de 0.171 (4mm,32); le poids du cuivre est de 52 et celui de la gutta-percha de 59 livres par mille (respectivement 14kil.,650 et 16kil.,623 par kilomètres). *(Note du Bur. internat.)*.

IMPRIMERIE RIEDER & SIMMEN A BERNE.

lectricité statique des piles au lieu de l'électricité dynamique, amène M. Ehlers à la conclusion que les dernières investigations de ce célèbre électricien dans la matière sont encore un secret.

6. *Méthode de Sir William Thomson pour sonder les grandes profondeurs de la mer avec du fil de cordes de piano.* (Electrical News, vol. I, page 64).

Le fil employé pour les cordes de piano présente quelques avantages sur les cordes dont on se servait autrefois, parce qu'il est très-mince et lisse et n'offre par conséquent qu'une petite résistance à l'eau. La machinerie pour faire descendre le fil est disposée de telle sorte que le tambour sur lequel le fil est enroulé s'arrête automatiquement quand la sonde a atteint le sol. Une aiguille indique alors la longueur du fil déroulé.

7. *Rapport de Sir William Thomson sur les expériences faites sur le câble direct des Etats-Unis.* (Electrical News, vol. I, pages 205 et 213).

Les expériences ont eu lieu les 16 et 17 Septembre dernier. Elles ont été beaucoup contrariées par la présence de courants terrestres.

Après 5 heures d'expériences, Sir William Thomson a obtenu les résultats suivants :

Résistance de la gaine isolante: 5445 à 8470 millions unités Siemens par nœud.

Résistance du cuivre: pour la longueur totale (2420 nœuds) 7300 unités Siemens ou 3.02 unités Siemens par nœud.

Capacité électrique: du câble entier 991 microfarads ou 0,41 par nœud.

8. *La durée des câbles.* (Telegraphic Journal, vol. III, page 169).

La durée des câbles est très-irrégulière. Tandis que celle des uns ne peut se compter que par mois, par jours ou même par heures, d'autres servent depuis 20 ans. Les causes de la perte des câbles ne doivent pas être cherchées dans la gutta-percha qui, protégée contre l'oxygène et les variations trop vives de température, ne s'altère point avec le temps, mais dans l'armature en fer et la constitution du sol sur lequel le câble repose. A la suite des expériences faites depuis vingt-cinq ans sur les câbles, on peut leur attribuer une durée moyenne de 15 ans. Mais il est permis d'espérer que l'on parviendra à doubler et même tripler cette durée.

(A suivre).

Nouvelles.

Nous avons reproduit dans notre dernier numéro les nouvelles dispositions qui règlent le tarif intérieur

6. Les câbles sous-marins et souterrains. (Journal of the Telegraph, vol. VIII, page 359).

7. Les lignes télégraphiques souterraines.

Les essais de lignes télégraphiques souterraines datent du commencement de la télégraphie. La première ligne souterraine fut construite en 1839 entre Padding-

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DEEP SEA CABLES.

The question of cheaper and yet more durable cables than our present types must constantly form a subject for discussion and invention. The present type of Atlantic cables has answered undoubtedly the requirements of Atlantic telegraphy: for as long as monopoly existed the price of the cable was not of great importance; and as regards durability, they have also been tolerably successful, in spite of one having been out of order for three years. But other localities show that a cheaper cable is required, for the ordinary shares of our long-line companies remain steadily at a discount.

Light cables—cables without any outer sheathing—are suggested as the remedy, and against the present types, besides their expense, it is argued that the steel or iron, corroding at places where they hang over uneven ground, expose the cable to the chances of gradually dropping to pieces, and undoubtedly some of the old iron-covered cables, which had no protection from rust, and which were laid very tight, suffered greatly from this cause. The cable in places gets heavier, by the coral and marine vegetation that clings to it, whilst getting weaker. The protection afforded by yarn and asphalte has, no doubt, lessened this danger; but the yarn at some places in a few years becomes rotten, and the least disturbance removes it. Suppress the iron wires altogether, say the light cable advocates; but then what are we to place instead of it?

An ordinary guttapercha-covered copper wire will scarcely support two miles of its own length in water. If the ship has to be stopped for a fault of insulation, or even for a false alarm, the line would therefore simply break. Something more is required, therefore, even to lay the wire. Some suggest hemp outside, and others steel between the copper and the insulating material—Allan's patent. There are difficulties with both. The hemp, if laid up loosely, will not support the guttapercha, and, if laid tight, is liable to distort itself into kinks. We do not say the difficulty may not be overcome. With the Allan cable, the electrical conductivity would be greatly reduced with a given diameter of compound conductor, and, consequently, the speed of signalling. The joints are also a difficulty. No doubt the Allan cable would have the advantage when down of having such strength as the steel wires give it well protected from decay. On the other hand, both cables would be quite unprotected from marine insects, and, should a fault occur after they were down, their small absolute tensile strength would render them difficult to feel when dredging. Such cables would also run the chances of marine accumulations on them to weight them, if hanging in festoons over rough ground, just as much as the iron or steel covered cables.

Of the patterns that have been at various times proposed, we have the Allan cable—viz., copper, surrounded by fine steel wires—and this compound conductor insulated with guttapercha. Next, Mr. Siemens' cable of ordinary conductor and insulaters, with hemp strands and copper sheathing, and the same with iron or steel wires, hemp and copper sheathing. Mr. Varley proposed a light cable where the insulated wire was laid up with two hemp cords. The cable introduced a few years ago by Mr. Bullevant, of two servings of hemp strands round an insulated wire, with a whipping round the whole, was an improvement on that which Mr. Rowett some years pushed forward, and which consisted of an insulated wire, placed as the heart of an ordinary manilla rope. But Mr. Newall had, previous to this, laid a portion of a line between Candia and Alexandria of almost the same pattern, except that the proportion of hemp to the core was much more scanty than in the samples of Rowett's that were handed about at the time that Mr. Rowett was endeavouring to introduce his cable. The Candia cable was lost. But even this was not the first hemp-covered cable attempted to be laid, for in about the year 1852 or '53, a hemp-covered cable was attempted between Donaghadee and Portpatrick, but it never got further than a few fathoms from the shore, and we once heard one of those engaged on this work describe the attachment of pieces of stone by spun yarn stops to it to moor it.

Another kind of cable of a smaller and lighter pattern than the usual form is described by Mr. Newall in the evidence before the joint committee on telegraph cables in 1861. It consisted of Hooper's core surrounded by very fine steel wires embedded in a single covering of vulcanized India-rubber. Such a cable would, if it can be manufactured, present many advantages. The steel wires would give it strength and be protected very perfectly from the action of the water quite as well as in the Allan cable, whilst the conductor would remain of copper uncompounded with steel. As regards the cost, we do not suppose that it would, weight for weight of material, be exactly a very cheap cable, but it would certainly be very durable.

The cable lately laid between Australia and New Zealand is the latest attempt to make a cheap cable. It consists of the ordinary core and serving, covered with a sheathing composed alternately of strands of hemp and of steel wires, and the whole served with hemp and asphalte. We can see no particular advantage in this form. The hemp it is very improbable can take its strain with the steel, whilst the principle of the arch as regards the wires touching one another and thus preventing stretch, is even more ignored than in the Atlantic pattern of served wires. In a few years, when the hemp gets soft and rotten, the wires will form a wretched "bird-cage" round the core, and will be easily displaced by any irregular strains that may come on the cable in dredging or hauling in into a hopeless jumble of wire and core.

That improvements will be made in submarine

42

plenty of tanks—she cannot have too many—besides numerous other arrangements for facilitating the work. Yet when a new ship is built or bought she generally is quite devoid of any of these qualities.

The traffic receipts of the Direct Spanish Telegraph Company for the month of February were £679 7s. 9d., against £1,104 1s. 8d. for the corresponding period of last year. The Santander Lizard section was interrupted from the 3rd to 27th of February.

The traffic receipts of the Great Northern Telegraph Company for the month of February were £303,090fr. as against 254,643fr. for the corresponding period of last year.

At an adjourned meeting, on February 23rd, of the Western and Brazilian Telegraph Company, the accounts for the year ending 30th September last were adopted.

At the meeting, on February 29, of the Mediterranean Extension Telegraph Company (Limited), the usual half-yearly dividend on the Eight per Cent. Preference Stock, and a dividend at the rate of 3 per cent. per annum on the ordinary shares were declared, and £500 was carried to the reserve fund, raising that fund to £8,488.

The traffic receipts of the Brazilian Submarine Telegraph Company (Limited), for the month of February, amounted to £12,443, as against £9,857 for the corresponding period of 1875.

The number of messages passing over the lines of the Cuba Submarine Telegraph Company (Limited), during the month of February was 2,642, estimated to produce £2,500, against 2,080 messages, producing £2,195, in the corresponding month of last year.

The Eastern Telegraph Company's traffic receipts for the month of February amounted to £37,044, against £32,765, in the corresponding period of 1875.

The Traffic receipts of the Eastern Extension, Australasia, and China Telegraph Company (Limited) for the month of February amounted to £19,027, and to £16,415 for the corresponding period of 1875.

The directors of the Eastern Telegraph Company (Limited) invite subscriptions for an issue of 6 per cent. first preference share capital in 70,000 shares of £10 each at par. The new capital is required for the duplication of the company's Red Sea and Indian Ocean cables.

The directors of the Brazilian Submarine Telegraoh Company (Limited) on March the 3rd, declared an interim dividend of 2s. 6d. per share or 5 per cent. per annum, free of income tax, for the quarter ending 31st December, 1875, and payable on Saturday, the 25th instant.

The report of the Indiarubber, Guttapercha and Telegraph Works Company (Limited) has been issued to the meeting on the 14th inst., and shows that the result of the year's trading is a net profit of £42,617, which the Directors propose to apply to the reduction of the amount of £66,799, standing at the debit of profit and loss account on 31st December, 1874. The sum of £8,724 has been written off from the Company's property for depreciation as usual. The sales for the past year, it is mentioned, not reckoning the Peru and Chili Cables, amounted to £291,001, as against £258,854 for the year 1874, and it is added that the general business of the Company has been fairly remunerative.

The cable from Vigo to Carcavellos broke down on the 5th of February.

The Para Pernambuco cable broke down on the 13th of November, and was repaired on the 18th of February, but on the 24th it broke down again.

The report of the *Great Eastern* Steamship Company (Limited) states as follows:—"The directors, in submitting the accounts for the past year are glad to report that, as explained at the special general meeting, held on 8th December last, all matters connected with the defalcations of the late Secretary have been settled, and, after paying a dividend of 5 per cent., declared 14th August last, there is now a balance to credit of Revenue Account of £7,784, and a cash balance on capital account of £13,284. Until the ship is again employed, the directors think it better not to reduce the balance in hand by paying a dividend. The ship was delivered to this Company at Milford Haven by the Telegraph Construction and Maintenance Company in August last, and she has since been placed upon a gridiron that has been constructed for her within the works of the proposed Milford Docks, which are now in progress, and the directors trust that in a short time a graving dock will be completed sufficient for her accommodation. The hull is now being well cleaned and painted, and such other repairs done to her as will fit her for sea. Several proposals have been made to the directors for the employment of the ship, but as yet no arrangement has been concluded: the matter is having the best consideration of the directors."

The *Olstereichische Landwithschafthiche Wochenblätter* states that Dr. Virson, Superintendent of the Italian Experimental Silk Farm at Padua, has

43

Underground Telegraphs.

The two valuable practical papers, "Underground Telegraphs," by Mr. Willoughby Smith, and "Underground Telegraphs in France," by Mr. John Aylmer, C.E., of Paris—which were read before the Society of Telegraph Engineers at their last meeting, on the 28th ult., has served to bring again into prominence the subject of covered telegraph lines.

Taking up a statement of Mr. Prescott's which appeared in the American *Journal of the Telegraph* some six or eight months ago, that the "use of underground telegraph lines had thus far been attended with very unsatisfactory results," Mr. Willoughby Smith sought to establish, and undoubtedly succeeded in establishing, the fact that underground telegraph lines need be attended with no greater risks than open lines—nay that, were the proper material only employed, and due care taken in the execution of the work, there is no reason why covered lines should not be made as safe and durable as need be desired. The most interesting feature, however, of Mr. Willoughby Smith's communication was the argument which he brought forward against the employment of tar on gutta percha covered wire. A covering of tarred tape is, as is well known, all but universally adopted at present as the final protective covering. This, it is alleged, is a grave mistake; for by reason of its use the insulation resistance is materially diminished, and the germs of decay, which in time lead to the complete destruction of the coating, are implanted in the gutta percha. The tar ought to be abandoned, and in its place tannin, whose employment was stated to have been highly satisfactory, ought to be adopted. In the valuable address delivered some time since by Professor Abel, at the Society's opening meeting, this same subject was dealt with, and the state of our knowledge with reference to the causes of decay in gutta percha was shown to be crude in the extreme.

Granting, however, that tar is an objectionable feature in the manufacture of gutta percha covered wire, was there not some point in what was remarked, by one of the speakers in the animated discussion which followed, that surely then Chatterton's compound was not altogether an unmixed advantage? Chatterton's compound consists of one part of Stockholm tar to one of resin and three of gutta percha, and has long been regarded as the panacea for every evil that could befall gutta percha covered wires. No coating can be considered complete, it is said, no wires can be welded homogeneously together, without Chatterton's compound; and if tar is the *bête noir* it is now stated to be, what becomes of the influence of Chatterton's compound? It is all very well to be told, as Mr. Willoughby Smith told us the other evening, that "in the compound the sting of the tar was taken out." It is a pity that the same process of sting-abstraction could not be applied with equal success to the tar in the tape. No, we shall wait for a few further data and a few additional experiments before condemning the tar wholesale and making it accountable for all the mischief; and we will be content to look for the deterioration of the gutta percha, to a very great extent at least, in the cheap and consequently indifferent material which has never been properly tested, and hasty manufacture over which no efficient check has yet been introduced.

No one will now attempt to call in question the possibility of manufacturing really good covered wires: the battle of india rubber and gutta percha need not be fought over again, for the improvements effected in the latter have been so decided of recent years that its position is well-nigh unassailable by its old rival. If danger is to be anticipated from any quarter, paraffin and the products of paraffin will probably show it the most dangerous front. Meanwhile, every one will admit that covered wires as good as need be looked for in the existing state of our knowledge can without difficulty be manufactured, and no one will deny that their laying is a matter which requires nothing more than care to be attended with success. When, therefore, the need for underground telegraphs on a more extended scale than at present does arise, either from the crowded state of the open lines on every

for the testing apparatus occupied the front end of the wagon, opposite the rear entrance. The mirror galvanometer, however, was not placed directly on the table, but upon a small stand just above the latter, and supported by a stout iron tripod and rod passing through a small circular opening in the table. The tripod rested upon the ground beneath the wagon, and quite independent of the latter, so as to give the proper steadiness to the instrument. The graduated scale which receives the reflected spot of light from the mirror occupied a place on the table opposite the galvanometer; while back of the latter, and in front of a small opening in the same, was placed the lamp whose reflected light was thrown upon the scale. Shunts or artificial resistances representing exactly 1-9th, 1-99th, 1-999th of the resistance of the galvanometer were placed in front of the latter and in connection with the same, so that when one or the other was placed in circuit with the galvanometer, the current passing through the latter was reduced to 1-10th, 1-100th or 1-1000th, as the case might be, of what it would be were the galvanometer used alone. The other apparatus was placed on the table between the galvanometer and scale, and the speaking apparatus on the battery chest, whose cover also served as a table.

Testing the resistance of the conductors.—According to the principle of the Wheatstone Bridge (Fig. 1), the relation existing between the resistances in the different arms of the bridge is as follows:

$$r : \rho = R : x$$

r and q representing any constant and convenient resistance; R a variable resistance, and x the unknown resistance whose value is sought. From this we have:

$$x = R \frac{\rho}{r}$$

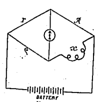


Fig. 1.

In order to obtain the resistance of the conductor alone it is necessary to eliminate any other unknown resistance, such as that of the earth, from the measurements. This may be done by connecting two of the conductors together, when the result obtained will represent the sum of the resistances of both conductors, and the earth is not connected in circuit at all. All of the Halle-Berlin conductors were tested in this manner, and their separate resistances ascertained afterwards by calculation. If we designate the resistances of any three conductors selected at random by I, II, III, the results of the measurements may be written as follows:

(1) $\quad I + II = A$

(2) $\quad I + III = B$

(3) $\quad II + III = C.$

and subtracting (2) from (1), we have:

(4) $\quad II - III = A - B.$

Now adding (3) and (4), we find:

$$II = \frac{A + C - B}{2}$$

And substituting this value in (1), gives:

$$I = \frac{A + B - C}{2}$$

And in (3):

$$III = \frac{B + C - A}{2}$$

To determine the resistances A, B and C, that is, the values of x in the formula above, the apparatus was connected up as shown in fig. 2, with a battery of 10 cells.

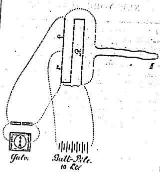


Fig. 2.

If we now take the proportion

$$r : \rho = 1 : 10.$$

then $\frac{\rho}{r} = 10$ and $x = 10$ R, and if we vary the resistance R in the rheostat until the spot of light is brought to zero, finding when this is the case that R = 52 (this figure being taken as an example only), we should then have:

$$x = 10 \times 52 = 520 \text{ Siemens' units.}$$

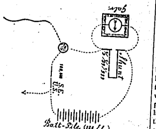


Fig. 3.

In making the insulation tests the connections were arranged as represented in fig. 3, and 100 cells of battery used instead of 10, as in the former test for conductivity. The constant of the instrument was now taken, which consisted in placing the battery in circuit with the galvanometer and a resistance of 100,000 Siemens' units, and noting the deflection. The galvanometer was shunted with the 1-999th shunt, so that the current circulating in its coils was only 1-1000th of that in the rest of the circuit, or in other words, was equal to what would have been obtained if the same battery and instrument without a shunt had been included in a circuit of $1,000 \times 100,000 = 100,000,000$ Siemens' units.

The cable with the Halle end insulated was now joined in circuit in place of the above mentioned resistance, the galvanometer shunted with the one-ninth shunt and the deflection again observed. It will, of course, be seen that under these conditions the strength of current in the galvanometer coils was the same as would have been obtained had the instrument without any shunt been joined directly in circuit with a resistance ten greater than that of the gutta percha cover.

Representing the deflection first obtained by C, that with the insulated cable in circuit by L, and the resistance of the core itself by W, we have

$$\frac{C}{L} = \frac{10\ W}{100 \text{ millions}} \text{ or } W = \frac{C}{L}\ 10 \text{ millions Siemens'}$$

units, supposing, of course, that the deflections on the scale are proportional to the strength of current circulating in the galvanometer coils. We give here one illustration of the application of this formula. On the 21st of May, 80 miles of cable was laid and tested, the constant of the instrument was 460°, and with the No. 2 core of the cable in circuit the deflection was 200 degrees, or C = 460 and L = 200 when

$$\text{ever } W = \frac{460}{200} \times 10 \text{ millions} = 23 \text{ millions Siemens' units.}$$

The resistance of the gutta-percha does not remain constant, it diminishes very sensibly with increase of temperature, and increases in the same manner with its fall, so that it is always necessary to take the question of temperature into consideration when measuring gutta-percha if we would avoid serious error.

From the Telegraphic Journal.

Battery Versus Magneto-Electric Current Machines.

The relative values of batteries and magneto-electric current machines for telegraphic and manufacturing purposes is a question which has excited considerable difference of opinion in the electrical world.

The word "battery," although it does not convey a definite idea to the unscientific mind, nevertheless is well understood by electricians and telegraphists to signify an arrangement for generating electricity by means of chemical action, whilst the expression "magneto-electric machine" is understood to represent the idea of an apparatus for generating electricity by mechanical force.

As regards the telegraph system, so long as the employment of the telegraph was limited, and the number of instruments in an office was consequently also limited, the annual cost of maintenance of batteries formed but a comparatively small item in the general working expenses of the establishment; but, at the present time, when the number of instruments at head offices may be numbered almost by hundreds, the substitution of mechanical for chemical power becomes a question which may not be passed over without consideration.

The question when carefully considered, resolves itself into one of £ s d. Can electricity, for working telegraph instruments, be produced the more economically by batteries or by magneto-machines? To answer this query, several points must be considered. Setting aside the employment of magneto-machines at small offices, we will confine our attention to their use at large offices, where some hundreds of battery cells are employed.

To work a number of instruments properly, we must have the means of varying the electric power according to the requirements of each circuit, the shorter circuits requiring obviously less power than the longer ones; climatic consideration may alter conditions, and we may require to add power to the circuits should their insulation fall low.

45

Ocean Telegraph Cables.

As we have received several inquiries in regard to the details of the submarine telegraph cables, we will condense some information on this subject in so far as it has reached us. N.Y.B. June 77

Between the United States and England.—By land lines to Sidney, Cape Breton; thence by cables to Placenta, Newfoundland; thence by three cables to Valentia, Ireland; thence by land lines to Wexford, Ireland; thence by cable to Haverfordwest, England; thence by land lines to London.

Between the United States and France.—By cable from Duxbury, Mass., to St. Pierre, and thence by cable to Brest, France.

Between the United States and the European Continent.—Besides the direct cable to France, communication may be had via England, as this is connected with various continental states by two cables to Denmark, two to Germany, two to Holland, two to Belgium, one to Norway, one to Portugal, two to Spain, and six to France.

Between the United States and the West Indies.—From Punta Rassa, Fla., via Key West to Havana by cables; thence by land lines to Batabano; thence by cable to Santiago de Cuba; thence by cable to Kingston, Jamaica. From Kingston a series of cables extend to Demerara, South America, touching at Porto Rico, St. Thomas, St. Kitt's, Antigua, Guadaloupe, Dominica, Martinique, St. Lucia, St. Vincent, Barbadoes, Grenada, and Trinidad. A cable also extends from Jamaica to Aspinwall on the Isthmus of Panama. When the cable is completed and in working order from Port of Spain, Trinidad, to Ponce, Porto Rico, touching at St. Croix, Cienfuegos, Cuba, and Jamaica, the United States and the West Indies will be substantially united by a double series of cables, so that in case of failure of any one of them, communication will not be interrupted.

Between the United States and South America.—It is expected that soon there will be a complete line of telegraphic communication between the United States and Rio Janeiro, South America; and when another link is laid between Rio Grande do Sul and Maldonado, Uruguay, the United States will be in telegraphic communication with all of South America, bordering on the Atlantic ocean, north of Buenos Ayres, and with Chili on the Pacific. A singular fatality has thus far attended the laying of the cable between Rio Grande do Sul and Maldonado. The telegraph steamer *Gamas* was first wrecked in laying it, and the *La Plata*, chartered to pursue the work, was wrecked in the Bay of Biscay, the cable and all persons on board being lost.

Until the cable is laid down between Cayenne and Demerara, communication between the United States and other parts of South America must be forwarded via Europe, the cable between Lisbon, Portugal, and Pernambuco, Brazil, furnishing the only means of telegraphic intercourse.

Connection of other Countries.—One cable between France and Denmark; one between France and Spain; two between France and Algeria; two between Portugal and Gibraltar; one between Gibraltar and Malta; one between Algeria and Gibraltar; two between Sicily and Gibraltar; one between Malta and Alexandria; one between Italy and Alexandria, touching at Corfu, Zante, and Candia; one cable between Russia and Turkey, through the Black Sea; one between Norway and Denmark; one between Denmark and Sweden; one between Sweden and Russia; one between Denmark and Russia; one between Sweden and Germany; one between Egypt and India, through the Red Sea and Indian Ocean, touching at Aden; one between Persia and India, through the Persian Gulf, touching at Gwadar in Beloochistan; one from Madras, India, to Penang in the Strait of Malacca; one from Penang to Singapore; one from Singapore to Saigon, Cochin China; one from Saigon to Hong Kong and Shanghai, China; one from Shanghai to Nagasaki, Japan; one from Nagasaki to Hiogo and Yokohama, Japan; one from Nagasaki to Wladivastok, Asiatic Russia; one from Singapore to Batavia, Java; one from Java to Australia; one from Australia to Tasmania or Van Diemen's Land.

The following cables are projected: from Australia to New Zealand; from Ceylon to Australia; from Singapore to Borneo; from Borneo to Luzon; from Luzon to Hong Kong; from Yokohama to Hokodadi; from Siberia, mouth of the Amoor, to Kamtchatka; from Calcutta to Penang; from Hong Kong, China, to San Francisco, Cal., touching at the Sandwich Islands; from Havana to Vera Cruz; from Aspinwall, Isthmus of Panama, to Carthagena, South America; from Panama to Buenaventura, New Grenada; from Buenaventura to Callao, Lima; from Callao to Valparaiso, Chili; from England to Virginia, touching at the Azores and the Bermudas; from Portugal to New York, touching at the Azores; from Scotland to Labrador, touching at the Faroe Islands, Iceland, and Greenland.

Communication between England and India is mainly confined to the following routes: First, from Penzance on the southeastern coast of England to Lisbon, Portugal; thence to Gibraltar; thence to Malta; thence to Alexandria, Egypt; thence by land line to Suez, and thence by cable to Aden and Bombay. Second, by cable from Lowestoft, England, to Emden, Germany; thence by land line via Berlin, Germany, Warsaw, Jitomer, Odessa, Kertsch, and Tiflis, Russia; thence to Teheran, Bushire, Henjaum, and Jask, Persia; thence to Gwadar, Beloochistan, and Kurrachee, India. This is known as the special Indo-European line, and is worked in one circuit from London to Teheran, a distance of 6,000 miles. From Kurrachee and Bombay land lines extend to Calcutta, Madras, and Paumben; from Paumben a cable extends to the Island of Ceylon; one from Madras to Benang and Singapore; from Singapore cables extend to Saigon, Cochin China, and thence to Hong Kong and Shanghai in China and Nagasaki, Hiogo, and Yokohama, in Japan; one from Nagasaki to Wladivostok, the terminus of the Russian land lines in Siberia; from Singapore a cable extends to Batavia in the Dutch island of Java; from Java one extends to Port Darwin, Australia, and there connects with a land line extending to Victoria, Australia; from Australia a cable connects with Tasmania or Van Diemen's Land. Telegraphic communication exists between Victoria, British Columbia, and Hobart Town, Tasmania, embracing 273 degrees of longitude, thus lacking but 78 degrees of encircling the globe; and when the projected cable from San Francisco to China is laid, the circle will be completed. When this latter enterprise is carried out, the telegraphic correspondence between North and South America and the West of Europe, with China, Japan, and Australia will take this route, as it will be the shortest, cheapest, and most expeditious.

Subterranean Telegraphy.—The last portion of the great underground cable from Berlin to Mayence was laid at the latter place on Monday week in the presence of the Postmaster-General of Germany, a numerous staff, and a large number of gentlemen. The Emperor William sent a telegram from Gastein, congratulating the Postmaster-General and those assembled on the completion of the work. This event deserves notice, for the Berlin and Mayence cable is the first long subterranean cable that has been laid down. In 1848 Germany laid down a wire between Berlin and Cologne, but this proved a total failure. The process of manufacturing guttapercha and making cables was then imperfect. For instance, sulphur, the greatest enemy to guttapercha, was mixed with it. The result was that after a few weeks the faults multiplied to such an extent that correspondence became impossible. This created a prejudice against subterranean telegraphy, and more than 25 years elapsed before an underground cable on a large scale could be projected. The cable is about 600 kilometres in length, and passes from Berlin through Halle, Leipsic, and Frankfort to Mayence, the wires twisted together, and covered with hemp and iron. The cost is about six times more than the same number of overground wires would cost. Germany now possesses seven underground lines between its capital and its western frontier. Aug 77

New System of Electric Telegraphy.

M. Tomassi has described to the Physical Society of Paris a new system of electric telegraphy applicable to submarine cables of great length. He employs a new relay, the sensitiveness of which is such that 5 per cent. only of the current of a single Minotto element, after having traversed a resistance equal to that of 2,520 miles of Transatlantic cable, and a plate of wood lightly moistened (which represents a much greater resistance), suffices to cause it to act on the printing instruments with the greatest rapidity. A second relay automatically interrupts the current of the local battery after each emission, hindering a spark from being produced in the first relay. This spark, which may occasion inconvenience in a very delicate apparatus, such as the first relay, produces none in the second, because of the energy of the contact, which renders the consequences of the spark absolutely inoffensive. This relay acts in turn on the printing apparatus and on another local battery. The receiving instrument is composed of two electro-magnets, which operate converging metallic points. One point impresses a red and the other a blue trace on the same band of paper, according as the operator transmits the Minotto current in positive or negative direction. Different combinations of these red and blue marks indicate numbers, letters, words, and even entire phrases. The transmitting apparatus automatically reverses the current after each emission, and the emissions are exactly of the same duration.

Submarine Cable Statistics.

Of submarine cables, private parties own 149; miles of cable 59,547; miles of wire 65,535. Governments own 420 cables; 4,442 miles of cable and 5,725 miles of wire. Norway has 103 cables, Sweden 4, Denmark 29, Holland 18, Russia 3, Germany 40, Turkey and Greece 13, Italy 12, Spain 6, France 20, and Great Britain 52. The Anglo-American company has the longest submarine cable in the world, 2,585½ nautical miles, and has five Atlantic cables in all, besides twelve other cables, a total length of 12,815 miles. The Eastern Telegraph Company has 48 cables, with 21,883 nautical miles. Nov 77

Underground Telegraphs.

Between Berlin and Halle an underground telegraph wire has been in use for one year, and underground wires are about to be laid between Berlin and the cities of Cologne, Frankfort, Strasburg, Breslau, Hamburg, Kiel and Königsberg, thereby dispensing with posts and insulators, and avoiding the cost of their maintenance. The copper wires which convey the electric current are enclosed in wrought iron pipes, and are hermetically enclosed by insulating material, which protects them from the action of air and water, and prevents oxidation.

77 UNDERGROUND TELEGRAPH WIRES.—Mr. Stephan, Postmaster-General of the German Empire, is replacing open-air telegraphs by underground wires. Already Berlin is thus connected with Kiel and Hamburg in the north and Mayence in the south. These subterranean telegraphs being comparatively safe from injury, their importance, especially in time of war, is obvious.

The Cable Steamer Hibernia Wrecked.

The Telegraph Construction and Maintenance Company, despatched their cable steamer *Hibernia* October 29th last, from the Thames, having on board the new cable designed to restore communication between the Para and Pernambuco Stations of the Western and Brazilian Telegraph Company. The *Hibernia* was wrecked November 22d, in Marranham Bay. No lives were lost.

Réseau télégraphique souterrain de l'Allemagne. — L'Allemagne poursuit activement l'achèvement de son réseau de lignes télégraphiques souterraines. Ces lignes, plus spécialement tracées en vue des nécessités politiques et militaires, rayonnent dans toutes les directions en partant de Berlin. Les câbles sont placés dans le sol à une profondeur de un mètre environ. La pose se fait, lorsque la nature du sol le permet, au moyen d'une machine spéciale qui creuse la tranchée, y dépose le câble et le recouvre d'une manière continue, de telle sorte que la main de l'homme n'ait à intervenir que pour régulariser la surface du sol après le passage de la machine. Sur la plupart des routes, cette machine fonctionne d'une manière très-satisfaisante.

Elle se compose essentiellement d'une locomobile donnant le mouvement à une roue de grand diamètre placée sur un essieu mobile. Cette roue, armée de dents et de palettes, creuse le sol à la profondeur voulue et enlève la terre pour la déverser en arrière sur le câble, qu'un mécanisme spécial dépose au fond de la tranchée au fur et à mesure de l'avancement de la machine. On peut ainsi placer très-rapidement et très-économiquement une grande longueur de câble; les difficultés ne commencent que lorsqu'on rencontre un terrain très-dur et rocailleux, alors il faut renoncer à l'emploi de la machine et creuser la tranchée par les moyens ordinaires, beaucoup plus lents et plus coûteux.

GIRAUDIÈRE.

Jan 78

23,000 cables

1879. 423,000.

13,000,000 sq. ft.

92,000 miles

THE DESTRUCTION OF SUBMARINE CABLES.

SUBMARINE CABLES are subject to numerous causes of deterioration. In the first place, on northern shores, there are the banks of floating icebergs, which sometimes extend to a depth of 500 or 600 meters. In their journey southward, these ground and break under water; the broken masses dislodge the cable which crosses their path. This kind of accident often occurs to the Atlantic cables on the coasts of Newfoundland.

Next to ice-banks must be mentioned wear and tear on rocky bottoms. Near the coast-line, says M. Ternant, in a treatise on the repairing of submarine cables, the depth may vary rapidly, so that the cable does not lie evenly on its bed; one end lying on a rock may have to bear the entire weight of the portion of the cable which is unsupported. A continuous to-and-fro movement, arising from the agitation of the sea or from ordinary tides or currents, determines the gradual wearing away, albeit slow, of the external wires. The sheathing once destroyed, the conducting wires yield and break, or the continued attrition of the core lays bare the conductor, making earth and stopping communication. The cable between Bonifacio and Sardinia was interrupted in 1861 from this cause; and the six conductors it contained were broken by the stretching inside the gutta-percha, which only yielded to the strain in picking up. We may further mention as causes of destruction, coral beds, earthquakes, submarine eruptions, and high temperature on tropical coasts.

The enemies in the animal kingdom are not less numerous. A curious observation was made after the laying of the cables on the Brazilian coast. As is known, Brazil was connected with Portugal in 1875. At the same time a series of cables round the coast completed the system from Pernambuco to Para, Cayenne, Demerara, and the Antilles. The observation referred to was made in the Para Cayenne section. It consisted of singular bites due to attacks made by the saw-fish, which abounds in those parts. A similar occurrence to the Singapore Cable in 1871 was described in *La Nature* in 1873 (Vol. I., p. 160). Mr. Buckland found among his collection a fish-jaw, from which he detached the saw; and with this he reproduced upon a piece of cable a fault similar to that which had caused the interruption.

In Brazil this kind of fault has become chronic; we gather our information from the engineers in charge of the laying. In the first piece which failed, one of the protecting iron wires was wrenched so as to expose the hemp with which the core was served. In the center of this part a piece of bone, apparently the scale of a fish-tooth, was found thrust through the hemp into the gutta-percha. On the same side of the cable, about two inches distant, another piece of bone was found in a similar position. Each of these scales was about one inch in length, and about one-eighth of an inch in diameter.

In another fault, one of the wires was bent inward, the remainder of the strand being slightly deformed and the "lay" taken out. One of the crew, during the heaving in, drew out from the cable a triangular splinter of enameled tooth, about a quarter of an inch thick; this piece was fixed between the wires. On stripping the core, a small puncture was discovered, as if made with a broach.

A third fault was of a more mysterious nature. The cable showed no appearance of being defective. When the external coverings were stripped off, and the core bared, a hole about the size of a pin's head was seen, filled with a whitish substance resembling glazier's putty. One wire of the internal sheathing was found severed exactly over this hole; the external iron wire which lay immediately over was bent into a crook about two inches off. A small portion of the exterior serving was displaced in the region of the fault. On cutting through the core close to the fault, so as to expose the conductor, more of this soft, crushed, pasty matter was found. Two small fragments of hard bony substance were found in the interior serving. These bites showed traces of decomposition; but they were so small that it was difficult to say if the foreign matter was bone or scale. The fragments were somewhat fibrous and semi-transparent: there is little doubt, having regard to other signs, that they came from a fish. The white substance was certainly decomposed dental matter.

These three faults were all found within 15 miles of each other, about 130 miles from Para. A fourth one was found in the deep-sea type; and although no fragments of teeth were discovered in it, the distortion of the sheathing wires showed that it was due to the same cause as the preceding. A fifth fault, picked up 270 miles from Para, half way to Cayenne, was not so evidently caused by fish, although such is just possible. The core in this case was pierced as before, but this time the hole was filled with a black substance; the copper gave signs of indentations like teeth marks. The teeth must have been very strong to have freed themselves. Mr. Warren has told how, after these faults had been taken out, the cable was again interrupted in the following year with five more fish bites at about the same place. From one of these a piece of hard bony substance, an inch and a half long, was taken, while the piece still fixed in the cable was an inch in circumference. Mr. Warren was much puzzled to know by what fish these attacks were made, until arriving at Demerara, where he identified the teeth of the saw-fish, which abounds in those waters and on all the northern coast of Brazil.

After the saw-fish, three insects may be mentioned whose misdeeds have been known some years, which were described by Mr. Preece before the Society of Telegraph Engineers.

The *Teredo* is a worm which constructs a shelter in the form of a tube by secreting calcareous matter. The *Xylophaga* is a bivalve. The latter does not penetrate far into the gutta-percha; it only fixes one valve into it. In small cores this is sufficient to produce a considerable loss of current.

The *Teredo* and the *Xylophaga* are found in the Mediterranean, in the Atlantic, and even in the northern seas.

The *Teredo norvegica* is a worm of considerable dimensions, and is armed with bivalves in the form of shells, which enable it to gnaw the hardest wood. It belongs to the class of acephalous mollusks; naturalists count at least twenty-four different species.

The *Limnoria lignorum*, called also *L. terebrans* by Dr. Carpenter, is a little crustacean of the size of an ant, so that it can get through the interstices of the sheathing wires even of the best made cable, and penetrate to the core, through which it burrows. In the Indian Ocean and the Persian Gulf, the *Limnoria* attains larger proportions, and effects excavations of considerable size. It is frequently met with on the shores of Ireland, where several cables have been seriously damaged by it.

CABLE STATIONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am not altogether eager to take up the cudgels on behalf of the companies. No doubt, abler men will do that; but I must at once raise the question as to the accuracy of "E. A.'s" strictures as stated in your issue of last week. So far as I know, the managers of the companies do everything your correspondent intimates they fail to do. At all the cable stations with which I am acquainted there are good libraries; whilst, for those who do not care so much for sedentary occupation, we have billiards, besides our boating and athletic clubs. In the evening our piano gives forth no uncertain sound, and, in fact, everything is done to make the monotony of our existence less monotonous. As for selection, what would you have in these days of competition? I know I had to study previous to obtaining my post. "E. A." should know that, even were his statements true in any one case, the majority of managers do take all possible care and interest in the welfare of those in their employ.

TELE.

June 78

Les lignes télégraphiques souterraines en Allemagne.— Les travaux pour la pose du câble télégraphique souterrain de Francfort à Strasbourg progressent activement. A la fin de mai, le creusement de la voie souterraine était terminé à Mannheim, et la pose des fils a été aussitôt commencée.

Le câble est formé de sept fils isolés entre eux, le tout recouvert d'une couche de briques et d'une armure en fer. Il sort des ateliers de l'usine Siemens et Halske, de Berlin, et son transport s'opère à l'aide de grands rouleaux spécialement construits dans ce but.

Les fils, au fur et à mesure que les rouleaux s'avancent, se déroulent d'eux-mêmes, et sont aussitôt répartis dans les canaux souterrains par des ouvriers exercés à ce genre de travail.

Les canaux une fois recouverts, on disposera à l'extérieur, et à intervalles égaux, des marques particulières correspondant à des divisions déterminées du câble, peur faciliter, en cas de dérangement des communications, la recherche du point à réparer.

June 78

48

Foreign Telegraphic Notes.

*At a meeting of the board of directors of the Anglo-American Telegraph Company (Limited), held March 29th, it was resolved, after placing £37,500 to the renewal fund, to declare an interim dividend for the quarter ending the 31st inst., of 1 per cent. on the Ordinary Stock, and of 2 per cent. on the Preferred Stock, both free of income-tax, payable on May 1 to the shareholders, registered on the books of the company on April 1, leaving a balance of about £7,500 to be carried forward to the next account.

The Eastern Extension Telegraph Company will pay for three months ended 31st December a dividend of 2s. 6d per share, making, with previous payments, a distribution of 5 per cent for the year 1877, and £30,905 is carried to reserve. The dividend is the same as for the year 1876, when £6,011 was carried to reserve.

The balance sheet of the Great Northern Telegraph Company for the year 1877 shows that the total receipts were, inclusive of £19,409 brought forward, £223,867, while the expenditure was £62,289. The interim dividends, at the rate of 5 per cent. absorbed £75,000, and an extra dividend of 2s. 9d. per share required £20,833; to the reserve fund £44,444 was added; and, after paying directors' remuneration and pension-fund allowance, the sum of £19,277 is carried over.

The severe snow storms and gales in England in the latter part of March caused serious interruptions to the telegraphic communication in various parts of the country, and especially in the West of England and South Wales.

It is said that the Chinese are particularly well pleased with the telephone, and that messages have been sent in China over 500 miles of wire.

The steamers John Pender and Chiltern left Malta, March 13, with submarine cables on board, having been chartered by the Government to lay them at various points in the Levant.

A meeting of South African merchants was held recently in London, and resolutions were passed in favor of the establishment of a telegraph line to Cape Colony. A committee was appointed to represent the views of the colonists to Sir Michael Hicks-Beach, and to press upon the Government the urgent necessity for the early laying of a line of cable to connect England and South Africa, leaving it to the Government to judge whether the cable should be laid on the east or west side of Africa.

The Post Office authorities notify that the cable between England and France and the Channel Islands is interrupted. The English cable also being interrupted, messages can now only be dispatched by steamer.

A message from Berne, Switzerland, dated March 21, states definitely that the Argentine Confederation would be admitted into the International Telegraph Union April 1.

A Grave Mistake.

The Chairman of the Direct Cable, in his remarks at the meeting of that company, held on the 22d of March, said:—Were a cable worked to its very utmost extent and fullest carrying capacity and only a moderate expense of working allowed for, at a one shilling tariff, it would only give a return of about two per cent. per annum, not "twenty per cent," as erroneously stated in the report, published in United States.

Cuba Submarine Telegraph Company.—The number of messages sent during October by this Company was 2,079 as against 2,009 during the corresponding month in 1877.

49

S.S. SHERARD-OSBORN AND CABLE LAYING.

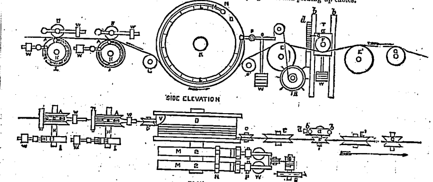
In our first number we stated that the Eastern Extension Company had just added the above-named vessel to the fleet of cable ships.

On Monday, 3rd inst., in response to the invitation of Mr. John Pender, as chairman of the company, a large number of scientific gentlemen and others interested in the cause of electrical progress proceeded by special steamer to Greenwich to inspect the *Sherard-Osborn* and the works of the company. The ship, fresh from the builders' hands, and gaily decorated with bunting in honour of the occasion, excited the unqualified admiration of her visitors, who were none the less pleased that her fittings throughout betokened that strength and utility had not been sacrificed for the sake of mere outward effect. Admirably adapted for the performance of her special duties as a cable ship, the *Sherard-Osborn* is, however, not lacking in the elements of comfort so necessary to those engaged in the arduous work of cable-laying in the burning climes for which she is destined. The four large tanks were as yet empty. At the works, however, to which the visitors next proceeded, the cable which is about to be embarked was rapidly approaching completion, so that the elaborate process could be examined in all its stages. The experience gained during the past few years has shown that the deep sea cable has many foes, and a new feature in the construction of the one destined to form the first cargo of the *Sherard-Osborn* had for its object the defeat of that most pertinacious enemy, the *teredo navalis*. For this purpose, amongst the eight coverings with which the precious copper is protected there has been introduced a wrapper of brass tape, and it is confidently anticipated that this final precaution will baffle even the *teredo navalis*.

When everything of interest had been thoroughly inspected, the company adjourned to the Ship tavern, where covers were laid for 150 guests. Mr. Pender, as president, was supported by Sir James Anderson, Sir Garnet Wolseley, Sir Spencer Robinson, Mr. Hussey Vivian, M.P., Mr. Donald Currie, M.P., Sir Archibald Michie, Mr. E. J. Reed, M.P., Sir William Thomson, Mr. Julius Beer, &c., &c.

In returning thanks for the Army and Navy respectively Sir G. Wolseley and Sir S. Robinson enlarged upon the debt which either branch of the service owed to men of science, and especially to those who had devoted themselves to the development of the marvellous powers of electricity. Sir A. Michie expressed the obligations felt by the colonists of Australia and New Zealand to the telegraph engineers, without whose labours they could never have attained their present prosperity; and Mr. Donald Currie forcibly urged the necessity of completing our communications by telegraph with the Cape of Good Hope—a necessity brought home just now to the breasts of all Englishmen by the thought of the struggle now going on between our countrymen and their native foes, the vicissitudes of which only came to our knowledge after a lapse of three long weeks.

Mr. Saunders, the electrician of the company, has kindly supplied further information relating to the ship, together with such diagrams and explanations as, we think, will render clear to all our readers the machinery employed to perform the work of laying down and picking up cables.



The Ship.

The *Sherard-Osborn* is 270 feet long, 32 broad, and 23 deep. The twin screws are driven by engines of 900 horse power nominal. The registered tonnage of the vessel is 875 tons, the gross tonnage, however, is 1,429 tons. There are four cable tanks, and water-tight bulkheads allow water ballast to be used to counteract the loss of weight when paying-out cable.

The Paying-out Gear.

In putting the cable on board for laying, sufficient end having been left out for testing, the coiling is begun from the large diameter of the tank in the direction of the lay of the cable, the turns being placed close to each other until the eye is reached, the latter being generally about one-third of the diameter of the tank and made telescopic, so that it can be gradually lowered as the coil decreases during the progress of paying-out. Each layer is called a flake. The cable is not coiled back upon the eye, but is laid out diagonally on the top of the flake to the side of the tank, and then coiled back to the eye, and so on until the tank is filled.

In laying the cable, the end is brought over a wheel placed over the centre of the tank, and thence along troughs until it enters the paying-out machinery, then passing over the V wheels A A, under the jockey wheels B B, which run on the top of the cable, and by their weight press it into the grooves of the V wheels already mentioned, thus keeping up a slight strain on the cable before it passes on to the paying-out drum D, around which it takes four or five turns, over the wheel E, under the wheel F of the Dynamometer, over the wheel E', and finally over the stern wheel G into the sea.

On the shafts H H of the V wheels A A are fitted friction brakes 1 1. The paying out drum has also a double break 2 2. The breaks consist of iron wheels or drums K K K, the peripheries of which are broad and flat. Around these press segments of wood L L L affixed to the steel band M. One end of this band is fixed to the frame-work of the machine at N, and after passing nearly around the drum K is hinged to the lever O, the fulcrum of which is at P, and on the other end of the lever weights W are placed according to the amount of friction required.

Attached to the frame of the machine is a wedge-shaped piece of iron, fitting close to the circumference of the paying out drum, and called the fleeting knife, its use being to fleet the turns of the cable, so that there shall be a clear space for the cable coming on the drum, and thus prevent the turns overriding each other.

The description of the brake to the paying out drum D will apply to those for the smaller brakes to the V wheels A A. The amount of friction can be very nicely regulated by means of the wheel R, which has spokes similar to those of a ship's steering wheel, and to prevent heating by friction the brakes run in tanks filled with cold water. On the shaft is a drum S, around which the chain fastened to the end of the lever can be wound, thus lifting the weights and regulating the amount of friction. The man stationed at this wheel watches the indicator of dynamometer T, and lessens or increases the friction according to the amount of strain indicated. A similar arrangement is attached to the small brakes and jockey wheels, by which the jockeys can be lifted and the amount of the friction on the breaks regulated.

The dynamometer consists of the slide *a* carrying the wheel F and weights W working between the two uprights B B according to the amount of strain in cwts. on the cable as shown by the pointer *c* on the scale *d*.

The different parts of the paying-out gear are placed relatively nearer each other in the drawing than they are on board ship,

50

this requiring to be noted more particularly in regard to the wheels E.E' and C T. It is of the greatest importance that a sufficient amount of slack be paid out to compensate for the inequalities of the bottom. Great attention must therefore be paid to the relative speed of the ship and that at which the cable passes overboard.

To enable the engineers to judge on this point a rotometer is attached to the main shaft of the paying-out drum, which indicates every revolution by striking a bell. Further, pointers on a dial show the total number of revolutions. The engineer, knowing what speed will be given to the ship by a certain number of revolutions per minute of her engines, and counting the number of revolutions per minute of the paying-out drum, the circumference of which he has accurately measured, is able to tell at once whether the relative speeds of ship and cable will give the proper amount of slack; if not, he either increases or diminishes the speed of the ship or the weights on the brakes of the paying-out drum. Sir William Thomson's wire-sounding apparatus enables soundings to be taken so quickly that it is of great service in laying cables; and lately during such operations one ship has proceeded in advance of the other for the purpose of taking soundings, which were at once telegraphed to the rear or paying-out vessel, so that the engineers on board the latter could regulate the amount of brake power necessary to ensure the proper amount of slack being allowed.

Diagrams of the picking-up gear, with the necessary amount of explanation, will be given in another paper.

Laying and Repairing Telegraph Cables. By V. Hoskiær. London: Spon. 1878.

The author, who is an officer in the Royal Danish Engineers, has been engaged in laying telegraph wires in the Baltic, the North Sea and off Japan; and he has been well-advised to publish, for the benefit of young engineers, the result of his ample experience. As the author's MS. has been revised by Mr. France, manager of the Brazilian telegraphs, there is not the faintest chance of discovering an error either in his statements or formulæ. The appendices, which constitute half the little volume, contain specimens of "records" and journals such as have to be carefully kept on board every ship engaged in laying cables. We by no means begrudge the gallant Dane the honour of doing a thing that should have been done long ago by an Englishman. He has acquitted himself of his work well, and—written in the tongue of the mother of a dozen nations—his book will unquestionably have a success which its well-balanced structure deserves. July

The Brazilian Submarine Telegraph Company's receipts for July were 11,759l., against 9,329l., showing an increase of 2,430l.

The receipts of the Eastern Extension, Australasia, and China Telegraph Company for July amounted to 24,927l., against 22,224l. in the corresponding month of last year, showing an increase of 2,703l.

The traffic receipts of the Great Northern Telegraph Company for July were 18,811l. For the seven months ended with July 31 the aggregate receipts were 118,163l., against 115,335l. and 115,876l. in the corresponding periods of 1877 and 1876.

The receipts of the Direct Spanish Telegraph Company for July were 812l., while the corrected receipts for the corresponding period of last year were 824l.

The estimated receipts of the West India and Panama Telegraph Company for the half-month ended with the 31st ult. were 2,175l., against 2,433l. in the corresponding period of 1877. 78

Subterranean Telegraph Wires in Germany.

In 1876 the first subterranean telegraph wire was laid down in Germany. Recently, subterranean lines have been completed from Berlin to Cologne, from Cologne to Elberfeld and Barmen, from Frankfort to Strasbourg, and from Hamburg to Cuxhaven. Altogether the length of these lines now amounts to 1,554 English miles. Most of the cables consist of seven wires, very few of four only. The difficulties encountered in laying down the cables in marshy or rocky ground, along the streets of large towns, across, or rather under, rivers, and through fortifications, have all been successfully overcome. Next year six other lines are to be laid down, and then the projected system of subterranean telegraphic communication throughout the German empire will be almost complete. The cost of the lines already laid down amounts to about $3,030,000.

July 24 Engineering

ELECTRICITY.

The *Electrician* says that the life of a submarine telegraph cable is from ten to twelve years. If a cable breaks in deep water after it is ten years old, it cannot be lifted for repairs, as it will break of its own weight, and cable companies are compelled to put aside a large reserve fund in order that they may be prepared to replace their cables every ten years. The action of the sea eats the iron away completely, and it crumbles to dust, while the core of the cable may be perfect. The breakages of cables are very costly, and it is a very difficult matter to repair them in comparison with a land line. A ship has to be chartered at $500 a day for two or three weeks in fixing the locality and in avoiding rough weather, as cables can only be repaired in calm weather. One break in the direct cable cost $100,000.

51

politan Gas Companies for the year 1876, and presented to Parliament, the following was the position of each of them ending December 31st.

The Gas Light and Coke Company had of stock and share capital a total of 8,205,000l. authorised, and 6,664,986l. paid up, with 1,436,500l. loan capital borrowed, and 1,125,000l. remaining to be borrowed; the total receipts on capital account amounted to 8,101,486l. The South Metropolitan Company, at the same date, had a total share capital of 460,000l., paid up, with no loans, leaving 40,000l. for issue. The Commercial had a total authorised capital of 830,000l., and of loan 300,000l., of which 611,638l. share and 15,670l. loan had been paid up, making a total of 627,308l. actually paid up. The London had 758,927l. paid up, against 873,842l. authorised, with loans of 78,402l., and 101,122l. remaining to be borrowed. The Phœnix had a capital of 900,000l., out of 1,044,000l. authorised, and 155,000l. loans, and 45,000l. to be borrowed. The Surrey consumers showed a total of capital of 290,000l., of which 230,000l. were share, and 60,000l. loan, leaving a net of share and loan together to be called up of 20,000l. Taking these figures in a gross total, it would appear that, at the end of 1876, the whole paid up share and loan capital of the Metropolitan Gas Companies was about 11½ millions, and of unissued shares or unissued loans about 3½ millions, thus ~~making the total capital in~~ connexion with London gas supply to amount to, say, 15,000,000l., within but, comparatively speaking, a small fraction.

We next refer to the accounts of the London Gas Companies, just issued for the year 1877. In regard to the Gas Light and Coke Company, while the total authorised share and loan capital remains the same as in 1876, there has been about 300,000l. additional share capital issued, this so far reducing the share and loan capital authorised. The share capital of the South Metropolitan was increased in the year to 750,000l., being 250,000l. more than authorised in 1876. Of this the total paid up is 480,000l., leaving 270,000l. capital unissued. In regard to loan capital this company has borrowing powers to the extent of 250,000l., none of which have yet been exercised. Practically it would appear, therefore, that taking ordinary share and loan capital the financial powers of this company show an increase of half a million, of which but 20,000l. was called up as share capital in 1877, that is, 460,000l. share capital paid up in 1876, as 480,000l. paid in 1877. In respect to the Commercial the authorised share and loan capital (830,000l. and 300,000l.) remains the same as in 1876. But there has been an extra issue of share and loan, making the totals 690,217l. in 1877, against 627,308l. in 1876 paid up and borrowed. The variation in the finances of the London Gas Light Company show little difference in the authorised share and loan capital, but there was an issue of 30,562l. of 4½ per cent. debenture stock in 1877, which with other items of increase and decrease, by conversion, paying off, &c., gives 864,179l. as total receipts in 1877, against 842,178l. in 1876. The Phœnix accounts for 1877 show an increase of 200,000l. share capital, or 1,244,000l., against 1,044,000l. in 1876. But the total receipts on account capital were in 1877 to the extent of 1,121,000l., against 1,055,000l. in 1876. In regard to the Surrey Consumers' the capital and loan accounts present no difference between the two years.

From the preceding figures it appears that, taking the total increase of expenditure, both as regards share and loan capital, of the six London gas companies in 1877, as compared with 1876, the difference is, comparatively speaking, of little account. This is certainly an element of strength, and compares favourably with the statistics of railway capital, which we gave on page 135 *ante*. In the case of railways we find a retrocession in almost every financial respect, with the exception of an increased expenditure of capital, while, on the other hand, investments in London gas companies present in all respects the most favourable features.

As it is more than probable that the Gas Light and Coke Company will eventually become the only one in London, by amalgamation with the rest, we shall, in dealing with the internal economy of the companies, only analyse its accounts, and that for the half years ending respectively on 31st of December, 1877 and 1876, by way of comparison. It appears from the revenue accounts of the Gas Light and Coke Company that the last half-year of 1877 showed sales of gas 892,726l., rental of meters 17,138l., sale of residual products 230,865l., miscellaneous 2716l., or a total receipt of 1,152,445l. against 1,180,985l. in 1876. The deficiency in 1877 was due to a diminution in the receipts for gas, and a still larger one for sale of residual products, showing a total of about 30,000l. decrease in 1877 compared with 1876. In regard to expenditure the amount charged in 1877 was 760,455l. against 771,487l., showing about 11,000l. economy in 1877 compared with the same period in 1876.

In regard to net revenue, 391,990l. accrued by the working of the company, which, with balances from last year, gave a total available fund for dividend and interest of 460,293l., which amounted at the same period in 1876 to 543,715l. After payment of interest, dividends on preference shares, and various stocks, in 1877 there was a balance of 326,537l. applicable to dividend on ordinary stock. The dividends on special stocks varied from 4 to 10 per cent., while that on the ordinary stock was 10 per cent. for the year.

Such are some of the most important financial features of the condition of the London Gas Companies for the year ended December 31, 1877, and they of course afford the basis of estimate as to the comparative status of each company in view of amalgamation. Under the present restriction imposed by the Board of Trade, and the controlling influence of the Metropolitan Board of Works, future amalgamation of all the companies promises to become a benefit rather than an evil. Of course in the present condition of London streets, burrowed with sewers, gas and water pipes, and telegraph wires, and bound on their surface by tram lines, in all directions from the City to the extremities of the metropolis, any attempt to introduce new gas or water companies would be as ridiculous as it would be impossible. The re-paving of our thoroughfares is bad enough in itself, but of course is an absolute necessity; it is certain, therefore, that the inhabitants of London would not tolerate the almost ruinous condition that would be involved in fresh competition, whether in respect to gas or water supply, no matter what benefits might follow from the introduction of new and independent sources. It only remains for the Board of Trade and the Metropolitan Board to introduce new or maintain the already existing restrictions in the interest of the ratepayers, in regard to quantity, quality, and price of the gas supplied. This being properly done, we need have no fear of any injury arising should all the London gas companies be merged into one large concern. Whatever success may eventually accrue to the application of electricity to lighting purposes, such must be very remote, and although great progress in that direction has been made during the last few years for the purposes of local illumination of large open spaces, or buildings, it cannot, under present circumstances, compete with gas for shop and domestic illumination. The gas companies have, therefore, little to fear from that source of competition, and the ratepayers but little to hope, at all events financially, for any such change.

Aug 27 '78

THE ATLANTIC CABLES.

Although the problem of deep-sea telegraphy, as regards first construction, has been long considered as solved, there remains the question of durability and maintenance, which is only slowly being answered as time gives us experience and data to determine the average durability of the various types of cable employed and the effect of different localities on them. The Atlantic cables form the most important group not only on account of their being the earliest of the deep-sea cables, but because most of the other deep-sea cables could, if absolutely necessary, be dispensed with by more circuitous routes in shallower water. We are now gaining some experience of the life of these cables, as two of the earliest laid—those of 1865 and 1866—may be considered as having terminated their existence, and the whole question of durability may be reconsidered. But although the dates of the laying and breakdown of these cables gives us an average life of about ten years, it will be seen that this need not necessarily be the limit of the life of those since laid, as improvements were introduced in their construction.

Last year an expedition for the repair of the 1865 Atlantic cable (which failed March 12, 1873), and of the 1866 cable (which failed January 13, 1877), returned after four months, having repaired one fault on the Newfoundland side and one on the Irish side in 1866 cable, and brought home a piece of cable cut out at this spot in excellent condition, but

THE GLOBE TELEGRAPH AND TRUST COMPANY (LIMITED).

The fifth ordinary general meeting of this company was held at the Cannon-street Hotel on Tuesday last, July 30, 1878, JOHN PENDER, Esq., M.P., in the chair.

The Secretary (Mr. Payton) read the notice convening the meeting. The minutes of the last meeting were read and confirmed, and the report was taken as read.

The CHAIRMAN: Gentlemen, I dare say you will observe from the report and the statement of stocks and shares that we have given you a little more information than we did before. There are two new columns which have been added, showing the respective amounts of dividends received from our investments, and the return on cost price, which will make matters clearer to the shareholders. The investments show little change. The 2,000 Direct Cable shares alluded to in last year's report have been taken up, and are now included in our list. The average cost of our Direct shares is 10l. 13s. 11d. per share, which, looking to the market price of the day, is a source of satisfaction. The dividend, as you will observe, is quoted as 3¾ in the List now. This means only for nine months, and not for twelve months, because the dividends for twelve months are at the rate of 5 per cent. per annum, which have been received and which are the first dividends that have been paid by the company, which was formed in 1877. A retrospect of the past two years will show that we have reason to congratulate ourselves on the improved position of Atlantic stocks, and our own shares. At this time, in 1876, Anglos stood at 57¼, and in 1877 at 58¾, now they are at 64. These calculations were made at the end of our financial year, namely, July 15th. They are a little lower to-day, but I am speaking of the period when your accounts were made up. They are somewhat lower since, on account of the failure to repair the 1866 cable. In 1876 Directs stood at 7¾, in 1877 at 13; they are now about 14. The increase in value in two years has been something like 6 per cent. in the case of the Anglos, and 30 per cent. in the case of the Directs. To put this in plain results, we may say that there has been a rise in Anglo stock equivalent to 420,000l. on the whole of the capital, and 67,000l. on the stock held by the Globe, and of 390,000l. in Direct shares taken as a whole, or 37,000l. on the Direct shares held by the Globe. This is attributable to the action of this company in bringing about a working arrangement between the Atlantic companies instead of leaving them to do, by hostile competition, private rebates, and commissions, as much injury as possible to each other. Our own shares have participated in the improvement. A little calculation shows that the total value of our stocks and shares on the 15th July, 1877, was about 2,260,700l., and at present quotations about 2,398,000l., or an increase of 137,300l., or say six per cent. all round, which is an important advance on the year. The value of our own shares, taken at the price of the day, is 2,541,000l., or a value over the stocks and shares we hold in trust of about six per cent. The difference arises from the appreciation of shareholders of the security given by this company in spreading the risks by investment in various companies. Our shares in combination, that is preference and ordinary, taken together, represent a market value of 85 per cent., that is, taking the preferences at 11 and the ordinaries, at 5½ and this is a higher quotation than any other telegraph company now possesses, the submarine alone excepted. Shareholders who have exchanged for Globe shares have nothing, therefore, to regret, but have a materially improved value in their Globe shares as against the stock they exchanged. As regards the revenue account, our receipts, as mentioned in the report, have been augmented by a larger dividend from the Anglo, namely, 4½ this year, as against 3¾ last year, and the first three dividends of the Direct Company, and that enables us to recommend a dividend of 4 per cent. on the ordinary shares, and to carry forward a balance. Our payments are altogether 100l. in excess of last year, but this arises from our having to increase our staff, owing to the large increase in the number of shareholders, which, from 2,700 in 1874, has grown to 4,500 in 1878. This large increase and our system of quarterly dividends entail extra expense. The item of Interest on Loans was incurred in respect of the carrying forward of the 2,000 direct shares. It would have been larger had it appeared in the form of dividends on shares issued to pay for the Directs, for we were able to borrow at a less rate than the dividend we are paying. The same observation applies to the loan of 26,000l. which appears in the balance-sheet. That amount is borrowed at Bank rate, and it suits us better to wait until our shares reach such a price as will enable us to issue them without any, or, at all events, very little discount. For the next year we have reason to anticipate our revenue with increase. The advance to the River Plate Company in the balance-sheet of 236l. 10s. will be repaid in a short time. It was a sum we advanced, in common with two other companies, to enable a commission to be sent to Brazil to look into the affairs of the River Plate Company. The mission has been successful, and the prospects of that company are such now, that this item of Globe-holding, although small, will, I believe, be very profitable. The item "interest in suspense," 1,796l. 9s. 11d., has reference to a former purchase of direct shares. We had to pay interest at the rate of four per cent. per annum until we took them up; but there is a dividend payable on shares as soon as dissentient shareholders are settled with by the liquidation of the Old Direct Company, which will extinguish that item. Now, gentlemen, I have given you these particulars because they immediately bear on the value of your property and also your balance sheet. I do it also for the reason that there are many people who do not understand the position of the Globe Company or the peculiar nature of their property. Some people suppose, because the Globe shares are at a discount, that so much loss has accrued to the shareholders; but in the remarks that I have made you will observe that any man who exchanged his shares in any other telegraph company into the Globe as they stand to-day, will find them of greater value than if they had remained in the company from which he had transferred them. Therefore, the satisfaction is in two ways; you will observe that our shareholders have doubled themselves in number, showing that there is increased confidence in the investment. That there should be increased confidence there ought to be no doubt, because you have all the different telegraph companies contributing, and, consequently, if one is a defaulter, another is paying something extra, and, therefore, in that way you get a fair average; for instance, in our own case, Direct shares have paid nothing until now. The business of the Indo-European Company was interrupted on account of the war for several months, and the consequence was that there was no dividend paid, but they are now working satisfactorily, and they have entered into an engagement with the Eastern Telegraph Company, which will enable them, I hope, in the future to pay a steady and a very fair dividend. As you are aware, this company entirely depends upon the successful working of those companies in which we hold shares. We may be said to be very large shareholders in all these companies. It is the business of the Globe so far to look after their dividends as to see that each company is working up to the points in economy and efficiency in every other way as to ensure to the shareholders a fair and steady dividend [hear, hear]. The more that these companies progress, of course the more the Globe must increase in their dividends. I think now that peace may be said to be established—at least, I hope it is established, and established upon a permanent basis—trade will be emancipated from the extreme depression which has prevailed for so many months, I might almost say years; and with the revival of trade you may depend upon it that there is no Telegraph Company which will not participate in the increase of receipts [applause]. With these remarks, gentlemen, I beg to move the following resolution:—"That the report and accounts of the directors for the year ending the 15th July, 1878, submitted to this meeting, be, and they are hereby received and adopted, and that in accordance with the recommendation of the Board the following dividends be now declared, viz., three shillings per share on the preference shares, making, with previous quarterly payments, 6 per cent. for the year ending 15th July, 1878, and two shillings per share on the ordinary shares, making, with previous quarterly distributions, 4 per cent. per annum for the year ending the same date."

SIR DANIEL GOOCH, Bart., M.P.: I have much pleasure in seconding that motion.

The CHAIRMAN: Before I put the resolution, if any shareholder has any question to ask I shall be very happy to answer it.

Mr. NEWTON: I should like to ask for some information with reference to the Anglo Company, particularly as to the condition of the cable. Is there any intention of issuing the remaining shares of this company? I think, sir, as you show such a great advantage to the holders of the Globe property, you would be doing well to telegraph property generally, and to the Globe especially, if you can increase the holding of telegraph property by exchanging further, and embarking more of your capital in the various companies.

The CHAIRMAN: I think it would not be quite wise on my part if I were to anticipate the statement of the Chairman of the Anglo-American Company, whose meeting is to be held on Friday. I can only say that, so far as I have heard, the core of the cable, that is, the gutta-percha, is now as perfect as on the day it was first put down. But, as I have said, I have no doubt a full statement will be made at that meeting, but I have that faith in scientific progress that I think the difficulties which we begin to realise in this new property of cables are likely to be overcome. I know there are gentlemen present who believe that an Atlantic cable may be made to live for all time. I only wish that proposition could be fairly established, because if it were fairly established the advantage to telegraph companies would be something enormous. However, we will not anticipate what is to be said on Friday, but I trust that science will be able to effect what we hope. As to the issue of further stock, the principle of the Globe is to exchange the shares of the Globe with existing companies, if they can be exchanged at a price which will be satisfactory to the Globe. Therefore I think, although we may consider our books closed at the present time, if we find anything like pressure, or anything like applications of such magnitude from outside people as to induce us to make a further issue, the board will of course consider it. As it is part of the principle of the Globe, I should think it would very likely adopt it; in the meantime we do not entertain any proposition just for the moment.

The CHAIRMAN then put the resolution, which was carried unanimously.

The CHAIRMAN: The next resolution I have to put to the meeting is—"That William Ford, Esq., be and is hereby re-elected a director of the company.

SIR JAMES ANDERSON: I have great pleasure in seconding the motion.

The motion was put, and carried unanimously.

The CHAIRMAN: The next resolution I have to put before you is—"That Sir Daniel Gooch, Bart., M.P., be and is hereby re-elected a director of this company."

Mr. FORD: I have the honour of seconding the motion.

The motion was put, and carried unanimously.

The CHAIRMAN: The next resolution will be moved by Mr. Griffiths.

Mr. GRIFFITHS: Mr. Chairman and gentlemen, I rise with much pleasure to tender our thanks to the directors for their able management during the past year. The unanimity with which you received the report, I think, is a convincing proof that you are satisfied therewith. It is a remarkable statement that our Chairman has made, that the number of shareholders has increased to such a large extent as from 2,700 to upwards of 4,000. Considering that the growth of the society is so large, the fact that so few members are present shows that the report gives satisfaction to the shareholders and public generally. I have glanced over the list of our shareholders, and it certainly contains the names of persons of great influence in all parts of the United Kingdom; and, also, persons of great talent and great scientific skill who are able to judge for themselves. Looking to the facts, I think we have also further cause for congratulation. Last year, the dividend had fallen off on the ordinary shares from the sum of 3s. to 2s., 1s. 9d., and even to 1s. 6d. It is a great thing that peace has been restored, and war is at an end, and that the dividend should again rise to 2s. This, I think, must be a cause of congratulation to us all. On the other hand, we must remember that the cause of the dividend falling off was not due to any fault of our directors, but rather to that spirit of warfare and antagonism which sprung up between the Direct Company and the Anglo-American Company. The warfare was forced on the directors of the Anglo-American by their own company; it was considered necessary. Therefore, although the dividends did fall off, I think the directors of that company were to be commended for the policy they adopted and for the results which have been attained. For those results I believe we are to a great extent indebted to our chairman, Mr. Pender [hear, hear]; he certainly showed great skill in a most difficult crisis. It is a great satisfaction to us that peace is now restored, and our dividend rising again. There is one subject more of regret which our report discloses, and that is that Mr. Cyrus Field has ceased to be a director. The name of Field is so well known in different circles—in political, legislative, and scientific circles, and especially in circles connected with the electric telegraph—it is a cause of regret that he no longer forms a member of our board. You are all probably aware that it is to the family of the Fields that the Anglo-American Company owes its origin, both in the suggestion, and the perseverance, and moral courage which, after so many phases, succeeded in uniting together the two continents of Europe and America. Good men and true men are scarce. Our company is of such large dimensions, and has grown to such magnitude, and its shareholders are so numerous, that we cannot afford to lose any good director. I should be rather in favour of increasing our number of directors, if we could find any equally good. But I think we should pay that debt of gratitude which is due to those gentlemen who are at present in office. They, no doubt, have a stupendous concern to manage, and their management has been distinguished by great skill and considerable success. The name of Pender must give confidence to all persons connected with electric telegraphs; the name of Massey, so well-known in political circles, must also increase our importance; while the name of Sir Daniel Gooch, a host in himself, well-known in the railway world, must add to the *prestige* and strength of our company. It is therefore with the greatest pleasure that I move a vote of thanks to the directors for their able management during the past year. As justice comes before generosity, I think we should also consider the remuneration which is due to them. We have gentlemen of great talent, great skill, and great reputation devoting themselves to our service. In times past we readily voted the sum of 1,000l. per annum. I think, under the circumstances, considering the progress of the company, the success which has attended their management, and their reputation with the public, that the least we can do on the present occasion is to vote them 1,500l. for their services. It is but a trifle when you consider the magnitude of our capital, nominal or real; it will not make any appreciable difference in the shareholders' dividends—500l. out of so many thousands is a mere drop in the ocean. On these grounds I have great pleasure in moving, "That the thanks of this meeting be given to the directors for their able management of the company's affairs during the past year, and recommend that the directors henceforth receive the sum of 1,500l. per annum.

Mr. LLOYD: I beg leave to second that motion.

Mr. BURGE: I beg leave to support the resolution. I am the holder of a great many thousand preference shares. I look upon this as the time when some further recompense should be given to the directors in recognition of their services. A year ago a great attack was made upon the chairman in a paper which is stranger than fiction. I think the directors of this company had to undergo the most powerful castigation unjustly that was ever imposed. They have carried us through a period of great trial and difficulty. I believe they have done a great deal to rescue from a large loss a very valuable property in the Atlantic. I think when we the shareholders of this company entrust to them capital to the extent of two millions-and-a-half, they have a very serious charge, and I do not understand how we can expect gentlemen of their reputation and position to undertake the responsibility of looking after that upon the same terms as those upon which they started, because they represent each shareholder. If we were private shareholders, considering the various companies that are in existance, we should take a very great deal of time to see that the company's affairs were well managed. I do not understand how our directors can be expected to look after the business of twelve or thirteen different companies unless they are a little more fairly remunerated. I think the trouble and difficulty which they have had to encounter, and the malignity with which they have been attacked in the Press, should cause us to recognise their value. I think, if we have an income of 150,000l. or 160,000l. a year dependent upon their exertions, that 1,500l. a year is not too much to give them in return. I have the greatest possible pleasure in supporting the resolution moved by Mr. Griffiths. I do not know one of the directors personally, but I cannot help thinking that we should be only doing justice to men who are looking after our interests to such an extent by remunerating them a little more handsomely [hear, hear].

Mr. GRIFFITHS then put the resolution, which was carried unanimously.

The CHAIRMAN: Gentlemen, I beg to thank you on behalf of my co-directors and myself for this renewed proof of your confidence. I dare say it will be in the recollection of some of the gentlemen in this room that shortly after this company was formed, I think about a couple of years, there was a motion made that the directors' remuneration should be 2,000l. I do not remember the name of the gentleman who made it, but I, on the part of my friends sitting around me, declined any increase upon the 1,000l. until we had got the company into a thoroughly satisfactory position. I think we are placed before you to-day in a very satisfactory position [hear, hear]. What one of the gentlemen who has just spoken said, that we have been very much maligned, is quite true; but, as long as men feel that they are doing their duty, and can show good results from their action, they are in the proud position of being able to treat with the most perfect contempt all attacks that may be made upon them, from whatever quarter they may come [hear, hear, and applause]. But, gentlemen, if we have the confidence of the body of shareholders (and we will only hold that confidence as long as we can show results) you may depend upon it your interests will be protected, and those who make those attacks which have been referred to, will in the end feel that they are rather doing us good instead of harm [hear, hear]. With these remarks I beg to thank you very much for the confidence you have reposed in us to-day. It is a very unusual thing indeed for a meeting to be so unanimous as you have been in increasing the directors' fees. I do not think that at any meeting which I have ever attended I have seen so much unanimity as I have to-day. You may depend upon it, it will have its proper effect upon the directors [applause].

Mr. NEWTON: I do not interpose, because I am a preference shareholder. I think that the resolution which has just been carried should have been proposed by an ordinary shareholder, seconded by an ordinary shareholder, and supported by an ordinary shareholder. I beg to say that I thoroughly oppose it. I did not vote against it, because I am only a preference shareholder. I have great pleasure in moving, "That William Newmarch, Esq., F.R.S., and John George Griffiths, Esq., be and are hereby re-elected the auditors of this company for the current year, at a remuneration of thirty guineas."

The CHAIRMAN: I always like, as far as one's knowledge goes, to give the shareholders the full benefit of my information. I may mention to Mr. Newton that he has a perfect right, as a preference shareholder in this company, to move or vote as he pleases. There is another company, at a meeting of which he made a motion, as he is aware, in which he was out of order; but, when this company was dealt with, it was thought better to amend the articles of association, so as to enable the preference shareholders to vote as well as the ordinary shareholders. I think, notwithstanding the remarks of Mr. Newton, who I know is a great economist, that there is not any man in this room who will more readily admit that the labourer is worthy of his hire [hear, hear]. I think that Mr. Newton will admit that during the time that we had that very hazardous battle to fight, and in which I do honestly believe that we rescued the Direct Telegraph Company from ruin, and I express my belief, although I may not have the concurrence of every gentleman in doing so, that it could be proved that the gain not only to this company, but to telegraphy as a property, was very great indeed. If Mr. Newton had been working with us, and paid at the rate we were paid, I suspect he should have had a very poor dinner to dine upon [laughter].

Mr. NEWTON: I am quite aware you gave us, the preference shareholders, the right to move and vote in this company; but I feel equally confident that I have the same right elsewhere.

The CHAIRMAN: Now, you will allow me to remind you that you are out of order.

Mr. OXENFORD: I beg leave to second the motion.

The motion was then put and carried unanimously.

The CHAIRMAN: I may mention that Mr. Burge, Mr. Griffiths, and Mr. Oxenford, are all ordinary shareholders.

Mr. McLAREN SMITH: May I be allowed one word of explanation? I held up my hand against that motion, and the reason I did so was this: I think this company was formed, not as a trust company, but to carry out a very different object. That I believe the directors are not doing. When once they are doing so I shall be very glad that they shall be remunerated on a more liberal scale.

The CHAIRMAN: If any gentleman holding shares in any other company will come forward, we are prepared to exchange Globe shares with him, but we cannot force that upon the other shareholders, that is not our business.

Mr. McLAREN SMITH: You may invite them.

The CHAIRMAN: We have done that periodically, and are not likely to do that again, because the expression of feeling so far has been against it. As I said before, if we find that shareholders in other companies are anxious to exchange into the Globe, we shall be glad to receive them. I think I have taken some pains to-day to show you by figures and facts that the Globe Company, with the exception of the Submarine Company, stands at the head of submarine telegraph companies as to the value of its property. I have also said that the reason of that is because it gives additional security. Beyond that I have nothing further to say. The general body of the shareholders must judge for themselves; but, if they are prepared to come into the Globe, we shall receive them with the greatest possible satisfaction. I think that that terminates the business of the meeting.

ANGLO-AMERICAN TELEGRAPH.

The report states that the total receipts from January 1 to June 30, including a balance of 3,223l. brought over from the last acount, amount to 274,386l. The total expenses of the half-year, including income-tax and repair of cables, as shown by the revenue account, amount to 44,265l. The directors, under the powers conferred upon them by the articles of association, have, before declaring the net profits, set apart the sum of 75,000l. to the renewal fund, leaving a balance of 155,120l. One quarterly interim

54

OCEAN TELEGRAPH CABLES.

Speaking of relays leads us to think of cables. There is, however, not much interest to be derived from seeing cables, as nothing very new is shown. In the English department the Telegraph Construction and Maintenance Company and Mr. R. S. Newall show specimens. The former are probably the largest cable manufacturers in the world. Still a fair display is found in the French annex. The latest improvement in cable manufacture is the protection of the cable from the teredo by a brass tape wound spirally round the insulated core. M. Barron exhibits a roll of cable used in Paris after his design, which after sixteen years' service is as good as it was when first laid. The question of the life of a cable is unsolved, but we incline to the opinion that under favorable circumstances there is no reason why a cable should not last for 100 or 200 years.

THE JERSEY CABLE.—The fault in the Jersey Cable was localised on the 6th inst., and found to be distant about 300 yards from the Dartmouth ends. The fault was a nearly complete disconnection, the cable not giving earth. This is an unusual kind of fault to occur in a gutta-percha core, though a frequent one in india-rubber cables. It is anticipated that the cable will very shortly be through again to Jersey.

A SHORT cable from Darien to Doboy Island, the port for Darien, has been laid and opened for business.

A WEDDING was recently consummated by telegraph between a bride in Ohio and a bridegroom in Colorado. The lady took the next train for Colorado.

DR. MUIRHEAD, who has been delayed in his work by repeated toredo interruptions on the cable, succeeded in completing the duplexing of the Madras to Penang cable in a few hours after it was placed at his disposal. He will return home early in January.

A vote of thanks was passed to the Chairman and directors for their satisfactory conduct of the affairs of the Company, and the meeting then separated.

MEDITERRANEAN EXTENSION TELEGRAPH COMPANY (LIMITED).

The 42nd ordinary general meeting of the shareholders in the above company was held on Wednesday, the 21st inst., at the City Terminus Hotel, Cannon-street, under the presidency of Sir James Carmichael, Bart., chairman of the board.

The report of the directors for the half year ending the 30th of June stated that there had been a sensible improvement over the working of the previous six months. They recommended the payment of the usual 8 per cent. dividend on the preference shares, less income-tax, and of 3 per cent. on the ordinary stock, free of income-tax, payable on and after the 1st prox., carrying 471*l.* 13*s.* 4*d.* to reserve fund.

The CHAIRMAN, in moving the adoption of the report and accounts, stated the report informed them of everything which had occurred since the last meeting. With regard to the cable which was injured, it was the old original cable—the Alga-Grande cable. He thought it was injured about seventeen or eighteen miles from the Sicilian coast. There was no difficulty in repairing it; but, unfortunately, the steamers which belonged to the Eastern Company, of which they hoped to avail themselves, had been very much employed lately. In the meantime their traffic went by other cables. They did not lose anything by this interruption, but it was a question of delay. They hoped in a few weeks to get a steamer, when no doubt the cable would not take more than two or three days to repair. It had been raised, and, considering the time it had been down, he did not think it was in very bad condition. With regard to the reserve fund, and the conflicting claims of the ordinary and preference shareholders, they would recollect that at the last meeting a wish was expressed by the proprietors that they should take counsel's opinion as to the exact position of that fund, or whether it belonged to the ordinary or preference shareholders, or both classes. Accordingly, their solicitor drew a case, which was shown to counsel, going through the whole matter from the beginning. This was laid before Mr. Kaye, Q.C., one of the most eminent members of the Chancery bar, and he had given his opinion on the case presented, that the ordinary and preference shareholders would be entitled to divide the assets, including the reserve fund, *pari passu*. In this opinion the solicitor of the company coincided. It was clear, therefore, from this that the reserve fund belonged to both classes. At the same time, as he had explained before, it was a fund for the maintenance of the cable, and they drew on it from time to time for the renewal of their line, which, therefore, benefited both classes. He concluded by moving the resolution.

Mr. FIELD having formally seconded the motion,

Mr. ROBINSON congratulated the meeting on the improvement in the receipts, as compared with the corresponding period of the previous year, and on the increase in the reserve fund. He spoke of the advantages to the ordinary shareholders of amalgamating the undertaking with the Eastern Extension Telegraph Company.

Mr. JOHN GRIFFITHS acquiesced in the last remarks of Mr. Robinson; and, in the interest of the ordinary shareholders, he urged on the directors the necessity of coming to some arrangement with the Eastern Company.

Mr. YEARS thought a too gloomy view had been taken of the position of the company's affairs.

Another Shareholder advocated the policy of amalgamating the undertaking with some larger company.

The CHAIRMAN, in reply, at the close of the discussion, said he was certainly of opinion that the ordinary expenses of repairing their cable ought to come out of the half year's revenue. He could hardly anticipate what the cost of the present repair would be. Directly he heard of Cyprus coming under the protection of the British Government, he put himself in communication with the Treasury to see whether anything could be done for the extension of their system in the Mediterranean. He believed that nothing definite had been decided on as to who should have the telegraphic communication between Alexandria and Cyprus. As to the question of the amalgamation, they were always open, and since their last meeting he had been in communication with a proprietor in this company, who was also a proprietor and the legal adviser of the Eastern Extension, to see if anything could be done, and that gentleman had promised to consult with this company's legal adviser. He did not know, however, what the Eastern would do. He had heard that the company did not care to take them; but he quite agreed that it would be to the advantage of the company, and wise of them, to take them. When their solicitor returned, he would consult with him as to further communicating with Mr. Kaye, but he thought they might take it for granted that the result would be the same.

The report was then unanimously adopted, the dividends were declared, and the retiring directors and auditors were re-elected.

The meeting separated after passing a vote of thanks to the chairman and directors.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).

The fourteenth ordinary general meeting of the shareholders in this company was held on Monday, the 19th inst., at the offices, No. 61, Old Broad-street, under the presidency of Mr. Thomas Hughes, Q.C.

The report of the directors stated that for the half year ending the 30th of June the gross receipts had been 18,278*l.* and the gross expenditure 15,920*l.*, leaving 2,358*l.* to the credit of revenue account. The unusually large expenditure arose entirely from the cost of the repair of the Cienfuegos-Santiago section of the original cable, amounting to 12,602*l.*, the ordinary expenses amounting to 3,317*l.*, being rather less than usual. They considered that they were warranted in charging 5,575*l.* of the cost of the repairs to the reserve fund, and this sum, added to the balance of the revenue account, would admit, after providing for the preference dividend, of a dividend on the ordinary shares at the rate of 6 per cent. per annum.

The CHAIRMAN, in moving the adoption of the report, said the shareholders would, of course, expect to hear something about the repair of the cable during the half year, and he thought it would be interesting to them to know something of its history, that they might judge of its probable future, and of the consequent chances of prosperity to the company. The cable, then, was laid in April, 1870, and as early as October, 1873, the first interruption occurred. It was a very serious matter, and he thought that the comparison of the state of things then and now would be very encouraging to the shareholders. On the first occasion the interruption lasted over six months—up to April, 1874, during the whole of which the cable remained dumb, resulting in a total loss of traffic, as the company then had only a single cable. The cost of the repair, too, was over 20,000*l.* In consequence of that interruption, and of what occurred at the time, it was resolved to lay a second cable, and the results of that policy were seen on the present occasion. The cable was cut and landed at Cienfuegos in April, 1875, and had been duplicated all the way to Santiago; and by this policy the whole of their traffic had been saved. They had lost nothing at all in the way of business through the late interruption. Their officer on the spot had executed the repairs in a most satisfactory manner, and the whole cost had been £12,602. The work, too, was executed in forty-five days instead of six months. They were able to do this in consequence of obtaining the services of a vessel on the spot—he referred to the repairing ship belonging to the West India Company; and Mr. Keith had conducted the operations on board that vessel entirely to the satisfaction of the board, and, he thought, in a manner which would prove thoroughly satisfactory to the company in the future. He thought they might now consider that they had their duplicate cable in thoroughly good order. As to the question of what was the prudent way to deal with the state of things referred to, it was clear that this species of property could not be regarded as permanent—the "life" of a cable could not be reckoned to be anything like perpetual. In fact, experience hitherto had been that the "life" of a cable did not exceed, even if it came up to, ten years, and he had no doubt that all who were interested in such matters were aware that two of the Atlantic cables had been abandoned, and he did not believe that the "life" of these cables would be found to average ten years. The conclusion from this would be that it was necessary for every company desiring to conduct its business prudently to lay by a considerable portion of its earnings to a reserve fund to meet these contingencies. This had been the policy of the Cuba board from the first, and the proposal that day to pay a smaller dividend than they had lately paid arose entirely from the desire of the board to keep the reserve fund in an entirely satisfactory position. In their view it would not be in such a satisfactory position as they could desire it till they had sufficient reserve to enable them, if it became necessary, as it might, to lay a new cable from one end to another. Till this happy result was obtained, the Board would not cease to urge on the shareholders the necessity of providing a reserve fund of an adequate amount. They had received several communications from shareholders acquiescing in the prudent course suggested by the Board, and expressing their willingness to accept the temporary diminution of dividend recommended to-day. After reading one of these letters, the Chairman, in continuing, said he was very glad to see so many of the shareholders taking an interest in the company's affairs, as their doing so strengthened the directors' hands. He might state that they now had over 400 shareholders, whereas when they started he believed that they had very little over 100. He thought this was probably an evidence of the increasing confidence in the company. As compared with the corresponding half year of 1877, their receipts showed a falling off from 19,500*l.* to 18,300*l.*; but the Board saw no reason to regard this as any sign of a permanent depreciation. They considered that the diminution was accounted for to a very great extent by the large increase of the tariff charged by the West India Company, which had had the effect not of reducing the number of messages; but it had had the great effect of lessening the number of words of the individual message, and the consequence was the considerable reduction he had mentioned. Mr. Keith, he was glad to say—for that gentleman was an exceedingly competent officer—was thoroughly satisfied with the state of all the cables. That gentleman had just completed a very important work for the company's neighbour, the International Ocean Company, whose cables had been broken. An application was made to them for the services of Mr. Keith to take the control of this repair, and they were very glad to allow this. It gave their officer more experience in a very difficult part of the ocean for laying cables. It also strengthened the good understanding between the company and the International Ocean Company, and also allowed the latter to test and to prove the value of their repairing ship. He concluded by moving the resolution for the adoption of the report, observing that he hoped the shareholders would approve the wisdom of the dividend being only at the rate of 6 per cent. on the ordinary capital.

Mr. N. BANNATYNE, one of the shareholders, formally seconded the motion.

Mr. NEWTON asked for some information as to the investments, and the probable effect on the company of the new traffic to South America. Was their system, too, entirely duplicated? He could not believe, as he had heard stated at another company's meeting, that this company's cable was laid "in circles."

Mr. GRIFFITH said he appreciated the value of caution, but in the present circumstances and condition of the company, as referred to by the Chairman, he thought they were erring on the side of too great caution in the dividend recommended that day. He admitted that any temporary fault should be charged to the half-year's revenue, but the late interruption and consequent repair arose from their cable being laid, not in circles, but badly, and having got in circles afterwards. He thought the dividend might be increased from the reserve fund, which he thought would increase the value of their shares. The preference share had risen in an extraordinary manner, while the ordinary shares had not risen. This fact, he thought, proved that the public considered that the ordinary shareholders had burdens thrown on them which were hardly equitable.

After some remarks from Messrs. QUILTER and HOOPER,

The CHAIRMAN, in reply, said, as to the first question asked, they had 10,000*l.* deposited with the Chartered Bank of Australia, and a similar amount with the Bank of New Zealand, and 4,000*l.* in Six per Cent. Debentures of the West India and Panama Company, which had been handed over to them as a compromise of the cross claims between the two companies. Their system was practically duplicated throughout the submarine portion which belonged to the company, was duplicate over the whole system, from Cienfuegos to Santiago, which was more than four-fifths of the system, and which included all the deep water. From Batabano to Cienfuegos their own submarine cable was single, but the Government lines were all running now. Their cable was certainly not laid in circles, but as direct as possible between the two points. All the unsatisfactory portions of the cable, as originally laid, had also now been cut out. He did not think there was much chance of the southern extension being made within any short time, but when it was it would add considerably to their traffic. He did not think it would be judicious to trench farther than they proposed on the reserve fund—to pay the dividend of 6 per cent. they were going to charge the reserve fund with 5,575*l.*

The report was then unanimously adopted, and the preference dividend at the rate of 10 per cent. per annum, and the dividend on the ordinary shares at the rate of 6 per cent. were declared.

The retiring director, M. Joaquim de Mancha, and the auditor, Mr. James Cowan, were re-elected, and a vote of thanks to the chairman and directors brought the proceedings to a close.

TELEGRAPH SHARE LIST.

COMPANIES.	CLOSING PRICES AUG. 21.		BUSINESS DONE WEEK ENDING AUG. 21. Highest.	Lowest.
Anglo-American	61½,	2	61¾	61
Do. Preferred	91,	2	91¼	90½
Do. Deferred	31½,	5	31¾	31½
Black Sea	2,	3	—	—
Brazilian	6½,	7	—	—
Cuba	9½,	10	7	6¾
Do. Ten per Cent. Preference	16½,	17½	9¾	9½
Direct Spanish	1	¼	—	—
Do. Ten per Cent. Preference	9½	10	9½	9½
Direct United States	13½,	¾ x d.	13¾	13
Eastern	7½,	¾	7 13-16	7 11-16
Do. Six per Cent. Debenture	106,	9	—	—
Do. Five per Cent. do.	100,	2	101½	101½
Do. Six per Cent. Preference	11½,	¾	11¾	11½
Eastern Extension	7½,	¾	7½	7½
Do. Six per Cent. Debentures	106,	9	—	—
German Union	8½,	¾	—	—
Globe Telegraph and Trust	5½,	¾	5½	5 5-16
Do. Six per Cent. Preference	10½,	11½	11	10¾
Great Northern	8½,	¾	8½	8 7-16
Indo-European	20½,	1½	21	21
Mediterranean Extension	3,	¼	3 1-16	3 1-16
Do. Eight per Cent. Preference	9½,	10½	9½	9½
Reuter's	10,	11	10½	10½
Submarine	228,	233	—	—
Do. Scrip	2½,	¾	—	—
West India and Panama	2½,	¾	2 7-16	2½
Do. Six per Cent. Preference	8½,	9	8½	8½
Do. Six per Cent. 2nd Preference	8½,	¾	—	—
Western and Brazilian	4½,	¾	—	—
Do. "A" Debenture	[illegible],	6	—	—
Do. "B" Debenture	91,	4	—	—
West. Union 7 p. Cent. 1st Mortgage	114,	18	—	—
Do. Six per Cent. Sterling	102,	4	—	—

56

An Improved Method of Carrying Underground Telegraph and Telephone Lines.

One of the most practical steps towards meeting the requirements of underground telegraphy, has been taken by the National Underground Electric Company, whose pipe line system for carrying wires and cables for telegraphic and telephonic purposes we describe and illustrate in the following.

The plan of this organization is novel, in that it does not propose to lay and operate telegraph or telephone lines of its own, but simply to furnish the existing telegraph and telephone companies with their underground pipe line, capable of accommodating any desired number of wires, and to keep and maintain the same in good working condition, for a term of years, under properly executed leases or contracts, the company expecting to derive its revenues from a system of rental based upon a certain schedule of charges per mile of wire. This plan is free from the impracticable features of some of the methods of underground telegraphy that have lately been proposed, in that it does not bring its advocates into conflict as business rivals with the existing telegraph and telephone companies, and is not committed to the use of any particular mode of construction, preparing and insulating wires or cables, but, on the contrary, proposes to accommodate all comers with the facilities for conveying their lines underground.

We have thought this preliminary explanation of the nature and objects of the company necessary, for the reason that we, as well doubtless as many others, have at first been misled by the name of the organization into the belief that it was an underground telegraph company. From the foregoing remarks, our readers will understand that it is a pipe line company for affording telegraph and telephone companies facilities for carrying their lines underground. With these explanations, we proceed with the description of the special plans of the company, which are protected by several letters-patent of the United States.

The method of constructing the pipe line is as follows: Cylindrical pipes of terra-cotta are made, perforated lengthwise with numerous small holes, forming continuous tubes, covered with a vitrified glazing on the outer and inner surfaces. The pipes are designed to be laid end to end underground, and firmly cemented together (this being easily accomplished, the pipes having a bell or socket on one end of each), thus making a continuous line of terra-cotta pipes, through which the wires or cables are run. The construction of these pipes is shown in Fig. 1. These are laid in sections, and at convenient distances excavations are made in the ground and carefully bricked and cemented up, thus making an underground water-proof chamber between each section (such sections being of any desired length), by which system of underground chambers, in connection with the conduits, the wires can be withdrawn and replaced at will, and the number decreased or increased as required for any purpose, without digging up the streets, which has been strongly urged as an objection to the underground telegraph in cities. As the pipes are laid, small wires are placed in the holes, all the wires in each section ending in the sunken chambers. The design of this is to enable the workmen in the chambers to draw the cable or bundle of wires through the perforated blocks, by means of a reel, as fast as needed.

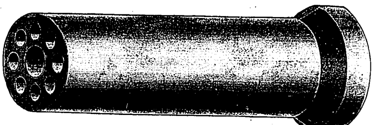


Fig. 1.—Perforated Terra-Cotta Pipe for Underground Telegraphy.

Fig. 2 is a section showing the pipe line in position, and the method of drawing the wires through the same.

When a section is laid and ready for use, a rubber pipe or hose is drawn through the holes in the pipes, and in this the insulated cable is placed, thus encasing it in a vitrified terra-cotta pipe, lined with rubber—a threefold protection against the dampness of the earth. The different kinds of wires may be completely separated, while a small pipe may carry a thousand wires without inconvenience. Branch lines will be laid to offices and buildings, by pipes laid under the pavements, from the chambers at the ends of the sections. These chambers are designed to be covered when not in use, and will not interfere with street traffic. The company claim that their system is much cheaper than any hitherto proposed, and it certainly has the merit of removing the wires from the streets and house tops, and at the same time preventing the continual tearing up of the roadway to lay new cables or repair old ones, which is a grave objection to other systems. By this system, there is no danger of our telegraph, telephone and other wires being broken down and communication interrupted, as was the case during the last winter on several occasions, and for days, thus entailing great loss on the business community.

The company claim for their pipe line system a number of advantages, of which the more prominent are named below: Efficient protection against ground moisture, which would affect the insulation of the line wires; the great facility which it affords for handling the wires or cables, either for introducing new ones or withdrawing or repairing the old ones; the complete avoidance of the objection of disturbing and tearing up streets and pavements to meet the demands for additional wires after the line is once laid; the fact that they propose to accommodate all comers with facilities of an underground conduit for all kinds of wires and cables; and the provision of separate chambers for wires of different lines.

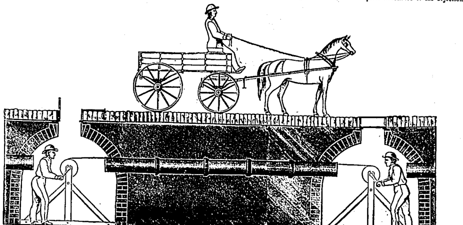


Fig. 2.—Section of Pipe, with Testing Stations, Showing Manner of Inserting Wires. These Testing Stations may be any Required Distance Apart.

From the above description, the company's system would appear to be as simple and efficient as any that could well be devised, and it certainly answers many of the objections that have been advanced against the underground telegraph in cities. When once laid down in the street, it is there for good, and capable of accommodating any reasonable increase in the number of wires that will be likely to occur for years. The material of the pipes is practically indestructible, which cannot be said of lead or iron under the same circumstances; and the means provided for manipulating the

and there is every reason to be proud of the success obtained. Similar experiments were made on the same day by different eclipse parties, among them that from the Smithsonian Institution, composed of Professor Newcombe, of Washington; Professor Young, of Princeton; Professor Langley, of the Alleghany Observatory, and others. According to telegraphic despatches the success was complete, but we must wait for further details before we can give the exact results.

STUDENTS' COLUMNS.

FRICTIONAL ELECTRICITY.—A NEW ELECTROSCOPE.

The form of electroscope now described was devised by me a few months ago.

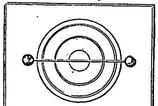
It seems remarkable that frictional electricity is not more studied. There is ample room in this field of electrical research for new discoveries.

The following is a brief outline of the construction of the instrument illustrated:—

The diagram is a plan of the electroscope. The stand of the instrument may be made of wood, brass, tin, or even stout card board. It is essential, however, that the stand of the instrument be weighty.

The arrangement looks neatest, as shown in the diagram, viz., circular. Fixed to the centre of the stand is a thick stick of sealing-wax, or a glass leg coated with shellac. This leg, as a matter of course, is at right angles to the plane of the stand of the electroscope. The length of this insulator need not be more than eight or ten inches. The dotted circle shown in the centre of the diagram, illustrates the position occupied by the insulated support. To the top of this support is affixed by sealing-wax a short pointed wire about one inch long.

The upper portion of this electroscope is made to rotate.



LOUDON ELECTROSCOPE

Resting on the insulated leg, and supported by a "cap," is a rod of light, dry, and straight wood. This part of the electroscope need not be any stouter than an ordinary penholder, the object being to have it as light as possible, attached to the ends of the rod is a pair of round balls.

The introduction of balls on electroscopes is to me a new feature. I have never seen such an arrangement mentioned in any of the text-books that fall into the hands of electrical students. Therefore, I have thought fit to name the electroscope as seen in the diagram.

Having given a general outline of the construction of the instrument, I will deal with its

Action.

a. If a positive (+) glass rod be brought *near* one of the balls, the electricities on the rotating part of the electroscope immediately separate; the ball then moves towards the + rod. This at once induces polarity in the electroscope.

b. Carry in front of the ball the + rod, and you will cause the electroscope to rotate on its axis many times. This is caused by the − E following the + E.

c. Let the moving portion of the electroscope come into contact with the + rod, and a new state of things is the result. The electroscope now no longer follows the path described by the + rod, but appears at once stationary. If the + rod be moved at this moment from off the rotating piece of wood, and then brought near to one of the balls, the moving system goes backward. This is owing to the + rod combining with the − E that resided on the electroscope, consequently repulsion at once occurs.

d. Laying down the + rod when the motion of the electroscope is showing the dual force of electrity, and taking up a rod of brass, or any conducting substance, bringing the conductor near one of the balls of the electroscope, attraction is manifested.

e. Let the instrument return to a neutral state. Excite your rod and bring it near one of the balls. Keep the ball revolving af[ter] the + rod, taking care that the balls *never* come in contact wi[th] the rod. By so doing, the moving portion will soon show sig[ns] of independency to the + glass rod. When the electrosco[pe] ceases to follow after the rod at this stage of action, on brin[g]ing the rod *near* one of the balls at the moment, they wand[er] backwards as before, yet contact has never taken place.

A dielectric may be suspended and carried in front of t[he] rotating balls. The same phenomena in this case takes plac[e]. Induction here turns a corner, or is exerted in a curved lin[e] which cannot be accounted for in any other way than supposin[g] the air between the glass rod, and the balls serve as a mediu[m] for the transmission of the rod's electrical action.

With this instrument Government teachers could illustrate a great part of the frictional branch of this science at little cost.

This instrument claims to show:—

1st. Electric polarity. (See *a* and *b*.)

2nd. Dual force of electricity, shown by the backward motio[n] of the balls. (See *c*.)

3rd. A tendency for the fluids to recombine, or a + body fo[l]lowing after a neutral one. (See *d*.)

4th. Electric induction manifested, showing similar results [on] contact. (See *e*.)

This instrument also serves as a ladder in understanding [the] theory of lightning conductors. By inserting a fine-poi[nted] wire into each ball, letting the end of such point freely into [the] air, the above experiments are rendered impossible.

Heworth. RALPH LOUDON

ANGLO-AMERICAN TELEGRAPH COMPANY, LIMITED.

Proceedings of ordinary general half-yearly meeting of the Anglo-American Telegraph Company (Limited), at the Cannon-street Hotel, 2nd of August, 1878, the Right Hon. Viscount Monck in the chair.

The SECRETARY (Mr. John Grant) read the notice convening the meeting and the minutes of the last general meeting.

The CHAIRMAN: Then, gentlemen, I presume you will take the Report as read, and it becomes my duty, in conformity with the practice on such occasions, to propose to you that the Report of the Directors be received and adopted, and, in doing so, to endeavour, as briefly as I can, to give you, as our constituents, an account of our proceedings during the last half-year. Gentlemen, in reference to that subject, the principal topics, in fact the only topics which are of very much interest, are the state of your property as regards its efficiency and preservation, the amount of income which we have received during the half-year, and the moneys which we have been obliged to pay for the receipt of that income. Well, gentlemen, with respect to the condition of the cables, one of the first paragraphs in the Report anticipates all that I have got to tell you on that subject. The three cables with which we have been operating during the past two years are in perfect order and doing our work as well as it could possibly be done. With regard to the receipts, you will see that the receipts of the last half-year are somewhat less than those of the preceding half-year; but, on the other hand, they are very large receipts in comparison with what we have had in previous half-years. The second half of the financial year has always, according to our experience, been the better half; and, therefore, the 260,639*l*. receipts of the past half-year, we may confidently expect, will be increased during the approaching half-year. Now, gentlemen, I think that is a very encouraging state of things, considering the circumstances under which this income has been received—in the first instance, though we have happily got rid of hostile competition—and I see my friend opposite, who is now a very friendly member of our company instead of being chairman of an opponent company—and we are working on the most perfectly amicable terms, still we have been obliged, as you all know, to give up a certain share of our receipts to our friends and partners, the Direct Cable Company. Well, notwithstanding that, we are taking as our share what enables us to pay a substantially good dividend on our whole stock. Well, gentlemen, I am not going to weary you by repeating what you have heard for the last three or four years at every meeting of shareholders in industrial enterprises which has been held in the city of London. I will not weary you by dilating on the depression of trade that has had an injurious effect on our enterprise, as well as that of all other industrial enterprises in the country. We may hope, I trust, that some of the causes, at all events, which caused that depression have been happily removed—the dread of war, and that sort of thing; and we may hope that the pressure of that depression will, to a certain extent, before long cease, and, I hope, soon entirely disappear. And I think it is almost a matter of certainty that if we have been enabled, with the effect of that depression operating upon us, to take so good an income as we have done during last year, we shall be enabled, when that depression ceases, largely to increase our receipts. Gentlemen, I think the state of our receipts, even under the depressing circumstances to which I have alluded, bears out what I have always stated as my opinion in our dealings with the Direct Cable Company before we came to agreement. I mean that I always maintained that there was room enough in the Atlantic for both of us to make a good profit. I believe that the longer we live and the more we continue to carry on our trade, the more convinced we shall become of that fact. Therefore, I think there is no cause for depression with regard to the future. I believe we have seen the worst; we are likely to meet with, and that in the future we shall improve our prospects and improve our receipts. Well, gentlemen, so much with regard to the income of our Company. Now, with regard to the cost to which we have been put. You will find on a reference to the report that the cost of working the Company for the past half-year has been 44,265*l*. Now, that includes an item of 11,000*l*. for the repair of cables, and we contributed, towards the repair of cables, [illegible]

59

THE PROSPECTIVE PERMANENCY OF SUBMARINE CABLES.

At the recent general meeting of the Globe Telegraph and Trust Company (Limited), which we reported in our last issue, the Chairman touched upon a point which is of the greatest moment to shareholders in submarine telegraph enterprise, and which is of scarcely less interest to electricians and telegraph engineers. "I know there are gentlemen present," said Mr. Pender, "who believe that an Atlantic cable may be made to live for all time; I only wish that proposition could be fairly established—because if it were fairly established the advantage to telegraph engineers would be something enormous. . . . I trust that science will be able to effect what we hope!"

Whilst disclaiming any pretension of adequately treating, within the limits of a single article, so large a question as that involved in the accumulated evidence bearing upon the permanency of cables, we may briefly consider, at least suggestively, whether there are any conditions under which we may reasonably conclude that a cable would remain electrically perfect for an indefinite period; and, if so, whether these conditions—mechanical, electrical, and chemical—are practically attainable with any degree of certainty, or approachable under a conjunction of favourable circumstances. It is now seventeen years since the Joint Committees of the Board of Trade and the Atlantic Telegraph Company recorded their opinion, based upon the voluminous evidence laid before them, that "the failures of the existing submarine lines had been due to causes which might have been guarded against." We have to inquire whether the same verdict is applicable, in some less degree, to recent failures—one of which, that of the 1866 Atlantic cable, would appear to be as final as that of the 1857 cable, albeit it was long deferred, and is happily less overwhelmingly disastrous than the first venture of the Atlantic Company?

In regard to the first point which suggests itself, that of the chemical stability of the insulating material when submerged, we think every electrician will endorse Mr. Pender's opinion that the gutta-percha of the 1866 cable is now as perfect as on the day it was first put down. We know that in air, more especially when exposed also to light, gutta-percha absorbs oxygen and becomes partly converted into a brittle resinous substance, soluble in alcohol and in dilute alkaline solutions. Only one other chemical change, so far as we are aware, has been noticed in this material—viz., that occurring in ground containing tanno-gallic acid from oak trees or posts, and due probably to the action of a minute fungus. Signs of electrolysis, by the action of a high electromotive force, may, no doubt, be exhibited; but, even in the case of a thinly-coated wire, no appreciable alteration either of the copper or of the insulator can be produced through it, under the conditions of practice, excepting at those points where the continuity of the gutta-percha is more or less defective, or, in other words, where "faults" may be detected. In regard to submerged gutta-percha, we have the evidence of Sir S. Canning that the material was found quite perfect when the Dover-Calais cable, laid in 1851, was raised for repairs in 1859; the subsequent evidence has all been in the same direction, and we believe nothing has occurred to negative the opinion of Mr. Willoughby Smith that the gutta-percha of a submerged cable is, chemically, quite permanent, and "will last for ever."

The next point which occurs to us is the liability of the insulator to damage from the attacks of marine organisms. Amongst these, the *xylophaga*, a bivalve shell fish, and the shipworm, or *teredo*, have the worst reputation; for, although their ravages are mainly confined to the hemp which surrounds the core of cables, there is positive evidence that the former, at least, has in certain cases actually attacked the gutta-percha. We do not know of any case, however, where a failure of insulation has been traced to these organisms; their attacks being quite superficial, in the form of an elongated groove. Moreover, they do not appear to exist in any very great depth of water; so that in the case of deep-sea cables they may be altogether left out of account. The same applies also to the sun-fish, which, in one or two cases, is said to have damaged the insulation of cables by means of its caudal spines. Still, even in the case of deep-sea cables, some kind of permanent protective sheathing appears to be desirable; and we believe that special attention is now being given to this matter.

We may now consider the insulating material from an electrical point of view. And here we would most strongly insist upon the necessity, in the case of deep-sea cables at least, of the most scrupulous care to prevent any fault, however minute or incipient, being left in the cable at the period of its submersion. It may be said that scrupulous care is, at the present day, in most cases exercised; we would reply, that in our opinion it might be augmented—though perhaps at the cost of considerable delay and additional expense. We would incur this delay and expense to secure an electrically faultless cable; and, with this object in view, we would if necessary augment the ratio of the weight of insulating material to that of copper, or otherwise increase the dielectric resistance. Probably we cannot do better, under this head, than give a suggestive quotation from the Report, dated the 21st February, 1876, of Sir W. Thomson and Mr. F. J. Bramwell to the directors of the Direct United States Cable Company (Limited).

After observing that the tests applied proved the great care that had been taken in the manufacture of the cable, they state that "The laying of the cable was also conducted with the greatest care, so as to avoid leaving in it any discoverable fault of insulation, however minute. On these occasions, while engaged in the deep-sea portion of the cable, its egress was stopped on account of faults, which were very minute; two of these were hauled back and cut out on board the ship, while the third was cut out and left at the bottom. The two which were brought back have been marked with two notches and three notches respectively; these we have carefully examined, and we find in each case the fault consists of a single exceedingly small airhole through the gutta-percha—a hole so small as to be barely visible to the naked eye. On cutting down through the gutta-percha to the copper core, we found the wires composing it to be altogether undisturbed and unchanged, and to be perfectly central in the gutta-percha, thus showing conclusively that the holes were not produced mechanically by puncturing inflicted by the wires of the copper core itself. There can be no doubt from their appearance but that the holes were produced in the course of manufacture by minute quantities of air, which had been left in the compound before applying the gutta-percha."

It is easy, in the light of past experience, to trace the consequences of submerging a cable with a few even of such minute faults or weak places. After a time, the worst of these becomes considerably enlarged, the leakage through it acting to some extent as a protection to the others; the cable is raised and this fault cut out, and subsequently the next in magnitude behaves in the same way. And, though we have heard a great deal as to the certainty with which deep-sea cables can be picked up and repaired, there is, unfortunately, a considerable amount of evidence in the other direction.

Other important points are the nature of the sea-bottom and the direction and character of the surface currents. Whilst we admit that the safest locality for an electrically perfect cable is undoubtedly a level *deep* sea bottom, we can but take a gloomy view of the chances of permanency in the case of a cable laid on a sea bottom like that which prevails on some portion of the route of the direct Lisbon cable. Here we can but look wistfully towards the hydrogaphers and nautical men who have already rendered signal service in deep-sea telegraphy. Can they, by the exercise of the same amount of scrupulous care as is demanded of the electrician, guard us against the dangers of the rugged deep, and avoid the graceful but deadly festooning of the cable from edge to edge of the rocky chasms, of which the existence in some cases can scarcely be doubted? We can only suggest that—in the absence of surface currents, and of any necessity for "laying-to"—the most suitable cable for such a rough bed would clearly appear to be one having a specific gravity but little superior to that of water, any iron sheathing being a source of weakness rather than strength. And, in relation to this sheathing, we would submit as a logical conclusion that, in the case of an electrically-*perfect* cable, laid over a level *deep*-sea bottom, any mechanical strength above what is required to secure safety in handling and laying the cable would be superfluous, and, probably, also detrimental. And, believing, as we do, that an electrically-perfect cable is practically obtainable, we look forward to the period when the raising and repairing of deep-sea cables may be regarded as a contingency no longer to be provided for—a remedy the means for which has often brought about the disease it was to cure.

Far different is it in the case of shore-ends, and in that of cables to be laid in shallow water and even in moderate depths. Here, we admit, experience is all in favour of heavy armour, and the necessity for raising and repairing cannot be avoided. Nor is it a necessity which, whilst our great submarine companies are provided with well-appointed repairing ships and skilled engineers, need be attended with any great anxiety or risk.

In conclusion—for our present space is limited—the conditions of absolute permanency in a cable appear to us to be summed up in two points, viz.:—1st. Perfect freedom from electrical faults; and, 2nd, a deep and level sea bottom. Both these conditions are, we think, practically attainable in the case of an Atlantic cable—excepting, of course, as regards the shore ends, the occasional failure of which would not endanger the deep-sea portion of the line. On some other routes, also, these conditions may, we have no doubt, be realised by the combined efforts of the electrician and the hydrographer. In shallow waters, a comparative permanency may be obtained through the adoption of the most effective means for raising and repairing the cable, one of the most important points being the protection and preservation of the iron sheathing. There remains, we fear, a considerable residue of cases where the second condition is unattainable, and where no aid is to be derived from this sheathing. Here the element of certainty appears to be entirely wanting, and a relative permanency is attainable only by a conjunction of fortunate accidents. Yet even here, under the almost prohibitive condition of a deep and rocky sea-bottom, there are important problems to be solved; and possibly much may be done by the association of the hydrographer and the telegraph engineer.

Anglo-American Telegraphy.

The subject of Anglo-American telegraphy is again occupying the attention of some of our contemporaries, who appear to think that above all things it is necessary that English shareholders should provide, at their own cost, the blessing of cheap telegraphy. It is even hinted that it is not improbable that a new company may be started in New York "to be brought out here;" in other words, that the formation of another enterprise, such as the Direct United States cable, may be attempted. A council of "traders and merchants of New York" will probably move that "cheap telegraphy would be of advantage to the merchants and traders of this city, that American capitalists have not hitherto invested any money in these undertakings, and do not intend to do so, resolve, therefore, that English shareholders be afforded an opportunity of doing for us what we decline to do for ourselves." When any such proposal is submitted to British investors they will probably remember the history of the Direct United States Cable Company formed about three or four years ago, for providing precisely the same blessings and under the same kind recommendations, and that that company was only saved from absolute ruin by being taken over by the company whose rival it was intended to be. After great disappointment and delay the cable of the Direct Company was laid, but the shareholders never received any dividend, and the majority of the shares were disposed of at a discount of about 50 per cent. There are large claims still outstanding against the company on the part of contractors and others, and it will be some time before the shareholders, even under the present arrangement, will receive any return on their money. What reasonable pretexts or prospects can exist for the formation of another company for carrying out this "desirable" object those who invested their money in the Direct Company will have peculiarly favorable data for judging.—*The Railway News.*

We learn from the *Journal of the Telegraph* that a project is on foot to connect Cape San Antonio, Cuba, with Guatemala by submarine telegraph, and that concessions have already been obtained in Honduras and Salvador.

The short cables from Newark to Heligoland and from Trinidad to Demerara are interrupted. Para is reconnected to Pernambuco on the south, but no attempt has of late been made to restore communication with Cayenne and Demerara on the north.

Feb 79

The Cape Cable.—The Eastern Telegraph Company have offered the Government the 1,400 miles of Australian cable now shipped, but the Government refused the guarantee against accident which the company stipulated for, and the negotiations were broken off. The India Rubber Company have offered to make and lay a cable within this year.

Public complaint has been made of the errors in the names of the killed and wounded in the Zulu war, as telegraphed from St. Vincent.

Apropos of the Cape Cable, our French contemporary *L'Electricite* calls for cable communication between France and her colonies of Senegal and New Caledonia.

Oct 76 Anglo-American Telegraph.

The announcement made a few days since to the effect that no further attemps will be made this year to raise the 1865 cable, which, upon being grappled, was found to be unsatisfactory, will probably have a useful deterrent effect in damping the ardor of those who are so eager to witness an active competition of ocean telegraphy. If the 1865 cable be as unsatisfactory as it is reported to be, it is obvious that any new company possessing only one cable cannot afford to indulge the public with the luxury of cheap telegrams, as the amount of reserve which must be set aside to provide for renewals of cable would make very large inroads upon net profits. A cable which costs something like £1,000,000 before it is laid across the Atlantic, and which lasts only ten years, will require nearly 10 per cent. of its cost to be set aside every year, and the whole of the earnings of a single cable carrying messages at 1s. per word—as suggested by some very sanguine persons—will hardly suffice to provide the reserve fund, to say nothing of dividends for the shareholders. The bitter experience which the investors in the Direct United States Cable Company have purchased so dearly will make investors more cautious in the future, of entering into an undertaking which is recommended to them as competitive rather than necessary or remunerative. The shareholders in this company having paid £20 for their shares have eagerly availed themselves of the opportunity of selling them at about 50 per cent. discount, leaving the purchasers to compete or combine as they think conducive to their own interest. A great deal of silly talk has been indulged in at the enormity of the conduct of those who bought up the shares of the Direct Company for the purpose of carrying into effect a working arrangement between that company and the Anglo-American; but if it was deserving of censure to buy these shares, those who sold cannot be wholly blameless in the transaction.

If there were no sellers there would have been no buyers. The fact that the holders were willing to sell their shares was evidence that they had grown weary of a competition which, after three years of repeated disappointment and constant anxiety, had left them without reasonable prospect of a dividend. The experience thus obtained will not be lost upon those who may, at some future day, be asked to join in the Anglo-American telegraphic competition; but, if they should be disposed "to listen to the voice of the charmer," it may be well to remember that the cable laid in 1865, portions of which have been raised, is in an unsatisfactory condition, and except for the value of its core, will probably not again be disturbed in its ocean bed.

With respect to certain threatened proceedings by the Atlantic and Pacific Telegraph Company against the Direct Cable Company for the heinous offence of combination with a similar interest, it is curious to observe that by latest advices the intended plaintiff company has adopted a precisely similar policy to that against which it was to be used in opposition. Arrangements have just been completed for a *fusion* of interests between the two remaining American companies, and the Western Union will be left virtually in undisturbed control of the telegraphic business of the United States, it having been resolved to "pool" the earnings in the proportion of ⅞ to the larger company, and ⅛ to the Atlantic and Pacific Corporation. It will thus be seen that the movement in which the latter company was to be made the cat's-paw falls to the ground.—*The Railway News.*

The Success of Submarine Telegraphy.

It is only twenty years since the first attempt was made to lay a deep-sea telegraph cable across the Atlantic; and the oldest Atlantic cable now in use is only fourteen years old. There are now no less than six cables from Europe to North America; one from Europe to South America; two running the length of the Mediterranean, the Red Sea, and across the Indian Ocean to Bombay; one extending from Madras to Port Darwin, one from Sydney to Wellington, and many others of less length in different parts of the world. There are probably not far short of 100,000 miles of deep-sea cable laid and in daily working in all parts of the world; and an additional 20,000 miles are projected, and likely at no distant date to be actually put into operation. These figures alone are sufficient to dispose of any doubts as to the success of this branch of modern telegraphic engineering. When we consider the difficulties to be contended with in the construction and maintenance of a deep sea cable, this success is the more surprising. A thousand theoretical dangers may be suggested which would be likely to interfere with the effective working of a solitary line, lying miles deep, far from human ken, on the bed of the mighty ocean; and yet, as a matter of fact, interruptions are of rare occurrence, and cause, thanks to duplicate routes, little inconvenience to the general public. With all the difficulties and delays of re-transmission through alternate lengths of land wire and of submarine cable, a message may be sent to the Antipodes and its answer received in little over twelve hours. Mishaps must, and do, occur at times; but they are actually less frequent than the disasters to lines laid overland, for even "land lines" are not free from risk. To say nothing of the effects of hurricanes and thunderstorms in temperate climes, the elephants, monkeys, white ants, and other kinds of tropical fauna in uncivilized lands, would seem, if possible dangers were always realized in practice, to render the life of an overland telegraph line very precarious. But fortunately submarine dangers may even be guarded against. The "shore ends," which are liable to damage from friction against the shingle or rocks of the coast, or to be picked up, fractured, or otherwise injured by the anchors of passing vessels, are protected by heavy coats of thick wire. The Atlantic cables are exposed to the danger of, and have even now and then been broken by, the grounding of huge icebergs, which have crashed along the shallow shore, and broken even the thick iron-bound cylinders to which the shore ends may be compared. But such violent "wear and tear" is not usual, though other dangers naturally suggest themselves. Reposing on the deep bed of the ocean,

January 10, 1879] JOU

free from the disturbing influences of wind and wave, the thin black line is liable to the attacks of various enemies which may bore through the comparatively soft covering, and expose the delicate copper wire to earth contact. In the Arctic and Antarctic regions narwhals may pierce the gutta-percha while routing about for their food, while in the tropics swordfish and sawfish are equally likely to inflict similar injury on the cable. The Penang-Singapore line has been once interrupted by the blow from the toothed beak of a sawfish, which ripped open the outer sheath and fractured the internal wire. The heat of the tropics alone would be thought to be sufficient to interfere with the effective working of deep-sea cables, the gutta-percha covering of which is rendered soft and easily penetrable by the great warmth of the water. The active enemies of the lines might then find their work of destruction easy, but, in fact, the insects of which we have heard so much of late generally content themselves by scooping shallow channels along the surface of the gutta-percha, which they do not find to their liking. Even such dangers can be obviated by coating the cables laid in warm water with a solid metal sheath, which will protect them from all injury. We have referred to these possible enemies of submarine cables to show that they exist more in imagination than in fact; the improvements effected in the manufacture of the cables render them proof against nearly every kind of enemy. Temporary delays do occasionally occur, but even these may be obviated by securing duplicate routes in every case.—*The Colonies.*

Cables. Jan 79

In a letter to the *Times* Mr. Richard Herring contends that the duplex system does not double the working capacity of the wires; that the longer the wire the more "steady" must be the sending; that on so long a cable as that of the Anglo-American very little more if as many as half the number of words extra as are now transmitted "single" will be possible when the cable is balanced for "duplex" sending. In reply to the letter of Mr. Herring referred to, Sir James Anderson writes to contradict the statement that, under the duplex system, no greatly increased power is obtained. He says: "Upon our Marseilles-Malta cables, a distance of 825 miles, we are to-day working simplex fifteen words per minute, duplex twenty-six words per minute. As far back as March, 1877, the working increase of speed upon our Bombay-Aden cable, which in electrical capacity about equals the Anglo-American cables, was 40 per cent. Upon the Aiden-Suez cable, a distance of 1,460 miles, the increase was 60 per cent., and upon the Marseilles-Malta cable at the same date the increase was 71 per cent. To-day Marseilles-Malta averages 84 per cent. increase in regular working. Upon our Bombay-Aden cable the first day duplex was established, the increase was 40 per cent., on the second day, 67·27 per cent.; and on the third day, 72·72 per cent. I have not at hand any more precise data; but I am within the mark when I assert that we can command a steady increase of 70 per cent. in favor of duplex over simplex upon all our long sections, and that we can as a *tour de force* upon our short sections between Marseilles-Bona and Malta-Bona reach 100 per cent. increase."

CABLE SIGNALLING.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I have read with great interest the letter of Richard Herring, Esq., on "Submarine Telegraphy," published in your paper of 21st ult. His treatment of the subject is purely scientific, and free from theory; and it is to be hoped that the obvious conclusions which he has drawn from the well-established facts in regard to the movements and effects of electric currents will lead to the utilisation of those facts, so that the *maximum* speed of transmission of signals through long submarine cables will be obtained; and thereby greatly increase their working capacity, and necessarily their profits, and perhaps justify the companies to reduce their tariffs.

Paragraph No. 16 of his letter gives the welcome information that he has a device to so utilize the well-established facts as to produce the great result, that is, the maximum speed of transmission.

It is sincerely to be wished that he is not deceived as to the practicability of his "device," and that he does not give to us hopes that may soon be disappointed, like many of those promises of the *great* and *modest American Inventor!!!* who announced in the newspapers that he had discovered the means to render noiseless the movement of trains of waggons on the elevated railroads in New York City, which noise, one of the New York newspapers with becoming gravity announced, was to be bottled up by the great discoverer, and to be sold to the Government to be used as fog whistles on the sea coasts. The facts stated by Mr. Herring are not theoretical deductions, but well established and uncontroverted facts, and there certainly cannot be any room for correction of his statements. The causes assigned for some of those facts, namely, for the differences of duration of charge, and of discharge, are purely *theoretical*, and may or may not be the true causes; nevertheless, the facts remain established.

It must be a matter of great astonishment that those facts, so well known, and upon which all the known systems of telegraphy are based, have not been applied in such a combination as to obtain the great result. The very fact that no such result has been obtained must suggest to everyone great doubts as to its practicability. The means capable of producing this result are so clearly demonstrated by those well known facts themselves that it really seems a wonder why no device to use these means has not long since been discovered; and the failure hitherto to make such a discovery almost forces upon the mind the conclusion that it is an impossibility. It may be, however, that science will show that this is not impossible, as it has so many other things which but a few years ago were deemed impossible.

While I will not presume to suggest even any correction of the statement of facts by Mr. Herring, I beg to submit a few remarks. In paragraph No. 14 Mr. Herring states:—

"When a conductor has received a charge of one kind of electricity, and is then put to earth at both ends, and also a charge of an opposite kind of electricity is sent into it from both ends, the conductor is restored to its neutral state in a duration of time not longer than that of the charge, whatever this latter duration may be."

This certainly is not a theory, but is a self-evident fact; but the great problem has been how to arrange to send at the proper time the opposite kind of electricity into the cable at the receiving end. That accomplished, the great result is obtained, and with impatience we await the promised disclosure of the device, and with sincere hopes that it may prove to be successful.

From reference in Mr. Herring's letter to "marks in special paper" I infer he employs on his receiving instrument paper saturated with some chemical solution. I believe that of all chemical solutions that of iodide of potassium is the most sensitive to the electric current, but its use has, I believe, been abandoned because of the evanescent quality of the marks. It would, no doubt, be a great *desideratum* if those marks could be made permanent as these signals sent through long cables, such as those crossing the Atlantic Ocean, could be recorded in Morse characters.

I may state, as an evidence of the great sensitiveness of iodide of potassium to the electric current, that I have been present when 200 words were perfectly recorded in Morse characters in one minute through a resistance of 37,730 ohms, with ten cells small size Leclanché battery. I have also seen 500 words recorded in one minute through 10,220 ohms with three cells of same size and kind. Perhaps some of your readers may know of some process by which the marks may be made less evanescent, or even permanent.

INQUIRER.

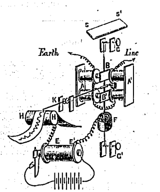
London, Dec. 30, 1878.

62

AILHAUD'S RECORDER FOR SUBMARINE CABLES.

THE currents employed on submarine lines being very weak, the electro-magnetic force of the receiver is not sufficient to overcome the inertia of the parts usually employed for recording, and more especially the friction of the paper slip against the inker.

We know how Sir William Thomson has obviated this difficulty in the construction of his Siphon Recorder. M. Ailhaud has just devised a small instrument which fulfils the same purpose.



Two electro-magnets A and A' are arranged as shown in the figure; two small magnetic armatures B, B', face the soft iron cores. These are carried by an aluminium wire, terminating below in an iron point, which dips into an iron mercury-cup F. To the centre of this wire, which is kept vertical by cocoon fibres wound upon adjusting screws G, G', is fixed a long slender indicator of aluminium, C. The received current thus deflects the indicator according to the direction in which it passes through the coils.

The recording is effected by the action of an induction spark upon a chemically prepared slip of paper which is carried by a metallic cylinder H, H, below the marking point.

The induction coil furnished with a contact maker, is actuated by a battery of large-surface plates, its ends E, E', being connected, one with the mercury cup, the other with the cylinder H, H. Thus, when the vibrating contact-maker is in action, a sparking is produced between the point and the paper slip; and inasmuch as there is no friction, the movements of the indicator are perfectly free. Two stops, K, which limit the extent of these movements, and a directing magnet S, S', complete the arrangement.

This receiver works very well with a local circuit comprising a Callaud element and ten thousand ohms resistance.

Upon the Marseilles-Algiers cable it is worked with five cells. The chemical paper is impregnated with a solution of potassium iodide and starch.—*Annales Télégraphiques.*

UNDERGROUND LINES IN PHILADELPHIA.—In 1877 several underground lines were laid in Philadelphia after a plan of Mr. David Brooks, and in connection with the working of the city railways. One of these lines crossed the Schuykill river. The line consists in cotton-covered copper wires laid together into cables and pulled through iron pipes, which are then filled with paraffin oil. In this way fifty No. 18 copper wires are easily drawn into a pipe 1 inch in diameter. The most convenient length for drawing in and splicing is 1,000 feet. The oil solidifies at 20° below zero F. The insulation is 2,500 megohms per mile at 40° F. The system, which is specially useful for telephone circuits, has been patented in all foreign countries, and a company has been formed to work it under the title of the "Brooks Underground Telegraph Construction Company, Limited," Philadelphia.

WE have received the following small drama from our facetious correspondent *Will-o'-the-Wisp.*

THE INVENTOR AND THE OFFICIAL.

SCENE.—The general Post Office, St. Martins-le-Grand.

BRITISH TELEGRAPH OFFICIAL discovered at his desk.

Enter an OLD INVENTOR.

B. T. O. *(Warmly.)* "How do you do, Mr. Crazytop? Delighted to see you. I haven't seen you for an age."

O. I. *(Humbly.)* "Pretty well, thank you. I've been very busy lately. I've got something good here to show you; a fine idea; save no end of money. I patented it a year ago, and I've been at work on it ever since."

B. T. O. *(Warmly.)* "Oh, indeed; I'm very glad to hear it. You know we are always ready to welcome any new thing."

O. I. "Especially if it's American."

B. T. O. "Hum. Let us see this instrument."

O. I. "There she is." [*Explains its merits.*] "You see that it will be a great saving to the service."

B. T. O. *(Warmly.)* "Well, we'll have it tried, Mr. Crazytop."

O. I. *(Humbly.)* "If you please, I should like to experiment with it a little while myself on a real line, so as to improve and perfect it. Of course I have no telegraph line in my house, and I must come to you for one."

B. T. O. *(Warmly.)* "By all means, Mr. Crazytop, if you pay for it."

City Notes.

Old Broad Street, Jan. 29, 1879.

THE directors of the Anglo-American Telegraph Company (Limited) have resolved (after placing £37,500 to the credit of the Renewal Fund) to recommend to the proprietors of the next half-yearly general meeting of the company, to be held on the 7th February next, the declaration of the following dividends, all free of income tax:—1. A balance dividend of 1½ per cent. upon the ordinary Consolidated Stock for the half year ended Dec. 31, 1878. 2. A first and final dividend of 3 per cent. on the Deferred Stock for the year ended Dec. 31, 1878. After paying the foregoing dividends there will be a balance of about £3,587 to be carried forward to the next

63

account. The above dividend, together with those already paid, amount to 4½ per cent. upon the ordinary Consolidated Stock of the company for the year 1878.

The directors of the Direct United States Cable Company have resolved upon the payment of an interim dividend of 5s. per share, being at the rate of 5 per cent. per annum, for the quarter ending 31st December 1878, such dividend to be payable on and after the 15th February.

The report of the directors of the Eastern Telegraph Company, to be presented to the Thirteenth Ordinary General Meeting, 30th January, 1879, shows the Company's revenue for the six months ended 30th September, 1878, amounted to £207,347 19s. 6d., from which is deducted £56,339 17s. 3d. for the ordinary expenses of the Company, and £20,154 3s. 3d. for special expenditure during the half year, as shown in the annexed accounts, which, with £2,726 2s. 6d. for income-tax, leaves the sum of £128,127 16s. 6d. net profit. From this amount, £32,269 13s. 2d. the interest on debentures and the dividend on the Six per Cent. Preference Shares to 30th September, together with two interim dividends on the ordinary shares for the quarters ending 30th June and 30th September, 1878, amounting together to £92,425, have been paid, leaving a balance of £3,433 3s. 4d. to be carried forward. The several sections of the Company's cables remain in good working order, with the exception of the Lisbon Cable, which is now under repair. The Company's cable repairing ships, stationed in the Mediterranean and the Red Sea, are in efficient condition, and in readiness for the Company's requirements. The Joint Purse Agreement between the Indo-European Telegraph Department of H.M. Indian Government, the Indo-European Telegraph Company, and this Company, continues to work satisfactorily. By the resolution of the Extraordinary General Meeting of Shareholders, held on 9th August last, the directors were empowered to acquire the shares and undertaking of the Black Sea Telegraph Company (Limited), and to raise capital for the purpose; and for the laying of a new cable between Alexandria and the Island of Cyprus. The transfer of the shares of the Black Sea Telegraph Company has been completed, and the cable (from Constantinople to Odessa) is now worked as part of this Company's system. In accordance with arrangements made with H.M. Government the Company has connected Cyprus with Alexandria by cable, and is now constructing land lines in the island. The capital required for the new works has been raised by an issue of five per cent. debentures, payable 1st August, 1887, of which £181,900 has been issued to the shareholders up to this date. Two of the directors, the Marquis of Tweeddale (Lord W. M. Hay, M.P.) and the Right Hon. W. N. Massey, M.P., retire by rotation, and being eligible, offer themselves for re-election.

The report of the directors of the Western and Brazilian Telegraph Company, to be presented at the sixth ordinary general meeting, 31st January, 1879, states the total earnings of the year amounted to £92,882 1s.; the working expenses (including £1,737 3s. 3d. rebate on issue of A, B, and C debentures) charged to revenue were £72,552 4s. 2d., which, together with £17,066 7s. 8d. interest for the year on the A, B, and C debentures, gives a total of £89,618 11s. 10d., leaving a net balance of £3,263 9s. 2d. to the credit of revenue account. It goes on to say:—"The ordinary working expenses show a reduction as compared with last year. The expenditure on account of maintenance and renewals exhibits on the other hand a very considerable increase. The revenue shows a falling off, compared with the previous year, of £5,652 18s. 11d. The general stagnation in commercial affairs will in part account for this, and the numerous interruptions of the company's cables have also influenced the revenue. The revenue account is subject to the settlement of the question raised by the Brazilian Submarine Company as to whether, in consequence of the lengthened interruption of the Pará-Pernambuco section, this company should participate to the extent of one-third in their gross receipts, as provided by the agreement existing between the two companies. It has therefore been necessary to estimate the amount due under this agreement. The expenditure on maintenance and renewal account this year charged against revenue has been £38,194 6s. 10d. The repairs and the extensive renewals effected have involved an expenditure of £69,194 6s. 10d., of which £38,194 6s. 10d. has been directly charged to revenue, and £31,000 to renewal account. The directors regret that so small a net revenue has been earned; a very great permanent improvement has been effected in the lines by the substitution of sheathed cable for that originally laid down; and although more work in the same direction still remains to be done, your cables are more secure and are working better, with greatly improved chances of unbroken communication. The directors commenced proceedings against Mr. Heugh, the late chairman of the company, for sums of money which the Board are advised he is accountable for, and these proceedings are being continued under the bankruptcy."

The Globe Telegraph and Trust Company (Limited) announce the payment, on and after February 7, of interim dividends for the quarter ending 18th January of 3s. per share on the Preference Shares, being at the rate of 6 per cent. per annum, and 2s. per share on the Ordinary Shares, being at the rate of 4 per cent. per annum.

The Eastern Extension Telegraph Company have given notice that the half-yearly coupons on their Six per Cent. Debentures, due on the 1st proximo, will be payable on and after that date, at the Consolidated Bank.

On Jan. 24th the Indo-European Telegraph Company notified that "The Black Sea direct cable from Odessa to Constantinople being restored, communication is now re-established by the special Indo-European route to Turkey."

The managing director of the Brazilian Submarine Telegraph Company (Limited) states that their cable to Madeira is working perfectly, and that there is no interruption either on the lines or cables of the Eastern Telegraph Company between London and their terminus at Lisbon.

The following are the latest quotations of telegraphs:—Anglo-American, Limited, 58½-59; Ditto, Preferred, 84-85; Ditto, Deferred, 33-34; Black Sea, Limited, —; Brazilian Submarine, Limited, 6½-6¾; Cuba, Limited, 8¾-9¼; Cuba, Limited, 10 per cent. Preference, 15¼-15¾; Direct Spanish, Limited, 1½-2; Direct Spanish, 10 per cent. Preference, 9¾-10¼; Direct United States Cable, Limited, 1877, 11¼-11¾; Eastern, Limited, 7-7¼; Eastern, 6 per cent. Debentures repayable October, 1883, 104-107; Eastern 5 per cent. Debentures repayable August, 1887, 102-105; Eastern, 6 per cent. Preference, 11-11½; Eastern Extension, Australasian and China Limited, 7-7½; Eastern Extension, 6 per cent. Debenture, repayable February, 1891, 107-110; German Union Telegraph and Trust, 7¾-8¼; Globe Telegraph and Trust, Limited, 5-5¼; Globe, 6 per cent. Preference, 10⅜-10⅝; Great Northern, 7⅞-8⅛; Indo-European, Limited, 19-20; Mediterranean Extension, Limited, 2¾-3¼; Mediterranean Extension, 8 per cent. Preference, 9-9½; Reuter's, Limited, 10-11; Submarine, 217-222; Submarine Scrip, 2-2¼; West India and Panama, Limited, 1¾-2¼; Ditto, 6 per cent. First Preference, 8-8½; Ditto, ditto, Second Preference, 7½-8; Western and Brazilian, Limited, 2½-3; Ditto, 6 per cent. Debentures "A," 88-90, Ditto, ditto, ditto, "B," 85-89; Western Union of U.S. 7 per cent., 1 Mortgage (Building) Bonds, 114-118; Ditto, 6 per cent. Sterling Bonds, 101-103; Telegraph Construction and Maintenance, Limited, 30-31; Ditto, 6 per cent. Bonds, —; Ditto, Second Bonus Trust Certificates, 2¼-2¾; India Rubber Co., 9¼-9¾.

NEW YORK, FEBRUARY 16, 1879.

THE PAST AND FUTURE OF THE ELECTRIC TELEGRAPH.

The rapid development of the electro-magnetic telegraph as a vitally essential and important social political and commercial agency, is a marked feature of modern life and history. The task of bringing it practically into use was a difficult one. It was at first doubtingly received, and the claims of those engaged in its introduction were regarded with incredulity. Its wonderful advantages were soon, however, demonstrated, and the public convinced of its value and importance. Crude and defective as were the methods at first employed, the telegraph soon became indispensable, and active efforts were inaugurated for its establishment not only throughout this country, but the world. It is not necessary to recapitulate the steps by which it advanced from what was popularly regarded as a doubtful experiment to an assured success. Many of those who were engaged in the service during the earlier years yet live, and some of them occupy prominent telegraphic positions which their experience specially qualifies them to fill advantageously. Most of those who engaged in the work during those years were young men, active, enterprising and enthusiastic, and the result has fully justified their faith and enthusiasm. The telegraph now reaches every portion of the civilized world, and has even penetrated to sections not yet regarded as civilized, and in a certain sense through its means all nations have become one people.

This country has been foremost in adopting and extending the telegraph service, and in adapting it generally to the necessities and requirements of the public. In addition to the regular commercial telegraphs, the special apparatus and systems of the Fire Alarm, the Gold and Stock, American District, private lines, etc., were invented, originated and practically introduced here. The notable improvements in telegraphic systems and apparatus of late years have either originated or were first reduced to practical usefulness in this country. In fact, in telegraphic history the United States occupy the leading position, and in no other country is electricity so completely and generally adapted to public service.

That here the telegraph has been left to private enterprise, and has not been hampered and restricted by official management and control, has undoubtedly been an important element in its rapid development and improvement. The active competition, or the possibility of competition, has compelled telegraphic managers to avail themselves of all possible improvements which would enable them to do the business entrusted to them reliably, speedily and economically. Inventors have been encouraged and invention fostered, and the beneficial results of such policy have been strikingly manifested.

There can be no doubt but that the future of the telegraph will be even more brilliant and successful than its past. The use of telegraphic facilities is constantly increasing, and as the necessity for further improvements becomes apparent, they will as heretofore be forthcoming. It seems to be impossible to limit the possibilities in this respect, and it would be absurd to suppose that science and invention have been exhausted. The demand for telegraphic facilities constantly increases, and the use of the telegraph seems likely in the future to become as universal as it has already become indispensable.

The Proposed New Atlantic Cable.

The attempt to revive and carry out the Poyer-Quertier scheme for the laying of two additional Atlantic Telegraph cables does not appear to be meeting with much encouragement. It is reported that the idea has, in fact, been abandoned, and that the new company will instead lease a cable from the Anglo-American Company—presumably the French cable from Brest to the island of St. Pierre and Duxbury, Mass. What truth there may be in this report we cannot say, but it certainly would be a much more sensible arrangement than to incur the expense of laying two additional cables, neither of which are likely to be needed for some years to come.

It is well known that the cables now laid and in operation are more than sufficient for the transmission of all the business that is or is likely to be offered. Although the Direct United States cable has been interrupted for some time, there has been no delay of business, the Anglo-American cables being amply sufficient to supply the telegraphic facilities required between this country and Europe. The repair of the Direct cable has been delayed by unfavorable weather, but the break is located within a short distance of Tor Bay, N. S., and a few days of suitable weather will suffice for its repair. This is likely to occur at any time, and it is not probable that it will be much longer delayed. It must be remembered also that the success which has attended the efforts of Mr. Stearns and Dr. Muirhead to duplex the long Atlantic cable have materially developed their capacity, and this of itself obviates any demand for additional cables.

A large proportion of the capital invested in the telegraph cable business has been contributed in England, and the unfortunate experience of the promoters of and investors in the Direct cable enterprise, which eventually sunk from 50 to 75 per cent. of its capital, has put a stop to further investments in Atlantic cables by English capitalists. In order, therefore, to carry out the new scheme the necessary capital would have to be obtained in France, if obtained at all, and since the pecuniary failure of the first French cable, French capitalists have not manifested any eagerness for further similar investments.

When the Direct cable was laid there was quite an extensive system of opposition lines with which it could connect in this country. There is at the present time no such system available, and this would preclude the success of any new enterprise, even if other conditions were favorable. The enormous losses which have resulted from the attempts to establish competing systems in this country have naturally disinclined the public to make further investments therein, and the promoters of such schemes do not meet with favorable responses to their attempts to dispose of stock for the construction of new lines, which are not required by the business or the people of the country. The existing lines furnish all the facilities required, and at as cheap rates as will suffice to make the business remunerative to those engaged in it. For these reasons we have had and have no faith in new Atlantic cable schemes which require the investment of ten millions of dollars, most, if not all, of which would be unquestionably lost to the investors. The chief promoters of such schemes are cable manufacturers, who, in their desire to supply the cables which would be required, overlook or disregard the interests of those expected to supply the funds to carry them out.

THE SOCIETY OF TELEGRAPH ENGINEERS.

ON "THE WORKING OF LONG SUBMARINE CABLES."

BY WILLOUGHBY SMITH.

(ABSTRACT CONTINUED FROM PAGE 149.)

The object in the system introduced by Mr. Willoughby Smith was to keep up a constant test for insulation and continuity, and at the same time to communicate freely through the cable between the ship and the shore.

After pointing out how a condenser may be formed by placing a certain length of cable-core in an insulated tank, and how an imperfectly insulating condenser was actually constructed by placing a series of sheets of tinfoil and gelatine alternately one on the other, the author stated that he connected one set of alternate sheets of tinfoil to the shore end of the cable conductor, whilst the other alternate sheets were connected to the terminal of a very sensitive astatic mirror galvanometer, of which the other terminal was led to earth. Consequently, the current which passed through the sheets of gelatine flowed through the galvanometer to earth, and a constant deflection was registered so long as the cable was kept charged at a uniform tension. But if the tension were altered, or the direction of the current reversed, the change of the deflection was immediately noticed by the person in charge of the galvanometer on shore, with whom the person in charge of the batteries on shipboard could thus communicate, by a pre-arranged code of signals, without interfering with the insulation test, since the current passing through the gelatine plates was hardly sufficient to increase the deflection on the ship galvanometer.

To enable the person in charge of the shore galvanometer to communicate the continuity or speaking signal to the ship, two resistance coils of unequal resistance, and a key through which the cable could be connected to earth through either coil, were employed, so that a minute portion of the cable charge could be allowed to pass to earth, the contact through one coil giving a signal corresponding to the Morse dot, and that through the other coil a signal corresponding to a dash.

This system was reported upon very favourably by Mr. Latimer Clark and Sir W. Thomson, who testified that it solved the problem of giving an absolutely continuous test of insulation whilst allowing signals to be transmitted in either direction and tests to be applied for continuity. At the suggestion of Mr. Laws the resistance coils were afterwards replaced by condensers of unequal capacity, an improvement by which several advantages were obtained. This plan, however, was superseded by one which was suggested by Messrs. Thomson and Varley, in which a single condenser only was used, the signals being produced by reversals from a local battery, which increased or diminished the deflection on the ship galvanometer by induction through the condenser. Mr. Willoughby Smith's system of simultaneous testing and signalling, thus modified, was employed during the laying of the 1866 and the completion of the 1865 cables, allowing of the transmission of 164 messages between the ship and the shore. It was, said the author, soon apparent that a higher speed would be obtained by the use of a condenser than by the "curb key;" consequently, the system of signalling was continued after the laying of the cable, and a speed of thirteen words per minute was attained with perfect ease.

Subsequently, on his return home, Mr. Willoughby Smith further altered and simplified the arrangements as follows:—The cable at each end was connected with a switch playing between a "receive" and a "send" contact. To the former was connected a condenser of a capacity equal to 75 miles of the cable; the other side of this condenser being to earth through the receiving galvanometer. The "send" contact stud was connected with a reversal key, by which currents from a 10-cell battery could be transmitted through the cable. The operator at either station, when wishing to speak, would "switch over" to the stud marked "send," and commence sending reversals to represent the usual call signal; then "switch over" again, and wait until he received the reply to his call, when he reverted to the former contact, and transmitted what he had to communicate. With this simple arrangement the author had seen 25 words per minute received at Valentia from Heart's Content, through 1,900 nautical miles of cable, with the most perfect ease. If, said he, we consider what 25 words per minute really mean, we shall be better able to realise the credit due to those gentlemen who are what is termed "good mirror clerks." To obtain this speed, the sender has to manipulate the springs of the key so as to make 375 contacts per minute, and the receiver has to distinguish, in the same space of time, the true from the false in the 750 movements of the small beam of light which moves either to the right or left on a strip of cardboard placed before him. This system has now been in use for twelve years on the Atlantic cables, and has been adopted for working all the cables laid during that period; and for speed, simplicity, economy, and accuracy it has not been surpassed.

After giving a practical instance of the superiority of this system, the author stated that the only objection he had ever heard brought against it was that the mirror galvanometer is not a recording instrument. To meet this objection, the very ingenious but complicated and expensive "Syphon Recorder" of Sir W. Thomson, patented in 1867, was introduced. When this is used it replaces the mirror galvanometer as the receiving instrument, the other parts of the system remaining intact. Mr. Willoughby Smith gave a simple description of this recording instrument, and stated that, in his opinion, the mirror is the superior instrument.

In 1873, Sir W. Thomson and Prof. Jenkin conjointly patented "the Automatic Curb Sender"—a combination of the "curb key" and Sir C. Wheatstone's well-known "automatic sender." This instrument, in the opinion of the author, is a step in the right direction, but will be of little value until a suitable receiving instrument is discovered to work with it.

After pointing out that the use, in conjunction with a condenser, of resistance coils connecting the cable to earth could only be of detriment in the present system of working long cables, the author of the paper referred to the fundamental law of induction on which this system is based, and afterwards entered into some very interesting details as to the extreme minuteness of the current producing the signal on the mirror galvanometer when a condenser is used. Assuming the currents from ten Menotti cells to be sent into the cable on each contact at the sending station, then the amount of induced current passing through the receiving galvanometer would be equal to about 1-40,000th part of that current. The cable is only partially discharged between each signal, by each spring of the sending key being put to earth after it has been depressed to charge the cable. To give some idea of the very small amount of current which actually gives the signal, it was mentioned that a sempstress, whilst manipulating with her needle and thimble, generates a stronger current, and that a knife and fork inserted into a steak or chop at lunch produces a current of six times the amount.

In regard to the employment of electro-magnets with a view to increase speed of signalling, an experiment was described in which the induced magneto-electric charge totally neutralised the charge from the battery, so that no discharge could be obtained from the cable. Nevertheless, experiments with electro-magnets, placed in every conceivable way, gave results which were in all cases unfavourable to the employment of electro-magnets as shunts.

Referring to the application to long submarine lines of the duplex system of working, Mr. Willoughby Smith explained that the principle of signalling remains the same as that above described, but the receiving instrument at each station is so placed that the current sent to the distant station does not affect it. To insure good duplex working, a true balance must be established at the sending end, so that no current will pass through the receiving instrument when placed as a bridge between the real and the artificial cables.

In concluding the Paper, which was illustrated by a number of diagrams and some interesting fac-similes of signals received under various conditions by the syphon-recorder, Mr. Willoughby Smith said that, although wonderful progress had been made in electrical science during the last few years, he believed that we are only on the threshold of what we may be permitted to know, and that there are before us gleams of light which, if rightly pursued, will richly reward the patient and honest explorer.

66

the Board as to the "life" of a cable, was of no more value than that of other persons connected with telegraphic business; but they had only to look to facts as connected with their own business; and although he admitted that their experience might be exceptional, he did not think they would be justified in treating their cable as likely to have an undisturbed "life" of more than ten years. Experience showed that the West Indian seas were not favourable to the "life" of a cable. As to the remarks about the defective nature of the last cable laid for them—the india-rubber cable—it had been constantly under the consideration of the Board whether there was any fault attributable to the manufacturer; but it was impossible for them to ascertain whether the fault lay with, and could be brought home to, the manufacturer or not till the fault was reached. The cable, however, was constantly inspected and severely tested during its manufacture by Mr. Keith, who was now repairing it. The motion was then unanimously adopted, and the dividends having been declared, a vote of thanks to the Chairman and directors terminated the proceedings.

According to the report of the Telegraph Construction and Maintenance Company (Limited) the accounts for the year show a net profit of £87,746, after charging the interest on the Debentures. To this sum must be added £61,247 brought forward from last year, making a total of £148,993. From this amount is deducted the interim dividend of 5 per cent., paid 10th July, 1878, amounting to £22,410, leaving £126,583 to be dealt with. Of this sum the directors propose to distribute a dividend of 15 per cent., or £67,230, being at the rate of £1 16s. per share, and making with the amount already paid, a total dividend for the year of £2 8s. per share in cash, free of income tax, leaving £59,353 to be carried forward to the next account.

The Western and Brazilian Telegraph Company (Limited) notified on the 15th inst. that telegraphic communication has been completed from Para to Monte Video. This places the Company's entire system, including the new line into Maranham, for the *first time* in complete working order. The cables are now working from Para to Monte Video, including all the intermediate ports required by the Company's concession. During the last twelve months, out of the original Western and Brazilian line from Rio de Janeiro to Para, viz., 2,517 miles, 830 miles of new cable, nearly all sheathed, has been relaid in shallow waters, leaving but a moderate length in these waters which it will be necessary hereafter to renew. The engineers report that the original cable, laid in deep water, is in excellent condition.

The Anglo-American Telegraph Company's Brest cable was broken on the morning of the 23rd inst. during a violent tempest, which had been raging for 36 hours. The cable was broken about 161 miles from St. Pierre, in 500 fathoms of water. The Company's ship has been ordered to sea at once to effect the repair. The Direct U.S. cable is not yet repaired, there are therefore at present but two Atlantic cables at work both are, however, duplexed.

The following are the latest quotations of telegraphs:—Anglo-American, Limited, 59-59½; Ditto, Preferred, 86-87; Ditto, Deferred, 31-31½; Black Sea, Limited, —; Brazilian Submarine, Limited, 6½-7½; Cuba, Limited, 8½-8¾; Cuba, Limited, 10 per cent. Preference, 15½-16½; Direct Spanish, Limited, 1½-2; Direct Spanish, 10 per cent. Preference, 10-10½; Direct United States Cable, Limited, 1877, 11½-11¾; Eastern, Limited, 7½-7¾; Eastern, 6 per cent. Debentures repayable October, 1883, 104-107; Eastern 5 per cent. Debentures repayable August, 1887, 100-103; Eastern, 6 per cent. Preference, 11½-11¾; Eastern Extension, Australasian and China Limited, 7½-7¾; Eastern Extension, 6 per cent. Debenture, repayable February, 1891, 105-108; German Union Telegraph and Trust, 7½-8½; Globe Telegraph and Trust, Limited, 4½-5½; Globe, 6 per cent. Preference, 10½-10¾; Great Northern, 8½-8¾; Indo-European, Limited, 20-21; Mediterranean Extension, Limited, 2½-3½; Mediterranean Extension, 8 per cent. Preference, 9-9½; Reuter's, Limited, 9½-10½; Submarine, 215-225; Submarine Scrip, 1½-2½; West India and Panama, Limited, 1½-2½; Ditto, 6 per cent. First Preference, 8½-9; Ditto, ditto, Second Preference, 7½-8½; Western and Brazilian, Limited, 4½-4¾; Ditto, 6 per cent. Debentures "A," 88-93, Ditto, ditto, ditto, "B," 83-88; Western Union of U.S. 7 per cent., 1 Mortgage (Building) Bonds, 114-118; Ditto, 6 per cent. Sterling Bonds, 102-104; Telegraph Construction and Maintenance, Limited, 31½-32½; Ditto, 6 per cent. Bonds, —; Ditto, Second Bonus Trust Certificates, 2½-2¾; India Rubber Co., 10¾-11¼.

TRAFFIC RECEIPTS.

Name of Co., with amount of issued capital, exclusive of preference and debenture stocks.	Anglo-American Co. £7,000,000.	Brazilian Sub. Co. £1,300,000.	Cuba Sub. Co. £160,000.	Direct Spanish Co. £116,379.	Direct U.S. Co. £1,102,420.	Eastern Co. £3,697,000.	Eastern Ex. Co. £1,997,500.	Gt. Northern Co. £1,500,000.	Indo-Euro. Co. £425,000.	Submarine Co. £338,225.	West Coast America Co. £300,000.	Western and Brazilian Co. £1,398,200	West India Co. £883,210.
	£	£	£	£	£	£	£	£	£	£	£	£	£
January, 1879 ...	50,400	13,778	*2,900	951	16,800	39,226	24,695	13,856	*b*	9,064	2,125	*b*	5,497
January, 1878 ...	49,940	11,883	3,001	944	13,730	41,531	22,905	13,511	... ...	9,621	1,725	... ...	5,284
Total Inc., 1879	*460	1,895	... ...	7	3,070	... ...	1,790	345	... ...	... ...	400	... ...	213
Total Dec., 1879	... ...	... ...	101	... ...	... ...	2,305	... ...	... ...	... ...	557	... ...	... ...	... ...

* Estimated. *b* Not published. Traffic Receipts of West Coast of America Co. for the month of December were £2,250.

(The figures in this Table are as accurate as it is in our power to make them, but we do not guarantee their correctness.)

JOURNAL OF THE TELEGRAPH.

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A NOTABLE CELEBRATION OF THE INITIATION OF OCEAN TELEGRAPHY.

The Twenty-Fifth Anniversary of the Organization of the Company which led to the Establishment of Submarine Telegraphy Worthily Commemorated. Four of the Five Original Promotors Personally Participate in the Festivities.—A Remarkable Gathering of Distinguished Personages.

At ten o'clock in the evening of March 10th, 1854, in the parlor of Mr. Cyrus W. Field, was signed the contract by which the New York, Newfoundland and London Telegraph Company was organized. The parties to this contract were Cyrus W. Field, Peter Cooper, Marshall O. Roberts, Moses Taylor and Chandler White. Peter Cooper became President of the company. The original purpose of the company was to complete a line 400 miles in length, from Cape Ray to St. Johns, Newfoundland, which had already been commenced, and thus by means of steamers to be run from the west coast of Ireland, to shorten the time required for communication to Europe from about two weeks, which were then required, to eight to ten days. The project had been taken up by Mr. Field, and through his earnest representations the gentlemen above named had been interested in it, and undertook to carry it through. The idea was naturally suggested that the line should be carried across the ocean, and Mr. Field accordingly obtained in March, 1854, from the Legislature of Newfoundland, a charter granting for fifty years an exclusive right to establish a telegraph from the Continent of America to Newfoundland and thence to Europe.

The land line was constructed across Newfoundland, much of the way through an unbroken wilderness. The difficulties of construction and the cost were enormous. In 1855, Mr. Field went to Europe and organized the Atlantic Telegraph Company to carry the line across the ocean. Most of our readers are familiar with the subsequent history of the enterprise. Through his exertions mainly the necessary capital was secured, and aid in ships was obtained from the American and British Governments. The cable was manufactured and two attempts to lay it in 1857 and 1858 failed, but the third was successful, and in 1858 the first telegraphic communication took place between England and America. The work had been pursued under most discouraging circumstances. There was but little faith in the practicability of transmitting signals through such long submarine lines, and less in the possibility of maintaining the line for any length of time even after it had been successfully laid. The fact that telegraphic communication had actually taken place between the two countries was, therefore, greeted with the wildest enthusiasm; congratulations, fêtes and celebrations of the event followed, and Mr. Field was the lion of the day.

There were, however, many who still doubted the actual transmission of communications over the line, but the evidences were so conclusive by the publication of news in London and New York within two days after the events recorded had occurred, that these were compelled to acknowledge that ocean telegraphy was an accomplished fact. The first public messages were congratulations between Queen Victoria and President Buchanan, which occupied in transmission 67 minutes each. From the first the cable worked very slowly, and with constantly increasing difficulty. Although the practicability of telegraphing over long submarine lines had been satisfactorily demonstrated, years were yet to pass before ocean telegraphy should be permenently established. The line soon ceased to work, and doubt and discouragement had again to be encountered and overcome. Mr. Field never lost faith in the enterprise, and made many trips to Europe in his endeavors to resuscitate the company and obtain the means for the construction and laying of another cable.

Of the four gentlemen who had with him engaged originally in the enterprise, Mr. White died two years after the organization of the N. Y. N. F. & L. Telegraph Company, and his place was taken by Mr. Wilson G. Hunt. These gentlemen adhered loyally and persistently to the enterprise which they had undertaken, and all lived to enjoy the success which ultimately crowned their exertions and sacrifices

The civil war in this country had broken out in the meantime, and it was not until 1865 that another expedition was prepared. During the intervening years great improvements in submarine telegraphy and in the construction of cables had taken place. The building of the Great Eastern, which had proved a failure for the purpose for which it was originally undertaken, afforded a steamer of enormous dimensions, and which was better adapted to the purpose of laying ocean cables than any which had before been available. The cable was coiled upon the Great Eastern, and she sailed for Newfoundland. After 1,200 miles of cable had been payed out, by a sudden lurch of the vessel it was broken and the end lost. The attempts to recover it were unsuccessful and the expedition returned to England. The fates seemed indeed to be against success of an enterprise which had cost so much time, labor and money. Additional cable was, however, manufactured, and in 1866 the Great Eastern sailed again. This time the fates were more propitious, and the 2,000 miles of cable were successfully laid, and telegraphic communication between the old and new worlds permanently established. Communication was perfected July 27, 1866, and has never since been entirely interrupted. After landing this cable the Great Eastern returned to mid-ocean and after two months grappling found the end of the cable lost the previous year. It was brought up from a depth of two miles, connected with the cable remaining on board and carried safely to the Western shore.

After twelve years of incessant labor, in which he crossed the ocean nearly fifty times, Mr. Field saw the crowning effort of his life accomplished. Congress voted him a gold medal with the thanks of the Nation; while the Prime Minister of England declared that it was only the fact that he was a citizen of another country that prevented his receiving high honors from the British Government.

The success which had after so many years been obtained, and the demonstration of the practicability not only of laying, maintaining, and operating long submarine cables, but also of recovering them when broken or needing repairs, from great depths of water, was followed by a rapid development of ocean telegraphy in all parts of the world, until now every sea and ocean, except the Pacific, are crossed by these electric cords, which bind together all nations of the earth. When the Pacific cable shall be laid from our Western Coast to China and Asia, the telegraphic circuit of the world will be completed. It is the remaining ambition of Mr. Field's life to accomplish this, and having already been so successful in more doubtful enterprises, it is by no means impossible that this ambition shall be gratified.

A quarter of a century has passed away since the contract for the organization of the New York, Newfoundland and London Telegraph Company was signed. To celebrate that event, Mr. Field gave a reception on the 10th instant, at his residence in Gramercy Park in this city. It was indeed a notable event and notable assemblage. The invitation card was artistic, elaborate and symbolical of the occasion. It is surmounted by the coat of arms of Mr. Field's family—a shield, sable, bearing three sheaves of wheat or, between a chevron, argent. The crest is a hand and arm, gules, rising from clouds, argent, and supporting a globe, all of the heraldic tinctures being beautifully printed in colors. The escutcheon is supported on one side by the British naval flag, on the other by the Stars and Stripes; and at the base is embossed on a silver scroll the appropriate motto, "Sans Dieu, Rien," The four quarters of the world that the cable has knotted together have their places in the four corners. Europe sits, queen-like, upon a bull; bronzed Asia, with golden armlets, is borne on a kneeling elephant, two brahmins beside her; Africa perches upon the hump of a camel, and America, with freer mien, bestrides a bison. Boughs, berries and leaves twine themselves round the medallions, and a cable, coiled and twisted, weaves itself into the letters "C. W. F." On one side is the date of the cable's birth, March 10, 1854; on the other the date of the celebration, March 10, 1879. In the centre is an oblong card of invitation. "Mr. Cyrus W. Field requests the pleasure of ———'s company Monday evening, March 10, from nine to twelve, Gramercy Park, New York, February 24, 1879." At the foot is the dining-room, with map and globe, and like-

68

THE DIRECT UNITED STATES CABLE COMPANY

Abstract of the Report to be presented at the third ordinary general meeting of the Company, on Friday, March 21:—The Directors submit with this report the usual statements of account for the half year ending 31st December, 1878. The revenue for the half year, after deducting out-payments, amounted to £89,943 14s. 8d. For the corresponding half year of 1877, the amount of revenue, after similar deductions, was £84,217 12s. 10d. The working and other expenses, interest on debentures of the old Company and income-tax amount to £21,748 9s. 11d., leaving a balance of £68,195 4s. 9d. as the net profit for the half year, making, with £2,933 3s. 7d. brought forward from the previous half year, a total of £71,128 8s. 4d. In the corresponding half year of 1877 the expenses and payments above mentioned, and cost of repair incurred during that period, amounted to £25,046 2s. 10d. Interim dividends of 1¼ per cent. each for the quarters ending 30th September and 31st December, 1878, together amounting to £30,355, have been declared and paid. A sum of £32,500 has been added to the reserve fund (thereby increasing it to £73,139 14s. 9d.), and a further sum of £3,000 has been written off the preliminary expenses, leaving a balance of £5,273 8s. 4d., which has been carried forward. The necessary six months' notice was given in July last of the intention to pay off the debentures of the old Company, and the amount and interest have since been paid. It was deemed expedient that a member of the Board should proceed to the United States and Canada with reference to questions which had arisen upon the reconstruction of the Company, to complete the necessary arrangements with associated companies, and generally to investigate the working of the Company's system on the western side. Accordingly, during the autumn of last year Captain Mayne visited the Dominion and the United States. The agreements between the Atlantic and Pacific Telegraph Company and the old Company, and between that Company and the Franklin Company, have been adopted with some modifications, and an agreement to carry out the negotiations with the Dominion Telegraph Company of Canada, referred to in the report presented to the members at the last half-yearly meeting, is now under consideration by that Company. The arbitration proceedings between the liquidators of the old Company and Mr. Loeffler, one of the dissentient members, have extended over a period of ten months, and occasioned considerable labour to your Directors and the staff. It is with much satisfaction the Directors state that the proceedings were closed on the 5th February last, and they now await the arbitrator's award. The Muirhead duplex system has been applied to the main cable. An interruption of the main cable occurred on the 4th January last. The break has been located at about six knots from the Torbay station. An interruption also occurred in the short cable on the 12th February. This break has been located on Brown's Bank, about 290 knots from Rye Beach. Both breaks are in shallow water, and, with favourable weather, the repairs will be speedily effected. Owing to the operation of the agreement with the Anglo Company, the receipts of this Company are not affected.

Underground Telegraph Wires.

In the Assembly, at Albany, on the 10th, Mr. Grady presented a bill relative to the locating of telegraph wires throughout the State, the first section of which provides: "Any telegraph company incorporated under the laws of the State of New York shall have the right to lay under ground, in any city or town of this state or along any highways thereof, its wires to make such telegraphic connections as may be called for in its articles of association, subject to the provisions under which poles for carrying telegraph wires are now placed in towns, cities, or along public highways or post roads. Feb 79

THE PROPOSED NEW FRENCH CABLE COMPANY.

With reference to the proposed new arrangement for Atlantic telegraphy, the Continental Exchange Agency sends the following extract from the Paris *Bulletin Financier*:

"We are informed that the formation of a new French company has been decided upon, having for its object the exploitation of a trans-atlantic cable altogether distinct from that of M. Pouyer-Quertier, and of which the bases will be published in a few days. The new company will take over the existing cables between Brest and St. Pierre and the United States of America, as well as the concession accorded by the French government in 1868, which assures important advantages on all ulterior concessions. The company will provide for the laying of new cables between Brest and North America for the period when the existing cables shall no longer be in a condition to work. The capital is fixed at twenty million francs, which is amply sufficient to cover the expenses of construction and of laying in the best possible conditions, as well as for meeting the first charges and constituting a fund for the working expenses, together with a first installment toward a reserve fund. The new company will be directed by a French council of administration. The communications, in case of interruption, are guaranteed by conventions with the English companies whose lines are in relation with Brest by submarine cables already existing. One of the most important financial establishments in Paris is now occupied with the issue of shares." apr 79

69

Anglo-American Telegraph.

The half-yearly meeting was held at the Cannon street hotel February 7th, Viscount Monk, the Chairman, presiding.

The report states that the total receipts from July 1 to December 31, 1878, including a balance of £15,120 carried over to the last account, amount to £309,570. The total expenses of the half year, including income-tax and the ordinary repair of cables, amount to £55,983. The expenses of the special repairing expedition of 1878, amounting to £14,146, have been charged to the renewal fund, viz.: £9,007 in the half year ending June 30, 1878, and £5,138 in the half year ending Dec. 31, 1878. The directors have set apart to the renewal fund the usual amount of £75,000, leaving a balance of £178,587 disposable for dividend. One quarterly interim dividend, at the rate of 4 per cent. per annum, free of income-tax, was paid on Nov. 1st last, absorbing £70,000, leaving a balance of £108,587, out of which the directors recommend the proprietors to declare a final dividend of 1½ per cent., free of income-tax, amounting to £105,000, making a total distribution for the year ended Dec. 31, 1878, of 4½ per cent. upon the ordinary consolidated stock of the company; 6 per cent. upon the preferred ordinary stock, and 3 per cent. upon the deferred ordinary stock, leaving a balance of £3,587 to be carried forward to the next account. The traffic receipts for the last six months of 1878, as compared with the corresponding period in 1877, show an increase of £16,241. The expedition composed of the s.s. *Seine* and s.s. *Calabria*, fitted out last spring, failed to repair the 1866 cable, and returned to this country on the 27th July last. The failure was caused by oxidation of the iron wire and decay of the hemp of which the outer covering of the cable consisted. The company's repairing ship, the *Minia*, has successfully diverted the Duxbury cable; the directors trust that this cable, as now laid, will be free from interference by fishing vessels, whose anchors have been the cause of nearly all former interruptions. The three deep-sea cables and the rest of the company's system are in good working order and condition. Since the last half-yearly general meeting of the company, Mr. J. B. Stearns has been engaged upon both sides of the Atlantic in placing his duplex system of telegraphy upon one of the company's cables between Valentia, Ireland, and Heart's Content, Newfoundland. The possibility of duplexing the company's deep-sea cables has now been placed beyond a doubt; but as the royalty to be paid for the use of the patents is fixed by agreement according to the increase of speed to be obtained, the system will not be accepted and paid for until the percentage of increase shall have been ascertained and settled by regular working of the traffic for a reasonable time. The directors have sanctioned an arrangement by which the employés may secure the payment to themselves of a limited sum at a given age, or to their families in case of death—the company paying one-half of the premiums required for this purpose. A resolution approving this arrangement was submitted to the meeting.

The chairman explained the report very fully, and strongly urged as a matter of justice and policy the approval of the arrangement to provide for the future of the employés of the company. This met with considerable opposition. In the course of the discussion which ensued the chairman said that for this fund £2,000 would be required, of which it was proposed that the company should pay one-half and the employés one-half. The employés contribute in proportion to their salaries, and the sum they will ultimately receive will be in proportion to their contributions. No man can receive more than £1,000 (about $5,000) but there may be smaller payments.

In reference to the proposed new company in opposition to the existing Atlantic Cable companies (the Pouyer-Quertier concession), the chairman said:

"I have no doubt many of you have seen in the money article of the leading journal yesterday morning a statement from Paris, which I take leave to say was written with a view of what is called 'forcing the hands of your directors' at the meeting today. It stated that the company was formed, and the caution money paid, and everything ready. I have nothing to do with that; but the fact is the caution money has not been paid. That is a matter of fact, and all I have to say on the subject is this, that your directors are fully alive to the importance of any attempt of this kind; and they have taken, and are taking, every means in their power to protect your interests, and I trust you will have sufficient confidence in them to leave the matter in their hands, and not play the game of the enemy by forcing us into premature disclosures. I don't think there is any other matter I need make any observation upon. I congratulate you on the state of your property. The cables are working well. The French cable, which has now been in the water nearly ten years, is in better condition for working than when it first began its career, and we trust will live many years more. The other cables are in excellent condition; the traffic is prosperous, and I trust that we shall be relieved from any fears, from any quarter, of interference with the prosperity of our company. I beg now to move the adoption of the report and accounts, and the payment of the dividend recommended in the report."

It was further stated by the chairman that 90 per cent. additional work had been got out of the cable upon which experiments had been made from the use of the duplex system.

The resolution approving and adopting the report and accounts was carried unanimously.

The retiring directors, Sir Daniel Gooch, Bart., M.P., and the Hon. Robert Grimston, were re-elected, as were the retiring auditors, Messrs. Dean and Glasse.

The Chairman then proposed a resolution authorizing the Board to constitute a superannuation fund, which was seconded by Mr. Rate, but met with considerable opposition from the meeting.

An amendment was proposed to the effect that the consideration of it should be postponed until the next general meeting, which was agreed to by the majority.

The Chairman said he had proxies in its favor representing £3,000,000 of stock, but if the amendment were withdrawn he would hold the matter over until the next meeting.

This was unanimously agreed to, and the meeting separated.

The French Atlantic Cable Broken.

The French Atlantic cable, operated by the Anglo-American Telegraph Company, is broken 161 miles from St. Pierre Miquelon, in 500 fathoms of water. The repairing steamer has been ordered to proceed to raise and repair it, and unless the weather should prevent, it will be speedily restored.

Application for Telegraph Cable Privileges Refused.

In the United States Senate, on Monday, Feb. 24, Mr. Hamlin, from the Committee on Foreign Relations, reported adversely on the Senate bill to grant to the American Ocean Cable and Telegraph Land Wire Association of Philadelphia, the right of way and privilege to lay, land and operate submarine

The Direct United States Cable Company.

At the third ordinary general meeting of the Direct United States Cable Company, held at the Cannon-Street Hotel, London, March 21st, the Chairman, Mr. John Pender, M. P., in moving the adoption of the report, (a synopsis of which was published in the last number of this paper,) said that the company had now, after a great deal of obstruction, arrived at a satisfactory position, although a great deal of money had been expended to secure that position. One of the dissentient holders had made a claim of

£76,143, or £76 per share, when the par value was only £20, but the amount awarded to that person was only £13,000, which sum was offered to him by the liquidators before he went to arbitration. That business had cost the company about £10,000, which might as well have been thrown into the sea. There had been a great deal of talk about a new French cable, and he had gone to Paris to make inquiries relative thereto. He was astonished to find that the promoters of the scheme were so little acquainted with facts and figures; for they were bringing before the public a scheme with a capital of £2,400,000 for two cables, which was close upon double the capital of the Direct Company, without anything like their security, and the shares of the Direct Company were at a discount of close upon 50 per cent. He pointed out to the men connected with the new scheme that the moment the cable was laid, competition would arise, and a 6d. tariff might be adopted; and, although there would be a diminution in the receipts of the Direct, it would entirely prevent the new company paying a shilling to their shareholders. There was no need whatever for the new cable, seeing that they (the Direct Company) had applied the duplex system, and thus increased their carrying powers. The result of the visit was that the promoters had wisely hesitated; for to float a company with the knowledge of the facts he had communicated to them would incur a grave responsibility, which might some day be used against them. He was told that the *amour propre* of the French people must be satisfied; that the whole of the great telegraph enterprise centered in England; and that France should share that; although, as he said, France only contributed 11 per cent. of the Atlantic traffic. He accepted that sentiment, believing that telegraphy should be of an international character, and to meet it the Atlantic Company proposed to establish a company in France, with a French representation, using the Brest cable for the scheme, and to work in harmony with the existing systems. But, had it not been for the change which had taken place in the reconstruction of the Direct Company, he believed that the new scheme would have been proceeded with. The promoters of the French scheme stated that they had received a concession from the French Government, and that the head of the combination was to receive £20,000 for the concession, with a permanent position as president of the company; that the manager of the company was to have a remunerative position, and that the financiers backing it were to receive a large sum of money. As to the concession for which the £20,000 were to be paid, he said that the Anglo-Company already held a concession from the French Government, which gave them great advantages, with a preference over all the French traffic—that concession having eleven years still to run. He was unable to see a copy of the concession to the new scheme, but was told that

it merely included a landing-right, which the French Government were prepared to give to any respectable company which might ask for it. He had no doubt that the promoters of such a scheme would be enriched, but it would have to come out of the pockets of the French subscribers, and he was yet hopeful that the scheme would fail, as had previous ones. Mr. Pender then spoke of the relations of the Direct Company with the governments and companies on the other side of the Atlantic, which he considered were satisfactory; and stated that during the present session the company's position would be distinctly recognized by the Canadian Parliament. The Americans were rather more disposed than usual to encourage telegraphy, but they did not, like the English, invest to any extent in that enterprise. He referred to the advantages accruing to

the public, especially through the medium of the cheap tariffs to the press, arising from telegraphy, which, however, he contended, would be destroyed were competition established by new companies being formed.

THE DIRECT UNITED STATES CABLE REPAIRED.

THE break on the Direct Cable, about two miles from Tor Bay, N. S., was repaired March 20th, and business over it was immediately resumed. This interruption occurred January 3d, and as it was in shallow water, could have been repaired in a few days, had it not been for unfavorable weather incident to the season.

It was found upon examination of the fractured ends of the cable that it had been originally laid on a ridge of rocks, and the sheathing wires had been gradually ground down to needle points, and the cable finally broken.

The Direct United States Cable Company.—Report for Last Six Months, 1878.

THE third ordinary general meeting of the Direct United States Cable Company was held at the City Terminus Hotel, London, March 21st. The report of the directors for the half year ended December 31st, 1878, was presented and adopted. The report states that the revenue for the half-year, after deducting out payments, amounted to £89,943, 14*s.* 8*d.* For the corresponding half-year of 1877, the amount of revenue, after similar deductions, was £84,217, 12*s.* 10*d.* The working and other expenses, interest and income tax, amounted to £21,748, 9*s.* 11*d.*,

leaving a balance of £68,195, 4*s.* 9*d.*, as the net profit for the half year, making, with £2,993, 3*s.* 7*d.* brought forward from the previous half-year, a total of £71,128, 8*s.* 4*d.* In the corresponding half-year of 1877, the expenses and payments and cost of repair amounted to £25,040, 2*s.* 10*d.*

Interim dividends of 1¼ per cent. each for the quarter ending 30th September and 31st December, 1878, amounting to £30,355, have been declared and paid. The sum of £32,500 has been added to the Reserve Fund, increasing it to £74,139, 14*s.* 9*d.*, and a balance of £5,273, 8*s.* 4*d.*, has been carried forward. The debentures of the old company have been paid off.

It was deemed expedient that a member of the board should proceed to the United States and Canada with reference to questions which had arisen upon the reconstruction of the company, to complete the necessary arrangements with associated companies, and generally to investigate the working of the company's system on the western side. Accordingly during the Autumn of last year Captain Mayne visited the Dominion and the United States. The agreements between the Atlantic and Pacific Telegraph Company and the old company, and between that company and the Franklin Company, have been adopted with some modifications, and an agreement to carry out the negotiations with the Dominion Telegraph Company of Canada referred to in the report presented to the members at the last half-yearly meeting is now under consideration by that company. An interruption of the main cable occurred on Jan. 4 last. The break has been located at about six knots from the Torbay station. An interruption also occurred in the short cable on Feb. 12. This break has been located on Brown's Bank, about 200 miles from Rye Beach. Both breaks are in shallow water, and with favorable weather the repairs will be speedily effected. Owing to the operation of the agreement with the Anglo Company the receipts of this company are not affected.

Another Atlantic Cable Company Projected.

A Paris paper, *The Bulletin Financier*, says: "A cable company is now organizing, with 20,000,000 francs ($4,000,000) capital, under the auspices of an important Parisian financial establishment. It will acquire the existing Brest and St. Pierre Cable, with the concession of 1868, assuring important advantages over all later concessions." This company is intended to work in conjunction with the existing system, with the view of antagonizing the Pouyer-Quertier scheme.

The International Telegraph Conference.

THE date of the meeting of the Congress has been fixed for the 10th of June. This is the first meeting of the conference in London.

The Telegraph in China.

WE hear that, through the enterprise and wise policy of the Viceroy, His Excellency Li Hong Chang, telegraph stores have been purchased, and that under the direction of Mr. J. A. Betts (the director of the Imperial Torpedo College, Tientsin) the *first* telegraph line for the transmission of *public messages* will be erected, and will probably be in working order within three or four months from this date. It will be a line of some 40 miles in length, and will, no doubt, be very rapidly extended. Thus we may expect to find that within the next decade the use of electricity in China will be as much a fact as in Europe or America.—*The Telegraphic Journal.*

72

A CABLE manufactured by Mr. Henley has been sent out to Russia, in order to be laid across the Caspian Sea.

THE acquisition by the Government of the undertaking of the United Kingdom Telegraph Company having been recently brought before Parliament, and a memorial presented to it by Mr. J. M. Gadd, alleging frauds against the directors of that company, these gentlemen have published a declaration refuting the assertions of the memorial in question.

MR. WILLOUGHBY SMITH's recent paper to the Society of Telegraph Engineers on the "working of Submarine Cables," has been separately published as a monograph, and will form an interesting contribution to the history of the subject.

MR. CHARLES STEWART, M.A., has been awarded a silver medal by the Academie Nationale of Paris, for his treatises on "International Correspondence, by means of numbers, an easy method whereby people of different nations may readily communicate with each other," and "how to learn the Morse Alphabet in half an hour." These books are published by Messrs. E. Marlborough and Co.

[From the *Journal Télégraphique*.—Translated for the JOURNAL OF THE TELEGRAPH.] June 1 Apr 79

EXPERIMENTS WITH A NEW DESCRIPTION OF TELEGRAPHIC CABLE.

By M. ROTHEN, *Sub-Director of Swiss Telegraphs.*

A COMPANY has recently been organized at Cortaillod, in French Switzerland, under the name of Berthoud, Borel & Company, for the purpose of manufacturing and introducing a new description of telegraph cable, the composition of which differs materially in the conductor and in the insulating material employed, as well as in the manner in which it is manufactured, from any at present in use. Exteriorly these cables somewhat resemble those made by Rattier & Co., at Paris, and well known in France and in other countries, where they have been extensively used. This exterior resemblance is, however, the only one, as, in fact, the conductor in the new cable is of lead instead of copper, and the dielectric a resinous or sulphurous substance instead of gutta-percha or india-rubber, and the protecting covering or sheath is a lead tubing. Notwithstanding the quasi solidity and small flexibility of the dielectric substances employed, the new cables are not less supple than those heretofore used, and in this respect are not inferior to other cables. The conductor, in this as in gutta-percha covered cables, is placed in the centre of the dielectric, and strictly retains this position in spite of the manipulations to which the cable may be subjected.

This is not the place to discuss the reasons which have governed the manufacturers in the selection of the materials used; but if to the method of manufacture is added the consideration that the cost of the new cable will be much less than that of those at present employed, it will be of interest and importance to learn the results of experiments with specimens of it, made in the presence of experts at Berne.

The specimens furnished by the company for experimental purposes were three in number, the first and second only differing in the diameter of the core, and the third in the substance of the dielectric; a sulphurous material replacing the resinous substance used on the former. These three specimens, which we will designate as cables No. I., No. II. and No. III., had but one conductor each, and were intended, as is shown by the character of the protecting sheath, for underground purposes, this wrapper not having sufficient tensile strength to stand immersion in considerable depth of water. The following were the length, diameter and weight of the three specimens of cable tested:

	No. I.	No. II.	No. III
Length of specimen..........	295 feet	361 feet	328 feet.
Diameter of core..............	·56 inch	·67 inch	·67 inch
Outside diameter of dielectric.	·114 "	·146 "	·164 "
Outside diameter of protecting wrapper....................	·189 "	·232 "	·236 "
Weight of specimen 328 feet....	30½ lbs.	45$\frac{1}{10}$ lbs.	46 lbs.

These cables had been immersed in water for five days before commencing the tests.

For the purpose of comparison, a copper wire, covered with gutta-percha, of the following dimensions, length 328 feet; diameter of core ·55 of an inch; outside diameter of gutta percha ·169 inch, was similarly immersed. In making the tests the following apparatus were used:

1. A Thomson's Galvanometer.

2. A Daniell's battery of 150 cells; a Wheatstone Bridge on the basis of Siemens Units; an artificial resistance of 328,800 Siemens Units, composed of glass tubes filled with a weak solution of sulphate of zinc, with large terminal plates of amalgamated zinc.

3. A special key.

The *Electro-static Capacity* was first determined, then the *insulation*, and lastly the *resistance of the conducting core*.

Electro-Static Capacity.

The charging was done with five Daniell's cells, and the process of charging was observed at the galvanometer. Three observations were taken for each sample, of which the following table, giving the deviations of the spot of light, shows the results.

Copper wire covered with gutta-percha.	No. I.	No. II.	No. III.
148	102	109	148
150	105	116	143
149	105	113	148
Average 149	104.3	112.7	146.3

While, for absolute accuracy, the dates given above would require correction, to compensate for the effect of the current or electric shock to the needle of the galvanometer at the instant of charging, yet as such accuracy is not essential in this case, we may consider the results noted as giving a sufficient approximation thereto.

Reducing the charge for all the cables to an equal length of 328 feet, the following proportions are shown.

Gutta Percha.	No. I.	No. II.	No III.
149	115.9	102.5	146.3

It was of interest to ascertain the electro-static capacity, expressed either in absolute measurement or in microfarads; but not having at the time a graduated condenser available, the capacity of the gutta percha cable had to be determined by the formula

$$\frac{0,1876\ 9}{\log. D - \log. d}$$ microfarad for the nautical mile; in which D indicates the exterior diameter of the dielectric, and d the diameter of the conductor. The electro-static capacity of the 328 feet of gutta percha covered cable, worked out by this formula, was .0237 microfarad; from which it follows that the electro-static capacity of 328 feet of the new cables respectively in microfarads amounted to

Cable	No. I.	No. II.	No. III.
	.0184	.0162.	.0232

while these tests for capacity were being made, the water in which the cables were submerged was at a temperature of 19° 6' C. (67 Fahrenheit.)

An attempt was made to calculate the resistance of insulation by the loss of charge, but this was not successful, as after one minute of insulation the samples of the new cable charged did not show any noticeable loss, or at most, in some isolated cases, very little traces of loss; while, on the contrary, the wire covered with gutta percha showed in the same time a loss of 1-150 of its primitive charge. Leaving cable No. III insulated for 2 hours, 15 minutes, the loss has been shown as 1-40 of the charge. In order to fully comprehend the causes of these small losses in charging, we should take into consideration, in addition to the short lengths of the cables, the low battery power with which they had been charged. Taking 1.079 volts as the average electro-motive force of a Daniell's cell, the potential was only 5·4 volts, and the total charge for 328 feet in microfarads did not exceed for the

Gutta Percha	Cable No. I.	No. II.	No. III.
.127	.089	.091	.124

Resistance of Insulation.

The experiments already made showed that a very considerable resistance of insulation must be expected, larger even for the cables than for the gutta percha covered wire. Consequently the ordinary method of measuring resistance by the Wheatstone bridge could not be applied, and the method of substitution was determined upon. First there was introduced in a circuit a Daniell element or cell; the artificial resistance of 328,800 Siemens' units; and the galvanometer with a shunt of 1-999 of its resistance:—the mean deflection was 28·3 degrees of the scale. Disregarding the relatively insignificent resistances of the galvanometer and the battery, we may assume that the same deviation would be obtained by the galvanometer without shunt, by introducing in the circuit a resistance of 328,800,000 Siemens' units. The constant of the galvanometer having been determined, it was then possible to proceed to the measurement of the insulation resistances of the samples of new cable, and the gutta percha covered wire. These having been substituted for the artificial resistance for this purpose, the single Daniell cell was replaced by 150 similar cells, and the entire current was caused to pass through the galvanometer. The average deflections so obtained were as follows:

For Gutta Percha wire.. ....11.7 degrees.
" Cable No. I.................................. ... 9.3 "
" " " II.................................. 9.3 "
" " " III .... 9.7 "

The product 328.8 × 150 × 28.3 divided by the deflections gives in each case the resistance in millions of Siemens' units. In this manner we get as resistance of the dielectric:

For Gutta Percha wire .... 93,708 millions of S. U.
" Cable No. I.........................147,960 " " "
" " " II.........................147,960 " " "
" " " III ....143,028 " " "

or, reducing all the cables to a length of 328 feet:

For Gutta Percha wire................ 93,708 millions of S. U.
" Cable No. I.........................133,164 " " "
" " " II.........................162,756 " " "
" " " III...... ....143,028 " " "

The temperature of the water during these experiments was 19° C.

To remove all causes of inaccuracy the electro-motive power of the 150 cells compared with that of the single cell should have been previously determined. The ratio between these two was certainly not strictly 150: 1, which would cause a slight modification of the factor 150. But this error of calculation is not important and may be overlooked. While a strictly accurate determination would vary the figures a little, it would not change the general impression which is obtained from the experiments with the cables, their comparison with gutta percha remaining the same.

Resistance of the Conducting Core.

The conductivity of the core was measured by the well-known Wheatstone bridge. The diff[erence of] temperature is explained by the fact that d[uring the] tests, the temperature of the bath was red[uced for] the purposes of other experiments. The re[sults ob]tained were as follows:

Gutta Percha Wire.	19.5 C.	.97 Siemens U[nits]	
Cable No. I.	19.5 C.	10.95	"
" No. II.	9.5 C.	8.24	"
" No. III.	9.5 C.	8.21	"

and by reducing all the cables to 328 feet, len[gths re]spectively:

Gutta Percha Wire.	.97 Siemens Unit[s]		
Cable No. I.	12.17	"	"
" No. II.	7.49	"	"
" No. III.	8.21	"	"

In the table at the end of this article the v[arious] results obtained in these tests are recapitulat[ed,] the data being based upon a uniform length o[f 328] feet for each sample tested.

An examination of this table will show that [as re]gards electro-static capacity and insulation, th[e new] cable gave better results than the gutta-perch[a cov]ered wire, but these good qualities are some[what] offset by the comparatively considerable resis[tance] of the conductor. This difficulty, however, is [un]important for short distances; for example, for [lines] in cities, lines through railroad tunnels, and [in] similar cases where resistance is of little co[nse]quence. In addition to the increased resistan[ce of] the conductor should be mentioned the specia[l ar]rangement for the ends of these cables requir[ed to] connect them with aerial lines. As the lead [con]ductor is altogether too malleable to connect dir[ectly] with a hard wire, a special ebony or ivory coup[ling] should be made use of for the purpose of mak[ing] the joints. This coupling, which has to be fixed [to] the lead wrapper, has inside a brass tube wh[ich] serves the purpose of a connection between the conductors.

With regard to the outer protecting wrapper [or] sheath upon which depends the duration of [the] cable itself, it certainly does not absolutely g[uar]antee permanence; but it is claimed by the ma[nu]facturers that lead is not the only protecting mate[rial] that can be made use of. For certain purpose[s it] may do well enough, but in the majority of ca[ses] this protection should be strengthened and supp[le]mented by either a coat of tar, inclosed by a tar[red] ribbon, or by the addition of a covering of i[ron] wires.

In summing up the advantages and disadvanta[ges] of these new cables, especially taking into consid[er]ation the reduction of cost to be obtained, it see[ms] to us that they are entitled to a thorough investi[ga]tion and to be practically tried. They afford a be[t]ter insulation than the other styles of cable; the[ir] flexibility admits of their following without dif[fi]culty the turnings and windings of an uneven ro[ad,] and the outside covering may even be used as a [re]turn wire. For telephone communications, for [in]stance, they are undoubtedly very suitable. Also [in] cases where by contact with air gutta-percha becom[es] deteriorated, the new cables may be substituted [with] the advantage.

Description of cable.	Diameter of core.	Outside diameter of dielectric.	Outside diameter of protecting wrapper.	Weight in pounds.	Electro-static capacity in microfarad.	Resistance of dielectric at 19° C. in millions S. U.	Resistance of the conductory core. Temperature.	Resistance, S. U.
Gutta percha covered copper wire.	0·063 (of an inch.)	1.69 (of an inch.)	point of wrapper.	6·73	0·0236	93,708	19·5 C.	0·97
Cable No. I.........	0·056	0·114	0·189	30·36	0·0181	133,164	19·5 C.	12·17
" " II.........	0·067	0·146	0·232	45·10	0·0162	162,756	9°5 C.	7·49
" " III.........	0·067	0·164	0·236	46.	0·0232	143,028	9°5 C.	8·21

74

A NEW KIND OF TELEGRAPH CABLE.

A COMPANY has recently been formed at Cortaillod, in Switzerland, for the purpose of manufacturing a new kind of telegraph cable, the conductor of which is formed of lead and the insulating material of a resinous or sulphurous substance, the whole being covered by a lead tube.

In spite of the slight flexibility of the insulating substance the new form of cable is very pliant, being by no means inferior in this respect to other forms; also the conductor rigorously preserves its

central position in spite of any bends which may be made in the cable.

In a recent number of the *Journal Télégraphique*, M. Rothen has given the results of some tests he has made of this form of cable.

Three specimens of this cable were experimented upon, the two first only differing from one another in their respective diameters, the insulating material being of a resinous nature. The third cable had an insulating dielectric of a sulphurous nature.

The lengths, weights, &c., of the cables were as follows:—

	No. 1 cable.	No. 2 cable.	No. 3 cable.
	Metres.	Metres.	Metres.
Length	90	110	100
	Millimetres.	Millimetres.	Millimetres.
Diameter of conductor	1·43	1·7	1·7
Exterior diameter of dielectric	2·9	3·7	3·9
Exterior diameter of protecting lead tube	4·8	5·9	6·3
	Kilogrammes.	Kilogrammes.	Kilogrammes.
Weight of 100 metres of cable	13·8	20·5	20·9

The cables before being tested were immersed in water for 5 days.

As a standard of comparison a gutta-percha covered copper wire 100 metres long was taken, the diameter of the conductor being 1·4 millimetres and the diameter of the dielectric 4·3 millimetres.

The tests were made with a battery of 150 Daniell cells.

The first tests made were for inductive capacity, the results being as follows:—

	No. 1 cable.	No. 2 cable.	No. 3 cable.
Capacity in microfarads per 100 metres ...	·0184	·0162	·0232

The capacity of the gutta-percha wire per 100 metres was ·0237 microfarads.

The insulation resistances of the cables measured by the ordinary deflection method were as follows:—

	No. 1 cable. Megs	No. 2 cable. Megr.	No. 3 cable. Megs.
Insulation resistance in Siemens' units per 100 meters ...	133,164	162,756	143,028

The resistance of a similar length of the gutta-percha wire was 93,708 megs., the temperature of the tank in which the cables were immersed being 19° C.

The conductor tests gave the following results:—

	No. 1 cable.	No. 2 cable.	No. 3 cable.
Resistance of conductor in Siemens' units per 100 metres.	12·17	7·49	8·21
Temperatures	10·5° C.	9·5° C.	9·5° C.

The resistance of the copper conductor of the gutta-percha covered wire per 100 metres at 19·5° C. was found to be ·97.

If we compare these results by allowing for the varying diameters of the cables we get the following:—

	Insulation resistance.	Inductive capacity.	Conductivity.
Gutta-percha cable with upper conductor.	1·000	1·000	10·000
No. 1 cable	1·987	·558	·998
No. 2 "	2·208	·540	1·147
No. 3 "	1·817	·826	1·047

These results show that the three cables have an average specific insulation resistance of about double that of gutta-percha, whilst the specific inductive capacity of cables 1 and 2 is rather more than one-half that of gutta-percha. The conductivity of the conductor is extremely low, being only about $\frac{1}{10}$th that of copper.

THE Chilian fleet has destroyed the submarine cable off Arica. Telegraphic communication with Autofagasta is also interrupted.

June 79

BY the conditions of our treaty with Afghanistan, a line of telegraph will be erected between Cabul and India, *via* the Khurum Valley.

75

PROGRESS IN SCIENCE AND THE ARTS.

General Science.

In the course of an editorial on the Brooks Underground Telegraph, concerning the merits of which we gave an account in last week's issue, the *Journal of the Telegraph* gives in its adhesion to the general principle of underground telegraphy in the following statement: "A thoroughly insulated and reliable telegraph cable, which shall supply the means of conducting telegraph wires underground in cities and under rivers and other bodies of water that must be crossed by the wires, has become a necessity." It then proceeds to give a cordial indorsement of the Brooks system as the best, cheapest, etc. Our contemporary is still disposed to confine the utility of the underground system of telegraphy to cities, in the face of the example of Germany. This partial concession, however, to the irresistible logic of events is somewhat inexplicable, in view of our contemporary's admission that "the Brooks cable can be put down at a relatively less cost than air-lines can be constructed (where a large number of wires is required), and the expense of maintenance will be but a small percentage of that of air-lines. It is estimated that the average yearly deterioration of air-lines is 10 per cent; but *these cable lines will be practically indestructible, and, once laid, can be relied upon indefinitely.*" [Italics are ours.—ED.] In the face of these admissions, and with the defects of the aërial system so obvious and notorious, the conservatism of our contemporary in limiting to the cities the utility of a system which it admits to be practically perfect, is incomprehensible.

Apropos of the Superiority of Subterranean Lines of telegraph, the Cologne *Gazette* further justifies our long-since expressed confidence in the system by the statement that the storms which have lately raged in Germany have demonstrated, in the most unmistakable manner, the fact that previous to the extended adoption of the underground plan, telegraphic communication was frequently interrupted throughout the empire with immense inconvenience. Since its introduction, in spite of snow and storm, not the slightest interruption has ever occurred in the telegraph service.

City Notes.

Old Broad Street, March 27th, 1879.

THE DIRECT UNITED STATES CABLE COMPANY.—The half-yearly general meeting of this company was held at the City Terminus Hotel, on Friday the 21st March. Mr. John Pinder, M.P., the chairman, presided, and in moving the adoption of the report, an abstract of which has appeared in *The Times*, after referring to the financial results of the half-year's working, which are given in the report, said the gross earnings, in spite of the general depression in trade, had increased by £5,700, being at the rate of nearly 7 per cent., as compared with the corresponding period of 1877. The total expenses showed a decrease of £3,300, equal to 13 per cent., due, however, principally to the comparison being made with the December half of 1877, in which period they incurred expenditure for repairs. Deducting this item, in order to make the comparison a fair one, the working expenditure had been slightly reduced. It would, however, have been very considerable but for the new charge for duplex royalty, which did not appear in the accounts of 1877. He then alluded with regret to the obstruction which the present Board had met with from interested parties, and said this had continued until the other day, when the arbitration was closed by the delivery of the award. The money for obtaining this must all come out of the shareholders' pockets, and it had been literally thrown away, for the award amounted to about what the liquidator offered to the dissentient shareholders—namely, £13 per share, but with interest, say £15. The dissentient shareholder put forward in his claim as the value of his interest the sum of £76,143—that was, he took his shares as worth £76 each, the par value being £20. The actual amount awarded to him was £15,000, or £15 per share. The expenses of the arbitration would not be far short of £10,000. They had heard lately of the attempt to get up an opposition company in France. The same parties, assisted by a French combination, were, he said, what he might term the promoters of this scheme. It had astonished him to find that French companies such as those who were taking an interest in this scheme should have looked so little into facts and figures. He had been to Paris accompanied by other gentlemen interested in Atlantic submarine telegraphy, and they had interviewed the leading men connected with those financial companies. He told those gentlemen that the Direct Company had many advantages in its greater security from its connexion with the the Anglo-American Company, and that in every sense it was a much more valuable property than their new cable could be, but that the shares of the Direct Company, at the time he was speaking to them, were at a discount of close upon 50 per cent. He pointed out that the company, if brought out, must of necessity come down to the same level, and that if they persisted in their scheme after this information the moment their cable was laid competition would arise—that a shilling, or probably a sixpenny tariff, must be adopted, and although there would be a diminution in this company's receipts, it would entirely prevent the new company from paying one shilling to their shareholders, and the result this company would look forward to would be that they would in time, if they chose, become possessed of the new cable at 30 or 35 per cent. of its cost. He pointed out to them that there was no necessity whatever for a new cable, seeing that the existing cables were equal to three or four times the amount of work now offered, and seeing that since the Anglo and Direct Companies had both applied the duplex principle, their carrying power had been very greatly increased. The result of the visit, which was three months ago, was no doubt to open the eyes of the financiers, who were still wisely hesitating. He was told that the *amour propre* of the French people must be satisfied, that the whole of this great telegraph enterprise centred in England, and that France should share it, although France contributed only about 11 per cent. of Atlantic traffic. He had always held that submarine telegraphy should have an international character, and with that view and in order to meet the French susceptibility, the Atlantic companies were prepared to establish a company in France, with a French representation, using the Brest cable for the scheme to work in harmony with the existing systems. The promoters of the new scheme said they had got a concession from the French Government. It had been stated that the head of the combination was to receive £20,000 for this concession with a permanent position as president of the company. He also understood that the gentleman who was to manage the company was to secure for himself a remunerative position, and that the financiers who were said to be backing it up were to receive a very large amount of money other than what was required for the construction of the cables. As to the concession, he might mention that there was already a concession from the French Government held by the Anglo Company, which gave them very important advantages, with a preference of all the French traffic, and this concession had still eleven years to run. He was anxious to obtain a sight of the new concession. He applied at the Government offices, but found for some reason, although one of the leading Ministers told him he saw no reason why a copy of it should not be given them, up to that moment they had not received a copy of it. He was told, however, by the same French Minister that it was merely a landing right, and that the French Government would be prepared to give such a concession to any respectable company who might ask for it. As to the amount of promotion money, so far as he could learn, the two cables for which they were asking subscriptions for over £2,000,000 might be contracted for that day for about

76

assets. When they had a surplus of revenue they would be in a position to pay a dividend on the ordinary shares. They could not prophesy when they would be able to pay a dividend on the ordinary shares—it depended entirely on their traffic. When the cables were laid down business was in a more active state in Peru than had been the case ever since, and the traffic had certainly not come up to the expectations originally formed of it, partly from this cause and partly from another cause not within their control—the interruptions to neighbouring lines. The steamer had made one voyage carrying water, and she had also been employed in carrying cargo and towing. She was fitted up and ready for employment in any of the ways stated in the report. She was an excellent vessel. All their cables were in working order, and the cable in store was in perfect electrical condition. They could not tell what effect the war between Chili and Bolivia would have on their traffic, but he thought he might say that for the present month it would have a very favourable effect on the local traffic. The debenture interest was 8 per cent. on £150,000. Any one could see what that amounted to, and the position of the ordinary shareholders as to dividend. Their expenses were excessively small, and it would be their policy to keep them down as much as possible consistent with efficiency. Mr. Gray remarked that the Company's cables extended from the capital of Peru, past Bolivia, on to the capital of Chili, Valparaiso, touching at various intermediate posts. Before war was declared they were asked to connect Autofogasta, one of the Bolivian ports. He then referred to the causes out of which the war arose, and afterwards stated that there would probably be one length, from Autofogasta to Iquique, through which no messages would go; but he anticipated a great local traffic. He felt satisfied that neither of the Governments would injure the cables, because in peace they derived such great benefits from them. In fact, the Presidents of Chili and Peru had told him that they would do all they could to preserve the cables. The report was then unanimously adopted. The other business was disposed of, and the meeting closed with the usual complimentary vote.

SUBMARINE CABLES TRUST.—According to the Report of the Trustees, the revenue for the year was £26,165, from which £1,890 was expended in the purchase of twenty certificates, and £2,000 has been deducted for expenses, leaving a balance of £22,275. Of this sum £10,362 has been applied to the payment of the coupons due on October 15th last, and the balance of £11,913 is carried forward. The amount required to pay the coupon on the 15th inst. is £10,362.

The Western and Brazilian Telegraph Company (Limited) notify that telegrams for Chili, Bolivia, and Peru are subjected to a scrutiny by the authorities in Valparaiso, and stopped or forwarded according to their discretion. The authorities in Valparaiso also intimate that no refund will be made for messages so stopped. This company likewise announce on April 25th, the repair of their Para-Maranham section.

In order to promote the carrying out of an arrangement concluded between the Telegraphic Administrations of Germany and Norway, a company was constituted on April 23rd, in the office of the United German Telegraph Company for the laying and maintenance of a cable between Germany and Norway.

Direct United States Cable Company (Limited). The Board of this Company have resolved upon the payment of an interim dividend of 5s. per share, being at the rate of five per cent. per annum, for the quarter ending March 31st last.

The following are the latest quotations of telegraphs:—Anglo-American, Limited, 55-55½; Ditto, Preferred, 84-85; Ditto, Deferred, 27-27½; Black Sea, Limited, —; Brazilian Submarine, Limited, 6⅛-6½; Cuba, Limited, 8-8½; Cuba, Limited, 10 per cent. Preference, 15½-16½; Direct Spanish, Limited, 1½-2½; Direct Spanish, 10 per cent. Preference, 10-10½; Direct United States Cable, Limited, 1877, 10½-11½; Eastern, Limited, 7¼-7¾; Eastern, 6 per cent. Debentures repayable October, 1883, 104-107; Eastern 5 per cent. Debentures repayable August, 1878, 100-103; Eastern, 6 per cent. Preference, 11½-12; Eastern Extension, Australasian and China Limited, 7¼-7¾; Eastern Extension, 6 per cent. Debenture, repayable February, 1891, 107-110; German Union Telegraph and Trust, 7½-8½; Globe Telegraph and Trust, Limited, 4¾-5; Globe, 6 per cent. Preference, 10¾-11¼; Great Northern, 7¾-8¼; Indo-European, Limited, 20-21; Mediterranean Extension, Limited, 2¾-3¼; Mediterranean Extension, 8 per cent. Preference, 9½-9¾; Reuter's, Limited 9½-10½; Submarine, 220-230; Submarine Scrip, 1½-2½; West Coast of America, Limited, 1¼-1¾; West India and Panama, Limited, 1¼-1¾; Ditto, 6 per cent. First Preference 8½-9; Ditto, ditto, Second Preference, 7½-8½; Western and Brazilian, Limited, 3½-4½; Ditto, 6 per cent. Debentures "A," 93-97, Ditto, ditto, ditto, "B," 87-92; Western Union of U.S. 7 per cent., 1 Mortgage (Building) Bonds, 114-118; Ditto, 6 per cent. Sterling Bonds, 102-104; Telegraph Construction and Maintenance, Limited, 29½-30½; Ditto, 6 per cent. Bonds, 107-109; Ditto, Second Bonus Trust Certificates, 2½-2¾; India Rubber Co., 10½-10¾.

TRAFFIC RECEIPTS.

Name of Co., with amount of issued capital, exclusive of preference and debenture stocks.	Anglo-American Co. £7,000,000.	Brazilian Sub. Co. £1,300,000.	Cuba Sub. Co. £160,000.	Direct Spanish Co. £116,379.	Direct U.S. Co. £1,213,900.	Eastern Co. £3,697,000.	Eastern Ex. Co. £1,997,500.	Gt. Northern Co. £1,500,000.	Indo-Euro. Co. £425,000.	Submarine Co. £338,225.	West Coast America Co. £300,000.	Western and Brazilian Co. £1,398,200.	West India Co. £883,210.
	£	£	£	£	£	£	£	£	£	£	£	£	£
March, 1879 ...	47,550	13,052	3,100	929	15,850	41,225	26,185	15,401	... ...	9,790	... ...	11,688	5,191
March, 1878 ...	48,630	14,239	3,517	880	11,580	38,201	23,112	18,156	... ...	10,055	3,425	12,300	6,377
Increase	... ...	... ...	... ...	49	4,270	3,024	3,073	... ...	... ...	... ...	... ...	... ...	... ...
Decrease	1,080	1,187	417	... ...	... ...	... ...	... ...	2,755	... ...	265	... ...	612	1,186

(The figures in this Table are as accurate as it is in our power to make them, but we do not guarantee their correctness.)

fund, which now stands at £75,017 15s. 11d.

A NEW KIND OF TELEGRAPH CABLE.

May 77

A COMPANY has recently been formed at Cortaillod, in Switzerland, for the purpose of manufacturing a new kind of telegraph cable, the conductor of which is formed of lead and the insulating material of a resinous or sulphurous substance, the whole being covered by a lead tube.

In spite of the slight flexibility of the insulating substance the new form of cable is very pliant, being by no means inferior in this respect to other forms; also the conductor rigorously preserves its central position in spite of any bends which may be made in the cable.

In a recent number of the *Journal Télégraphique*, M. Rothen has given the results of some tests he has made of this form of cable.

Three specimens of this cable were experimented upon, the two first only differing from one another in their respective diameters, the insulating material being of a resinous nature. The third cable had an insulating dielectric of a sulphurous nature.

The lengths, weights, etc., of the cables, were as follows:

	No. 1 cable.	No. 2 cable.	No. 3 cable.
	Meters.	Meters.	Meters.
Length	90	110	100
	Millimeters.	Millimeters.	Millimeters.
Diameter of conductor	1·43	1·7	1·7
Exterior diameter of dielectric	2·9	3·7	3·9
Exterior diameter of protecting lead tube	4·8	5·9	6.3
	Kilogrammes.	Kilogrammes.	Kilogrammes
Weight of 100 meters of cable	13·8	20·5	20·9

The cables before being tested were immersed in water for 5 days.

As a standard of comparison, a gutta percha covered copper wire 100 meters long was taken, the diameter of the conductor being 1·4 millimeters and the diameter of the dielectric 4·3 millimeters.

The tests were made with a battery of 150 Daniell cells.

The first tests made were for inductive capacity, the results being as follows:

	No. 1 cable.	No. 2 cable.	No. 3 cable.
Capacity in microfarads per 100 meters	·0181	·0162	·0232

The capacity of the gutta percha wire per 100 meters was ·0237 microfarad.

The insulation resistances of the cables, measured by the ordinary deflection method, were as follows:

	No. 1 cable.	No. 2 cable.	No. 3 cable.
	Megs.	Megs.	Megs
Insulation resistance in Siemens' units per 100 meters.	133,161	162,750	143,628

The resistance of a similar length of the gutta percha wire was 63,708 megs., the temperature of the tank in which the cables were immersed being 19° C.

The conductor tests gave the following results:

	No. 1 cable.	No. 2 cable.	No. 3 cable.
Resistance of conductor in Siemens' units per 100 meters	12·17	7·49	8·21
Temperatures	10·5° C.	9·5° C.	9·5° C.

The resistance of the copper conductor of the gutta percha covered wire per 100 meters, at 19·5° C., was found to be ·97.

If we compare these results by allowing for the varying diameters of the cables, we get the following:

	Insulation resistance.	Inductive capacity.	Conductivity.
Gutta percha cable with up. per conductor	1·000	1·000	10·000
No. 1 cable	1·987	·558	·098
No. 2 "	2·208	·510	1·147
No. 3 "	1·817	·826	1·017

These results show that the three cables have an average specific insulation resistance of about double that of gutta percha, while the specific inductive capacity of cables 1 and 2 is rather more than one-half that of gutta percha. The conductivity of the conductor is extremely low, being only about 1-10th that of copper.

77

The Brooks Underground Telegraph Cable.

THE Brooks underground telegraph system, the details of which, though familiar to telegraphic engineers, have received but little publicity, appears during the past two years to have been quietly establishing its claims as a simple and effective solution of the problem of underground telegraphy; and, from the developments of the last few days, it is very probable that it may soon come into general use, in this country at least.

The system of Mr. Brooks differs from all others in the fact that the material employed for maintaining the insulation of the line is a liquid—paraffine oil—which is known to possess, for this purpose, qualities of the highest order; and in laying it the wires—thirty, forty, or fifty, as may be required—covered with cotton binding, are placed in an iron pipe, conveniently located, and the pipe line filled with oil—allowed to run in until full, the maintenance of the supply being assured by providing an elevated vessel of the material at intervals, so that a constant pressure will be kept within the pipe. This is practically all there is about it, and its extreme simplicity appears to be not the least of its merits, as one of the great objections advanced by the advocates of the post system has been the great expense of laying and maintaining underground lines.

Upon the question of its practical working we now have very good testimony, and this, we are pleased to be able to state, is unqualifiedly favorable. The first line constructed upon this system, and which was actually put to work, was laid about two years ago. It was about a mile in length, and is reported to have been successful beyond all expectations; its insulation at the end of two years having improved rather than deteriorated. The next experiment was made at the instance of the P. W. & B. Railroad, a submerged line being laid across the Schuylkill. It gave good results, and has ever since been in operation, its insulation, like that of its predecessor, having increased. Since that time a number of lines have been laid; one connecting the switch-boxes with the signal tower of the Pennsylvania Railroad west of the passenger depot in West Philadelphia; another across the Christiana and Brandywine creeks at Wilmington; and two across the Hackensack river, at Jersey City. At the present time negotiations are pending, according to our authority, for connecting Camden with Philadelphia by a line across the Delaware, for the laying of a line across the Hudson at New York, and for a line between New York and Philadelphia. The advantages of a meritorious and reliable system of underground telegraph over the old aerial system have been so often pointed out in the *Journal* that their repetition here would be useless. We have simply to record the progress of events from week to week, a task in the case of this item that we perform with peculiar gratification.—*The Engineering and Mining Journal.*

78

THE NEW GERMAN-NORWEGIAN CABLE.

AT a recent conference held in Christiania, it was agreed between the representatives of the German Empire and the two Governments of Norway and Sweden, that Germany shall, at her own cost, lay down a three-wired cable from Romoe, an island off the west coast of the Schleswig and the Norwegian coast, at a point between Mandal and Arendal. From that place the Norwegian Government undertakes to carry the line on so as to connect it with the whole Scandinavian telegraph system.

The cable is estimated to cost two million crowns, about £95,000, and it remains in the possession of Germany who has also to repair it at her own cost. It is further specified to be laid by October 1st of this year. Norway is to put up a new wire from the landing point to the capital, together with a cable-house. As to the correspondence to be sent through this new cable, it is resolved upon that all telegrams from Norway to Germany itself, are to be transmitted by it, and at least three-fifths of all the other traffic with foreign countries, excepting the Russian, English and Danish, unless it should prove more expensive to use the new route than the other existing ones. On the other hand, Germany has power to forward all messages she is able to collect and forward them through her new cable, unless the sender has indicated another route.

Besides this new cable Norway has three ways for her telegraphic communication abroad, viz., through Sweden and by cable from Trelleborg to

* Blakey Bros. and Emmott.

Rügen, from Arendal to Fredericia in Denmark (cable to Hirtshals), and from Ekersund to Peterhead in Scotland, this last being reserved for her English traffic. If the new line is slower than the existing ones, Norway has a right to forward her telegrams by the best route. Besides, Norway may become free to forward her telegrams by any way she choses by purchasing one-half of the cable, or by giving notice to the convention at the end of 20 years. Norway has a very large correspondence with all sea-faring countries because of her extensive mercantile navy, and it is said that the correspondence of Germany with Norway is second only to her correspondence with England.

Hitherto Germany has been obliged to send her telegrams to Norway through Denmark and Sweden, a course which has been manifestly irksome to her, owing perhaps in part to the uneasy political relations between her and the Danes. In 1878 she tried to effect an arrangement similar to that which has just been concluded, but Norway refused because of the great expense which she was then asked to share. The new scheme will, of course, deprive Denmark of the traffic which formerly passed over her lines between Germany and Norway; and, seeing that the present means are ample for the necessities, the Danes are disposed to regard the new act of the German Government as proceeding from a desire to have a line of their own, in case of war between Germany and their own country. This idea was also expressed in the Norwegian Storthing or Parliament, when the Government asked for the money for the new line.

The Underground Telegraph in Germany.—In continuation of our late reference to the progress of the system of subterranean telegraphs in the German empire, we may note that an underground cable now connects the cities of Berlin, Halle, Leipsic, Cassel, Frankfort, Mayence, Mannheim, Carlsruhe, Rastadt, and Strassburg: another line connects Berlin, Magdeburg, Brunswick, Hanover, Münster, Düsseldorf, Elberfeld, and Cologne: another connects Berlin and Hamburg, with branch lines to Kiel and Cuxhaven; to Bremen and Emden, thus joining the North Sea cable communicating with England and America. The money lately voted (1,830,000 marks) by the Reichstag for the further extension of the underground telegraph, it is said, "will be employed in connecting the towns and harbors along the Baltic, and for the furtherance of commerce and coast defense." On the lines already completed, the sum of 18,000,000 marks ($4,500,000) has been expended. May 79

The Extension of the Pneumatic Tube System, which is at present going on in this city, will, when completed, connect the offices of the *Herald*, *Times*, *Tribune*, *World*, *Sun*, and *Staats-Zeitung* with the Western Union Telegraph building. At present the W. U. Telegraph Company has two lines of pneumatic tube in operation, one to 134 Pearl street, and the other to the Stock Exchange.

May 79

Brooks' Insulated Underground Cable.

A THOROUGHLY insulated and reliable telegraph cable, which shall supply the means of conducting telegraph wires underground in cities, and under rivers and other bodies of water that must be crossed by the wires, has become a necessity. The rapid increase of wires, especially in large cities, is already rendering further construction a difficult problem. Within the last two years this increase has been greatly stimulated by the demand for special wires and telephone communication, and the practicable limit for suspended wires in many places has very nearly been reached. It is probable that the time is near at hand when additional wires must be put underground, in cities at least, and eventually all wires in such places will be put out of sight, and where they can be better protected than is now possible. This would have been done before but for the fact that no system had been devised which filled the requisite conditions.

Much time, labor and money has been expended in the efforts to devise and perfect such a cable, but until the underground cable telegraph invention of Mr. David Brooks, of Philadelphia, was devised, the difficult problem has not been satisfactorily solved. This cable seems to have the requisite elements, and very thorough tests of it during the last three years have fully met the expectations of the inventor and others who have known of them and were interested in the result. The core of this cable may be of any number of copper wires, the superior conductivity of the copper compensating for the small size of the wire necessarily used when a large number of wires are to be made into one cable.

The advantages of this system, especially when a large number of wires and a perfect insulation are required, will be readily seen. Any required number of wires can be laid within a moderate compass. As they are underground or under water, they are not subject to the interruption and damage inseparable from air lines. Storms of wind, rain and sleet, which are so damaging and destructive to ordinary telegraph lines, have no effect upon these cables,

bers, if its value and usefulness were properly appreciated its membership would be doubled at least. It has been and is most judiciously and economically managed, and its reliability and permanence are assured by its accumulated fund. The payments required to be made are assessed in such a manner that any single payment is small in amount, and therefore does not bear heavily upon even those of moderate salaries and income. Under such circumstances it would seem as though all persons engaged in the telegraphic service, who had others dependent for support in whole or in part upon them, would, if eligible to membership, at once seek admission.

Those of us who were in the service before the organization of the Association, well remember the constant applications made for contributions to bury the dead, or relieve the living who were left helpless by the death of some telegrapher. It is a much more effective way of making such provision, to join the Association. The amount collected by subscription in individual cases is necessarily small and insufficient, but a thousand dollars affords substantial relief, and at a time when it is most needed. Besides there is the satisfaction of knowing that it is not charity asked for or received, but a provision for which a consideration has been paid, and a matter of right.

There is nothing novel in the views above presented, but they may serve to call the attention of some to the advantages offered by the association, and induce them to provide against the evil day when those dependent upon them shall find their supporter taken from them.

It might, perhaps, be found practicable either by extending the scope of the present Association or by the organization of one specially for the purpose to make further provision in cases of sickness or disability of telegraph employés. This seems to be a desirable end to be accomplished, and it may be well to agitate the matter with a view to ascertaining the opinions of the telegraphers upon the subject. Perhaps, if such an arrangement were properly started and under proper management, the managers of the Western Union Company would aid and favor it as they have done the Mutual Benefit. The idea is at this time merely thrown out for consideration. Whether anything shall come of it or not we have the Mutual Benefit, and are assured of effective assistance for those dependent upon us in case of death, if we choose to avail ourselves of its privileges.

MEMBER.

A Suggestion for Improvement of Callaud Batteries.

Objections to Underground Telegraph Lines

MR. W. H. PREECE, electrician of the Postal Telegraph Department, in a recent lecture before the Society of Arts, said there are 10,000 miles of underground wires in Great Britain, but the known facts which tell against the extension of the underground lines are: There is an increase of three or four times in the cost; their capacity for carrying currents is reduced three or four times; the gutta percha coating is attacked not only by rats and mice, but very largely by an insect called the *tempeltonia crystallina*, and is also influenced by a fungus.

May 79

79

The New German-Norwegian Cable.

AT a recent conference held in Christiania, it was agreed between the representatives of the German Empire and the two Governments of Norway and Sweden, that Germany shall, at her own cost, lay down a three-wired cable from Romoe, an island off the west coast of Schleswig and the Norwegian coast, at a point between Mandal and Arendal. From that place the Norwegian Goverment undertakes to carry the line on so as to connect it with the whole Scandinavian telegraph system.

The cable is estimated to cost 2,000,000 crowns (about $460,000), and remains in the possession of Germany, who has also to keep it in repair at her own cost. It is further specified to be laid by October 1st, of this year. Norway is to put up a new wire from the landing place to the capital, together

Telegraphy in South Australia.

THE number of local messages transmitted in South Australia in 1878, was 376,244. Of intercolonial messages 99,170 were sent, making a total of 475,414, for which cash to the amount of £32,425 was received in the colony. The rate in 1877 was rather less, as the corresponding number of messages in 1877 was only 408,477, and the cash receipts £27,747. There has been not only a large augmentation in the number of messages, but an increase also in their average length. The enlargement in the business between the Australian colonies and Europe is particularly striking, the increase in the number of

The South African Cable.

THE telegraph cable to connect the European and Asiatic telegraphic systems with Cape of Good Hope will be 4,000 miles long, extending from the Red Sea cable, at Aden, around Cape Gardafui and along the east coast of Africa to Port Natal, where it will make a junction with the present land line to Cape Town. The cable will be laid along the coast, the depth of water being moderate along that side of the continent, and the facility for repairing possible breakages has been carefully ascertained. The cable will touch at Zanzibar, Mozambique, Sofalo, Delagoa Bay, and thence to Durban, as the submarine terminus, from which point the land telegraph becomes available to complete the circuit to Cape Town. The cost of constructing and laying the cable is estimated at $7,500,000. The line from Durban to Zanzibar is to be finished in July, and the whole cable by the middle of November.

May 79

The Proposed French Atlantic Cable. Failure to obtain Subscriptions to the Stock. June 79

The combination of French financiers which is seeking to place these shares on the public have, if we are correctly informed, been very considerably disappointed in the result of their appeal to the patriotism and *amour propre* of the French people. These love their country well, but they are evidently not disposed to invest their money in an undertaking more than doubtful in its results, and at prices, by comparison with an existing enterprise of the same character, rather more than twice its actual value. Not only are the shares which are offered for subscription in the new company twice the market value of the shares in the Direct Cable Company, but they are offered at about 30 per cent. above the price which has been actually paid for them by the French syndicate, who are seeking to relieve themselves of the liability which they have incurred. One-half of the nominal capital required for the new company has been, it is said, taken by a group of financiers at 25 per cent. discount; the public are invited to subscribe for the remainder at 27½ per cent. above the price at which they have been thus taken by the syndicate. There is yet another interesting fact in connection with the prosecution of this undertaking, formed to secure for France what is termed her "telegraphic independence." The promoters of the scheme are to receive 1,000 shares of 500 fr., or £20,000, as a bonus, and they are to receive, in addition, 5 per cent. of the whole profits after the ordinary shareholders have received 5 per cent. as their proportion.

The bourgeoisie and the small capitalists of France whom it is sought to attract to this scheme have failed, in spite of all the efforts of the group of financiers, to see the advantages which are to be obtained from securing independence of telegraphic communication for France. The profits to be derived from making and laying the cable will go to a German manufacturing firm carrying on its business in London; the loss which will inevitably occur upon the enterprise will fall upon French citizens; the only benefit which will be obtained, that of temporary cheaper telegraphic communication with America, will be enjoyed exclusively by the great capitalists and financiers of Paris and elsewhere, who may have the advantage of the reduction of rates which competition with the Anglo-American Company will surely effect. The Anglo-American Company have already absorbed the French cable laid from Brest a few years since, and secured at a discount of about 50 per cent. the Direct United States Cable, which was to have accomplished so much for the cause of telegraphy, civilization, and the commerce of the world. They will as surely succeed in getting possession of the latest "want of the age," and they will obtain it on their own terms. They have four cables already at work, and they will, acting, and very properly so, in the protection of the interests of the shareholders, reduce the rates to a point at which it will be impossible for the new company to secure a profit, and then the end will be, as in every other case since the world began, that competition will end in combination, and the shareholders of the new French company will be fortunate indeed if they escape with a loss less severe than that which has befallen the unfortunate victims of the Direct United States Cable enterprise.

We believe, as already stated, that the response of the French people to the new scheme has been an all but complete failure. Already overtures have been made to the Anglo-American Company for terms. The French syndicate are alarmed at the extent of the liabilities which they have incurred, and contemplate with serious apprehension the future calls which may be made upon them for carrying out this wholly unnecessary and doubtful enterprise. The Anglo-American Company have made their arrangements for establishing a company having its headquarters in Paris. It will take over the original concession granted by the French Government, and the Brest cable, which was the fruit of that concession, will be handed over to this new company, with all its rights and privileges and all its business connections in France, England, and America. France will thus secure the object which the promoters of the new company profess to have in view—viz., "the telegraphic independence" of the country. What more is necessary? One thing is necessary, that is, that funds should be provided to give activity to the works, and employment for the telegraph ships of the contractors. The appeal for these funds has been met with a prompt, decided, and unequivocal answer from the French public. The money must be provided, therefore, by the French syndicate, or the proposed scheme must end, as others have done, in an arrangement with the Anglo-American Company.—*The Railway News.*

Underground Telegraphs.

Articles of incorporation of the Brooks Underground Telegraph Company have been filed in the County Clerk's office, New York. The route of the line is from the corner of Broadway and Dey street to West street, thence to some prominent point on the North River, across the North River to Jersey City, thence to Philadelphia, and thence to various points in the United States, following the route now occupied by the Western Union Telegraph Company. The capital stock is fixed at $200,000, divided into 2,000 shares of $100 each. The right to increase the capital stock to $1,000,000 is reserved. The shareholders of the company are David Brooks, of Philadelphia, 500 shares, and Anson Stager, of Chicago, and Norvin Green, of this city, 750 shares each. The company is incorporated for fifty years, beginning May 21, 1879, and terminating May 21, 1929. June 79

APH. [June 1, 1879

A Pacific Cable.

That eventually a cable will be laid from the Pacific coast to the Sandwich Islands, Japan and China there can be no doubt. When this line is established the telegraphic circuit of the world will be complete. Mr. Cyrus W. Field holds an exclusive concession from the government of the Sandwich Islands for such a cable, as was announced at the recent celebration of the twenty-fifth anniversary of the organization of the company which resulted in laying the Atlantic cable. Concessions will also be obtained from Japan, and probably from China. We understand that the organization of a company to carry out this project is proposed, and that Mr. Field has agreed to contribute $100,000 in cash as a subscription to its capital stock. It is expected that capitalists upon the Pacific coast, who will naturally feel a pride in the establishment of such a line, will also contribute liberally to give the project a start and carry it through. The business interests of the coast would be greatly facilitated by such a connection.

Mr. Field sailed for Liverpool on the 21st ult. in the Cunard steamship *Bothnia*, and during his sojourn in England will make such investigations in regard to the manufacture and laying of a Pacific cable as will enable him and his associates to act understandingly in furthering the proposed enterprise. No steps will be taken towards organizing a company until after the return of Mr. Field. It is to be hoped that sufficient encouragement will be extended to insure the construction of the line at no distant period.

Underground Telegraph Lines.

The subject of underground telegraph lines, especially for large cities, is attracting much attention from the public and press. We print extracts from several leading newspapers, with accounts of interviews with leading telegraph officials on the subject, which will be read with interest. If it shall be conclusively demonstrated, as there is good reason to believe it will be, that the invention of Mr. Brooks of a cable especially adapted to such lines has obviated the difficulties which have hitherto prevented carrying city wires beneath the streets, much relief will be afforded to telegraph companies as well as the public from a serious and constantly aggravated difficulty. There is apparently no limit to the demand for wires for telegraphic purposes, and to adequately provide for it a change in the construction of city lines is rapidly becoming a matter of absolute necessity. June 79

UNDERGROUND TELEGRAPHS IN CITIES.

The *New York Tribune* in an article on proposed changes in city telegraph lines in connection with the Brooks underground cable has the following:

General Stager, by whom the patent of the Brooks cable was purchased, said recently: "I regard the new plan as entirely feasible, and I believe it can be used with regularity and certainty for short distances. It has been in use in Philadelphia for a distance of two miles for two years. We have laid out three routes for this city along the line of the elevated railways. There are 16,000 poles now standing on this island, and our engineers estimate that when the new system is in operation there will be only 1,600 poles left standing in the cross-streets. If the city gives us the use of the streets we may be able to shorten the routes by placing the trunk lines of wires under ground instead of along the elevated railway structures. We shall offer the city the advantage of putting all its police and fire alarm wires under ground. Submarine cables at the most have only seven wires. There will be twenty wires in each of our tubes, and for telephone purposes probably fifty. Chicago has a line laid containing 100 wires which works splendidly. We have in one sense of the word begun work, as we are making machinery to prepare the wires. We do not propose to break ground until the system is perfected, which will take fully three months.

"There is no positive arrangement with the Western Union Company as yet for the employment of this system, further than a general agreement that if it can be shown to be serviceable and valuable it will be used. I propose to put it in operation alongside the wires now on poles, and to rely on its success for its adoption by the company." June 79

When asked if he anticipated any difficulty in securing the privilege of excavating in the streets, General Stager said: "There has been a desire for a long time that our poles be taken down. Our answer has been: 'Show us a system by which we can construct a subterranean telegraph and we will cheerfully do so.' We offered to accept any plan that would work, and I have scores of drawings and models, none of which met the emergency until the Brooks patent was tested. I believe that the authorities and the general public will cheerfully yield the privilege of the streets if we will remove the unsightly miles of wire which now obstruct the thoroughfares. It is very doubtful if permission to erect telegraph poles in the large cities will be granted to any corporations in the future. In Germany the rubber insulated underground wires have been abandoned, as it is asserted that the soil, mice and insects destroy the insulation and in time break the circuit. By the new system of insulation of the wires, the iron tubes and the oil exclude moisture, insects and mice. A new era in the adaptation of telegraphy in large cities and across streams may be said to have been begun."

82

the ebonite, and wider spaces than usual betwee the binding screws.

Mr. Conrad W. Cooke exhibited Sykes' electri lock and block system for railway working, and a ingenious new galvanometer of his own inventio for demonstrating the internal current in a voltai cell. The plates of the cell under test are immerse in the liquid at the upper ends of a curiously blow glass tube, which would have the form of a U tub were it not that the bent portion is drawn out fin and coiled into a spiral, in the middle of which i hung a galvanometer needle. The internal curren passing through the liquid in the glass spiral tells it presence by deflecting this needle.

Cowper's Telegraphic Pen; Crossley's Microphon (described in our issue for May 1); Firnhaber's patent synchronous electric clocks, exhibited by Messrs. Edmundson & Co., were also to be seen a work.

Messrs. Elliott Brothers maintained their high reputation as electrical mechanicians by a fine display of galvanometers, keys, and resistance coils; and Mr. Groves exhibited a finished specimen of the Induction Balance of Professor Hughes. An audiometer was also shown by Messrs. Krohne and Lesemann.

The India-Rubber and Gutter-Percha Telegraph Works Company displayed many specimens of their

reason for withholding

believed that all the difficulties will be readily overcome. The greatest objection to the terminus is that, owing to the frequent thunder-storms in the summer, the land wire thence is very frequently out of repair. An alternative route, via Pretoria, is now in course of construction.

The agreement between the Government and the contractors requires that the cables shall be capable of transmitting 14 words a minute; and that the company shall, save in case of *force majeure*, have the portion of the cable between Durban and Zanzibar, laid and open for the transmission of messages on or before the 31st day of July, 1879, and the portion between Zanzibar and Aden, on or before the 31st day of December, 1879. The companies are entitled to connect the cable with all lines of telegraph in the colony of Natal at such points as shall be approved by the Natal Government, and with all land and submarine telegraphs having stations or termini at Aden. The Eastern Telegraph Company agrees to maintain and provide a suitable and properly equipped steamship in the Red Sea or Indian Ocean for the purpose of making repairs to the said line of submarine telegraph between Durban and Aden, it being understood and agreed that such steamship may be employed for repairs to other lines owned or worked by that company. All Government messages (whether Imperial or Colonial) are to have priority to all other messages, at rates equal to one-half of those charged to the general public. The stations on the line are to be open from eight a.m., until eight p.m., and throughout the night, when there is any traffic to forward, or when specially required by her Majesty's Government (whether Imperial or Colonial) to be open. It is provided that the rates to be received by the company owning or working the line for messages (other than Government messages) transmitted thereby, exclusive of charges payable to other companies or administrations, shall not exceed the following; that is to say—between Durban and Aden, and vice versa, 5s. a word; between Zanzibar and Aden, and vice versa, 4s. a word; between Aden and London, and vice versa, by any of the lines of the said Eastern Telegraph Company, a total charge of 3s. 9d. a word, And the said rates shall not be increased without the

[From the *New York Herald*.]

Brooks' Underground Telegraph Cable.—Poles to Disappear from the Thoroughfares and Housetops of Cities.

IT is proposed to carry the telegraph wires of the city underground by means of insulated iron tubes, and eventually remove from the public thoroughfares and housetops all the unsightly poles or network of wires which have been gradually accumulating, especially since the introduction of the telephone, until they have grown to be a nuisance. In this city are 16,000 telegraph poles. When the new system is fully introduced it is thought that not six hundred poles will remain in this city, and these will be chiefly required to convey transverse lines from the main trunks running lengthwise of the island, as near as practicable to its "backbone." The trunk lines, it is thought, will be upon the avenues on which the elevated railroads are built. It is now under discussion whether the tubes will be ultimately carried on the beds of the elevated roads or buried under the streets. The great danger of interruption of the whole telegraphic system by reason of a fire or other serious accident is a strong objection urged in some quarters among scientific men against the use of the elevated railroad structures for the purpose of conveying the tubes.

In discussing the scheme last evening, with a map before him showing the various Western Union offices of the city marked upon it, President Green, of that corporation, said to a *Herald* reporter: "It is the purpose to do away with the pole lines in large cities, but to what extent the exchange will be made in New York is as yet not fully determined. The Brooks Company has had the friendly assistance of the Western Union Company for the purpose of its introduction in all large cities where there is an aggregation of wires at any single point. To what extent good pole lines will be removed for the purpose of transferring wires to underground tubes, is a question that has not yet been fully decided upon, as the expense attending the change has not been provided for. It is probable, however, that no more pole lines will be erected in cities. As fast as poles rot away or wear out the underground system will be substituted."

"Have you the right to go under the streets?"

"The charter of the company gives it the power to go over or under water or underground. The company must ask permission, however, to raise the pavement, and in doing so interfere as little as possible with the traffic of the streets. The new invention is considered a grand stride in practical telegraphy. It is the first practical and economical solution of the difficulties and annoyances of occupying poles and housetops with telegraphic and telephone wires."

"When will the work begin?"

"The down-town wires will be changed first. The company has but just been organized. Some tubes will be laid this summer. Wherever the wires are the most numerous and the poles are the most perishable the changes will be effected first. There are 16,000 poles in the city. Of this number the Western Union and its allies own about ten thousand. With the wires carried up the island in tubes, either on the bed of the elevated railroads or sunk under the earth, less than six hundred poles will be necessary to convey the transverse lines to the various intermediate offices on the island. Fires, for instance, would cripple the use of the tubes if affixed to the elevated roads. Underground they would be free from that danger at least. The rapid accumulation of telephone wires, especially in cities, has made the necessity for a change imperative."

Tel. Telegr. Journ. July 1. 1879

A PACIFIC CABLE.—That eventually a cable will be laid from the Pacific Coast to the Sandwich Islands, Japan and China, there can be no doubt. When this line is established the telegraphic circuit of the world will be complete. Mr. Cyrus W. Field holds an exclusive concession from the government of the Sandwich Islands for such a cable, as was announced at the recent celebration of the twenty-fifth anniversary of the organization of the company which resulted in laying the Atlantic cable. Concessions will also be obtained from Japan, and probably from China. We understand that the organization of a company to carry out this project is proposed, and that Mr. Field has agreed to contribute 100,000 dollars in cash as a subscription to its capital stock. It is expected that capitalists upon the Pacific coast, who will naturally feel a pride in the establishment of such a line, will also contribute liberally to give the project a start and carry it through. The business interests of the coast would be greatly facilitated by such a connection. Mr. Field sailed for Liverpool on the 21st ult. in the Cunard steamship *Bothnia*, and during his sojourn in England will make such investigations in regard to the manufacture and laying of a Pacific cable as will enable him and his associates to act understandingly in furthering the proposed enterprise. No steps will be taken towards organizing a company until after the return of Mr. Field. It is to be hoped that sufficient encouragement will be extended to insure the construction of the line at no distant period.—*The Journal of the Telegraph*, U.S.

83

AUSTRALASIAN TELEGRAPHY.—Of the 588 miles of electric cable to be carried out by the steamship *Scotia*, in order to continue the line of telegraph already complete from Penang to Malacca, and thence laid nearly as far as Singapore, the end was wound on board on the 25th ult., from the Telegraph Construction and Maintenance Company's Works at Greenwich. This fine vessel of 4,600 tons, formerly a paddle ship in the Cunard fleet, and since altered to a double screw, with an additional deck, measures 379ft. in length, her beam being 48ft. She has engines of 500 horse-power, and her speed is 13 knots. A large company of guests, including many representatives of foreign countries, who are assembled to take part in the International Telegraph Congress, went down from Westminster Pier on a river steamer, and boarded the *Scotia* during one of the heaviest showers of the day.

The following are the final quotations of telegraphs for the 26th ult.:—Anglo-American, Limited, 55-55½; Ditto, Preferred, 84½-85½; Ditto, Deferred, 27-27½; Black Sea, Limited, —; Brazilian Submarine, Limited, 6¾-7¼; Cuba, Limited, 8¼-8¾; Cuba, Limited, 10 per cent. Preference, 16-17; Direct Spanish, Limited, 1¾-2¼; Direct Spanish, 10 per cent. Preference, 10¾-11¼; Direct United States Cable, Limited, 1877, 10¼-10¾; Eastern, Limited, 7⅜-7⅞; Eastern, 6 per cent. Debentures repayable October, 1883, 104-107; Eastern 5 per cent. Debentures repayable August, 1878, 101-103; Eastern, 6 per cent. Preference, 11½-12; Eastern Extension, Australasian and China Limited, 7⅜-7⅞; Eastern Extension, 6 per cent. Debenture, repayable February, 1891, 108-111; German Union Telegraph and Trust, 7¾-8¼; Globe Telegraph and Trust, Limited, 4½-5; Globe, 6 per cent. Preference, 10⅞-11⅜; Great Northern, 8⅜-8⅞; Indo-European, Limited, 20½-21½; Mediterranean Extension, Limited, 2½-3; Mediterranean Extension, 8 per cent. Preference, 8¾-9¼; Reuter's, Limited 9-10; Submarine, 225-235; Submarine Scrip, 2-2½; West Coast of America, Limited, 1-1½; West India and Panama, Limited, 1⅛-1⅜; Ditto, 6 per cent. First Preference 8-8½; Ditto, ditto, Second Preference, 7½-7¾; Western and Brazilian, Limited, 3⅜-3⅞; Ditto, 6 per cent. Debentures "A," 96-100, Ditto, ditto, ditto, "B," 88-93; Western Union of U.S. 7 per cent., 1 Mortgage (Building) Bonds, 115-120; Ditto, 6 per cent. Sterling Bonds, 105-107; Telegraph Construction and Maintenance, Limited, 31-31½; Ditto, 6 per cent. Bonds, 109-111; Ditto, Second Bonus Trust Certificates, 2⅜-2⅞; India Rubber Co., 12½-13; Ditto, 6 per cent. Debenture, 105-108.

TRAFFIC RECEIPTS.

Name of Co., with amount of issued capital, exclusive of preference and debenture stocks.	Anglo-American Co. £7,000,000.	Brazilian Sub. Co. £1,300,000.	Cuba Sub. Co. £160,000.	Direct Spanish Co. £116,379.	Direct U.S. Co. £1,213,900.	Eastern Co. £3,697,000.	Eastern Ex. Co. £1,997,500.	Gt. Northern Co. £1,500,000.	Indo-Euro. Co. £425,000.	Submarine Co. £338,225.	West Coast America Co. £300,000.	Western and Brazilian Co. £1,398,200	West India Co. £883,210.
	£	£	£	£	£	£	£	£	£	£	£	£	£
May, 1879 ...	47,910	*12,810	3,100	984	15,970	38,371	25,845	18,917	... ...	11,452	... ...	124,30	5,526
May, 1878 ...	42,990	12,564	3,254	816	11,650	33,650	23,844	19,463	... ...	10,384	1,450	10,652	5,769
Increase	4,920	246	... ...	168	4,320	4,721	2,001	... ...	... ...	868	... ...	1,778	... ...
Decrease	... ...	... ...	154	... ...	... ...	... ...	... ...	546	... ...	... ...	... ...	... ...	243

* Four weeks against calendar month of last year.

(The figures in this Table are as accurate as it is in our power to make them, but we do not guarantee their correctness).

Iron July 5 1879

beginning the first Wednesday of September.

A TELEGRAPHIC CABLE.—*The Railway World*, of Philadelphia, says:—Arrangements have been almost completed for the laying of a cable of the Brooks underground telegraph across the river Delaware, from Walnut Street wharf to Camden. The cable will be composed of forty wires, of which ten are telephonic and the others Morse wires. The former are about the thickness of ordinary sewing thread, and the telegraphic wires are about as thick at druggist's twine. They will be inclosed in a welded iron tube, having an inch and a half diameter inside. This tube will be laid along the bed of the river on the course of the present cables of the Western Union Telegraph Company, and will be carried over Smith's Island, below the surface of which it will be sunk a depth of 2 feet.

THE ENGINEERING AND MINING JOURNAL.

JULY 2, 1881.]

See Notes

Underground Telegraph Wires.—Our article on the Philadelphia Mining Stock Market announces the fact that Philadelphia will be the first city in the United States to make a trial of the underground telegraph. The Common Council has granted to the National Underground Electric Company permission to lay its conduit for electric conductors under certain streets. The number of telegraph wires in all parts of the city makes it absolutely necessary to adopt that measure. The enterprise is reported to be in the hands of those who are fully capable of making it a success; after which, the company will extend its operations to New York, Boston, and other large cities. Mr. Fawcett, the Postmaster-General, in replying to a question recently asked in the British House of Commons, has communicated some very interesting facts. London, in proportion to its size, has suffered more from the dangers of overhead wires than any of the large towns and cities of Great Britain. Some of the streets are literally cobwebbed with wires crossed and recrossed in every conceivable direction, the danger to pedestrians and others in high winds or during extremely low temperatures having become a very grave matter. Mr. Fawcett says that the post-office authorities are endeavoring to reduce the mileage under the old system as rapidly as possible. The progress made is shown by the facts that in 1877 there were 1720 miles within a radius of four miles of the general post-office, whereas now the mileage is only 500, and the underground wires have increased from 3350 miles to 4308 miles in the same time. The tube manufacturers, founders, and those engaged in kindred industries will be especially benefited by the general adoption of the system.

86

il n'est pas superflu de rappeler l'expression brutale dans sa naïveté.

Voici ce que dit l'académicien Babinet à la page 19 du VII[e] volume des ÉTUDES SUR LES SCIENCES :

« *Après avoir constaté que tous les télégraphes maritimes à longue portée se trouvent maintenant hors d'état de fonctionner*, j'ai discuté les *difficultés* qu'il faudra surmonter pour la pose d'un télégraphe sous-marin unissant le Nouveau Monde et l'Ancien. Parmi ces difficultés, il y a la nécessité d'un calme de plusieurs jours pour déployer un fil de plus de mille lieues de longueur.

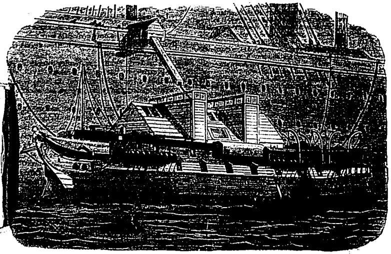
« Il y a le poids de ce conducteur qui fait la charge de deux grands vaisseaux qui se séparent au milieu de l'Atlantique, voguant l'un vers l'Europe, l'autre vers l'Amérique ; cette charge est au comble, même avec un fil gros comme le petit doigt.

« Il y a la profondeur de 7 kilomètres, à cause de laquelle le conducteur peut à peine supporter son propre poids avant d'arriver au fond de l'Océan.

« Il y a la crainte que les inégalités du sol de la mer et les actions mécaniques n'amènent la rupture du conducteur.

« Il y a la prompte détérioration de ce conducteur par l'action corrosive de l'eau salée, jointe à un prix de revient de 18 millions de francs.

« Il y a enfin un fonctionnement d'une efficacité très-problématique, puisqu'une dépense d'environ cinquante mots au moyen du Transatlantique qui a fonctionné peu de jours, a exigé trente heures pour sa transmission. Ce n'est pas tout que d'établir une communication entre deux points éloignés l'un de l'autre d'un hémisphère entier, il faut encore que le



Un chaland anglais apportant au *Great Eastern* le premier câble transatlantique français.

nombre des signaux échangés produise une véritable correspondance. Or, deux mots par heure ne font pas une correspondance suffisante. »

Ce précieux morceau, corroboré par d'autres ultérieurs, a été rédigé en 1860 et réimprimé sans en changer un i en 1863, comme si l'auteur tirait gloire des arguments qu'il avait publiés.

Ce livre se vend actuellement chez Gauthier-Villars. Il a été cliché pour ne point être épuisé. L'éditeur se réserve les droits de poursuivre les contrefacteurs.

La collection des *Etudes sur les Sciences d'observation et leurs applications pratiques* a eu tant de succès qu'elle a été continuée sous le même titre par un auteur non moins célèbre que M. Babinet, quoiqu'il ne fasse point encore partie de l'Académie.

Si l'on veut bien prendre la peine de lire ce curieux factum, on reconnaîtra que les hommes d'initiative et de pratique se sont chargés de fournir une réponse catégorique et complète aux objections qui dans la plupart des affaires scientifiques auxquelles il s'est trouvé mêlé.

L'année même de la mort de Babinet, une Compagnie française entreprenait la pose d'un câble transatlantique destiné à faire concurrence à la ligne anglaise.

Le *Great Eastern* venait à Brest pour procéder à cette gigantesque opération.

On croyait alors qu'il n'y avait que le navire géant qui pût servir à la pose du câble monstre. Comme il ne pouvait se mettre à quai de l'usine de Greenwich, où il avait été construit, on fut obligé d'employer pour le transporter à bord le secours de pontons.

L'*Illustration* du temps a conservé la trace de la manière dont s'est opéré le transport comme beaucoup d'autres précautions intermédiaires devenues superflues.

S'adresser pour tout ce qui concerne la rédaction et l'administration du Journal, 16, rue du Croissant, Paris.

Le Gérant : A. ARAUD

87

heating of the water at the terminal causes a circulation which is sufficient for keeping the latter cool. The wire forming the core of the terminal is pressed upwards by a weight, float, or spring against a small shoulder or burr at the mouth of the

THE TELEGRAPHIC JOURNAL AND ELECTRICAL REVIEW.

VOL. VIII.—No. 170.

CABLE PROPERTY.

THE past year has been a very advantageous one for the telegraph companies, at least, if we may judge by the considerable increase of the traffic receipts. In nearly every instance an addition to revenue has resulted on the year's business as compared with the previous year. The Anglo, Brazilian Submarine, Cuba Submarine, Direct Spanish, Direct United States, Eastern, Eastern Extension, the Great Northern, and The Submarine Companies all mark important increases. The returns of the West Coast of America and of the Western and Brazilian we have not at hand, whilst those of the West India and Panama Company show a slight decrease.

We do not think we shall be considered optimists when we assert that probably at no time in the comparatively recent history of submarine telegraphic enterprise has the future appeared more hopeful. Indeed, so rapidly does the business of the companies promise to extend that were it only possible to obtain greater permanency for the ocean threads, there would soon scarcely be found a better paying class of investment.

As, however, that lasting cable has not yet been proved to have been discovered, it is for the time necessary to pay particular attention to the accumulation of the respective reserve funds.

At what amount each should stand cannot well be told by any beyond the directorate or the scientific staff of any company, and not even by them, with any degree of accuracy.

This must depend on the nature of the ground over which the cable passes, the type of cable laid, the length of time it has been down, the amount of repair which has from time to time been effected on it, and also on so many considerations that it is impossible, as we before said, to estimate at what exact sums the reserve funds should stand; but, speaking generally, it will, we believe, be found that they are yet by far too meagre.

It has, therefore, been with considerable satisfaction that we have noted the constantly progressive increase of receipts, as it will enable the companies to obtain that position of security without which their properties seem destined to remain at their present low prices.

Another source of increasing value is to be found in the additions to existing systems, which should prove of pecuniary advantage to the parent stems, even though those additions may not be in themselves paying concerns. This would, of course, only be the case where the added but non-paying line was owned by a separate company. But where it is so, every extension of a system must render the pre-existing portion of that system of greater value than before.

On taking together the amounts of the receipts of twelve companies for 1879, and comparing them with those of 1878, we find the former exceed the latter by about £215,000, and this on a return of about £2,000,000. In the case of one of those companies whose returns we have not, namely, the Western and Brazilian, we hope that with Sir Edward Watkin's well known energy and talent it will now emerge from the cloud which has seemed to hang over it, and we trust that a similarly happy outcome may be found for the sorely tried West India and Panama Company.

Were it not for the competition which the American Cable Companies will have to meet, there seems every reason to think that the augmented receipts would not only be maintained but even still further increased—particularly as trade will, in all probability, more generally improve during the present year; but if sixpenny word tariffs are to prevail, immense loss must ensue to those companies engaged in the strife. It is to be hoped so suicidal a policy will not obtain, or, if it does, that it will be but of short duration.

In closing these few desultory remarks, we take this opportunity of congratulating the directorates and staffs generally, on the improved outlook, and of expressing the wish, that this time next year it will be our pleasing task to refer to submarine cable property as not only well paying, but also as well secured.

ON SOME OF THE EFFECTS PRODUCED BY AN INDUCTION COIL WITH A DE MERITENS MAGNETO-ELECTRIC MACHINE.

By WILLIAM SPOTTISWOODE, P.R.S.*

IN the *Philosophical Magazine* for November of last year I gave an account of a mode of exciting an induction coil by the direct application of one of M. de Méritens alternating machines, without the intervention of a contact-breaker or the use of a condenser. The experiments of Professor Dewar

* Proceedings of the Royal Society.

8588 Journal Teleg 1879 89

The South African Cable.

A Parliamentary paper has been printed giving the agreement May 9, 1879, entered into by the Government with the Telegraph Construction and Maintenance and Eastern Telegraph Companies for establishing telegraphic communication with the South African colonies. The route decided upon, as already announced, was the one submitted by Mr. Pender on behalf of the two companies—from Aden to Natal, touching at Zanzibar, Mozambique and Delagoa Bay. The Government subsidy was fixed at £35,000 per annum. The tariff was fixed at 4s. a word between Aden and Zanzibar, and 5s. a word between Aden and Mozambique, Delagoa Bay or Natal; and neither of these charges nor the present charge of 3s. 9d. a word between Aden and London are to be altered without the concurrence of the official director. The cables are to be capable of transmitting fourteen words a minute. The Governments of Victoria and New South Wales concur in the postponement for a short period of the duplication of the Australian line, in order that the cable already manufactured for that purpose might be used in laying the Cape line.

The New French Atlantic Cable.

The *Bulletin Financier* calls the attention of subscribers to the Pouyer-Quertier shares to the fact that the official quotation promised from the very beginning is not coming forward, and apprehends that it will not be obtained soon, or else the promoters would not allow the shares to decline 20 francs below the price of issue in a moment of furious rise, where there is even demand for all sorts of rubbishing low-priced stocks. Our contemporary expresses the opinion that the protest made concerning the landing of the cables in the United States has acted as an impediment with our official brokers; but the *Bulletin* gives this as a private opinion, and adds that the stock has not been applied for, and that the members of the syndicate begin to grow rather fidgety. Besides, the second instalment is due, and, in the absence of official quotation and of any market, for what is done in the shares bears a most limited character, it is not easy to sell out. What the situation will be when the third instalment falls due is evident. It leaks out now that the applicants rather subscribed with the view of pocketing a premium in reward of their patriotism than with that of becoming serious shareholders. The case is not without danger, especially if any difficulty arose respecting the landing of the cable.—*Paris Bourse.*

89

ENGINEERING NEWS.

Tribune Building, New York City.

GEO. H. FROST, Proprietor.

SATURDAY, SEPT. 3, 1881.

We received the following note from Prof. P. H. Philbrick, dated Iowa City, Aug. 23, 1881: "I hope Mr. E. J. Ward will be able to continue his articles on 'Wind Pressure.' The matter has been much neglected and slighted in the past."

TO THOSE INTERESTED IN WATER-WORKS.

Owing to the author's absence from this city on professional duty the manuscript of "The History and Statistics of American Water-Works" has not reached us in time for this week's issue. We take advantage of the space thus afforded us to call the attention of those officers of water-works who have not yet responded to the requests for information regarding their works to the scope and character of Mr. Croes' book, and we desire to again urge them to furnish the memoranda required to make this history complete. It is intended that it shall be complete, and the information will be obtained to make it so, in one way or another. The simplest and easiest way will be for those who possess all the data to contribute them as early as convenient.

We are fully aware of the fact that superintendents of water-works are overwhelmed with circulars from all quarters asking for elaborate information on every conceivable subject connected with the construction and management of works of water supply. If they reply, their answers are either buried in the files of some little company's office, or printed in a report of some obscure town which reaches only a small proportion of those who are interested in the matters treated. The work which we are now publishing will, to a very large extent, obviate the necessity for the asking of such questions. It will be a practical manual of water-works construction and management, treating not of theoretical questions, but giving the results of actual experience, without attempting to excuse blunders, explain away failures, extol successes, or expiate on the merits of any particular system of construction, supply or management.

The idea of this book grew out of the effort to procure a general description of the works of water supply in America for the Centennial exposition in 1876. The American Society of Civil Engineers exhibited then a very creditable collection of plans, models and statistics, gathered for the purpose by Mr. Croes, who had charge of that branch of the work of the society's Centennial Commission. The catalogue of that exhibit contained the first list of American towns having water-works ever published. It was necessarily incomplete, owing to the short time allowed for its compilation, but even then comprised the names of all the works of any importance, and seventy-five per cent. of all which were then in existence.

In the following year, Mr. Edward Prince, C. E., of Quincy, Ill., published a list of water-works which has been enlarged from time to time through his earnest and persistent efforts to procure information. He has kindly placed at Mr. Croes' disposal the catalogue of reports and documents obtained by him, and such brief abstracts of them as had been prepared by him.

The publication of Mr. Croes' book began in the issue of Engineering News for March 5, 1881. Up to this time, statistical and historical sketches of eighty-one water-works have appeared, as follows, the towns being at first arranged according to their population by the last census, an arrangement afterwards abandoned on account of the difficulty of procuring the very latest reports in time:

	Town.	Population.	Page.	Date.
I.	New York, N. Y.	1,206,590	91	March 5
II.	Philadelphia, Pa	846,984	102	12
III.	Brooklyn, N. Y.	566,689	114	19
IV.	Chicago, Ill	503,304	122	26
V.	Boston, Mass	362,535	131	April 2
VI.	St. Louis, Mo	350,522	142	9
VII.	Baltimore, Md	332,190	151	16
VIII.	Cincinnati, O	255,708	153	16
IX.	San Francisco, Cal	233,959	163	23
X.	New Orleans, La	216,140	163	23
XI.	Cleveland, O	160,142	163	23
XII.	Buffalo, N. Y.	155,137	173	30
XIII.	Washington, D. C.	147,307	174	30
XIV.	Newark, N. J.	136,400	183	May 7
XV.	Louisville, Ky	123,645	183	7
XVI.	Detroit, Mich	116,342	193	14
XVII.	Providence, R. I.	104,850	195	14
XVIII.	Montreal, Can	145,000	202	21
XIX.	Milwaukee, Wis	115,578	203	21
XX.	Jersey City, N. J.	120,728	223	June 4
XXI.	Albany, N. Y.	90,903	223	4
XXII.	Indianapolis, Ind	75,074	227	4
XXIII.	Rochester, N. Y.	89,363	233	11
XXIV.	Lowell, Mass	59,485	234	11
XXV.	Pittsburgh, Pa	156,381	234	11
XXVI.	Allegheny, Pa	78,681	243	18
XXVII.	Kansas City, Mo	55,813	253	July 2
XXVIII.	Cambridge, Mass	52,740	261	2
XXIX.	Fall River, Mass	49,006	261	2
XXX.	Richmond, Va	63,803	264	2
XXXI.	Toronto, Can	85,000	271	9
XXXII.	Worcester, Mass	58,295	272	9
XXXIII.	Troy, N. Y.	56,747	283	16
XXXIV.	Ottawa, Can	22,000	285	16
XXXV.	Lawrence, Mass	39,178	285	16
XXXVI.	Manchester, N. H.	32,630	287	16
XXXVII.	Bay City, Mich	20,653	287	16
XXXVIII.	Hartford, Conn	42,553	293	23
XXXIX.	Lynn, Mass	38,284	293	23
XL.	Grand Rapids, Mich	32,015	294	23
XLI.	Holyoke, Mass	21,851	294	23
XLII.	Hudson, N. Y.	8,670	294	23
XLIII.	Springfield, Mass	33,340	302	30
XLIV.	Salem, Mass	27,598	303	30
XLV.	Newport, Ky	20,433	304	30
XLVI.	Norwich, Conn	21,141	304	30
XLVII.	Williamsport, Pa	18,934	304	30
XLVIII.	Dayton, O	38,677	304	30
XLIX.	Toledo, O	50,143	305	30
L.	Sandusky, O	15,838	305	30
LI.	Charleston, S. C.	49,980	311	Aug. 6
LII.	Terre Haute, Ind	26,040	311	6
LIII.	Taunton, Mass	21,213	312	6
LIV.	Newton, Mass	16,995	312	6
LV.	Alexandria, Va	13,658	312	6
LVI.	Kalamazoo, Mich	11,937	312	6
LVII.	New London, Conn	10,529	312	6
LVIII.	Poughkeepsie, N. Y.	20,207	312	6
LIX.	New Bedford, Mass	26,875	327	13
LX.	Lambertville, N. J.	4,300	328	13
LXI.	London, Can	21,000	328	13
LXII.	New Albany, Ind	16,422	328	13
LXIII.	Montgomery, Ala	16,714	328	13
LXIV.	Northampton, Mass	12,172	329	13
LXV.	Columbus, O	51,000	329	13
LXVI.	Mankato, Minn	6,000	329	13
LXVII.	Waterbury, Conn	20,280	332	20
LXVIII.	Newburgh, N. Y.	18,050	332	20
LXIX.	Corning, N. Y.	4,803	332	20
LXX.	Norfolk, Va	21,966	333	20
LXXI.	Erie, Pa	27,730	333	20
LXXII.	Marshalltown, Iowa	6,000	333	20
LXXIII.	Binghamton, N. Y.	17,315	333	20
LXXIV.	Paris, Ill	4,350	333	20
LXXV.	Pawtucket, R. I.	10,030	333	20
LXXVI.	Peekskill, N. Y.	6,803	341	27
LXXVII.	Atlanta, Ga	34,398	342	27
LXXVIII.	Burlington, Iowa	19,450	342	27
LXXIX.	Altoona, Pa	19,740	342	27
LXXX.	Johnstown, N. Y.	10,026	342	27
LXXXI.	Yonkers, N. Y.	18,892	342	27

While this list includes but a small portion of the whole number of water-works in the country, the descriptions of the works contain already a more valuable collection of facts relating to water-works construction and maintenance, the accidents and failures of ill-considered and carelessly constructed structures, the cost of construction and maintenance, and the revenue derived from water supply, than any other single publication ever issued. To make this record complete is the author's intention and our desire. A large amount of material is now on hand for this purpose. *We want everything*, and we therefore again ask every superintendent, engineer, manager and commissioner to send us reports, facts and figures.

The sketches, comprising the first part of the book, are arranged according to the following order, for each town: Location and topography of town, date of first settlement and of incorporation, date of construction of water-works and description of same, both old and new: sources of supply, filters and wells, pumping engines or reservoirs, supply mains or conduits, reservoirs, distribution, sizes and kind of pipes; number of hydrants, taps and meters, cost of construction and maintenance, and the revenue, both total to date and particularly for the year 1880; organization and officers of works, daily average consumption. Failures and accidents of all kinds are specially noted. Hereafter tabular statements of the chief points of interest will be given, including duty and cost of pumping engines.

Many officers of works have contributed descriptions of their works admirably fitted for insertion in the book, without material change, and the compiler's labors are, of course, greatly lessened by such kind assistance. The interest taken in the work is exhibited in the most gratifying manner by correspondents from all parts of the country, and the author and the publisher are alike encouraged to carry out the design to its full extent.

SUBTERRANEAN CONDUCTORS.

The problem of providing some effective plan for placing electric wire underground is, at the present time, attracting much attention. In all large cities the network formed by these wires interferes most materially with the efficient working of the fire departments, and as it is exposed to every atmospheric change it is damaged, and in its damage hurts the interests of the entire community.

The number of these wires is rapidly increasing, caused by the extension of the telegraph, telephone and electric lighting systems, and a device is imperatively demanded by which the present practice may be done away with.

We have received a pamphlet from Mr. Stephen Chester, C. E., which discusses the question: Are subterranean telegraph lines practical? After citing the various evils consequent to the system now in vogue, the author enumerates the principal objections alleged to exist against the use of subterranean conductors, by reputable experts, as follows:

"First.—All underground conductors are relatively very much more costly than are air lines.

"Second.—Breaks in wires or imperfections in insulation cannot be readily located, and the repairs of the same would be expensive and difficult.

"Third.—No material yet used for insulation of subterranean wires has been satisfactorily proved to be indestructible, nor do any of such materials when buried in the ground retain their integrity nearly so well as do submarine conductors.

"Fourth.—The obstacles impeding the efficient use of long, continuous conductors because of "*Induction*" and "*Retardation*," are vastly greater in buried wires than they are in aerial lines of corresponding length."

These allegations are met by the statement that the subterranean conductors, referred to as enormously costly, have consisted of copper wires, first covered with an expensive insulating substance such as vulcanized rubber, kerite or gutta-percha, and still further protected by being inclosed in metal tubes.

In all the many uses to which insulated wires have been applied, it has been requisite that the insulating covering should be impervious to water, flexible, and of such tenacity and durability as not to be liable to injury in the handling necessary to place them in position, nor to deterioration in conducting or insulating qualities by reason of exposure to heat or cold, air or water, etc.

Up to the present time all compositions uniting these qualifications have been expensive, and only readily applied to very flexible and therefore small wires. The wires used have been mostly of copper, as this metal possesses a conducting power much greater than iron for equal sizes.

As such insulated conductors are relatively much more expensive than those used on aerial lines, and possess but little relative tensile strength, and the insulating covering is not of a character that will stand rough handling or abrasion without injury, they have but seldom been placed under ground or water without being further protected by some other non-insulating but hard and tough covering. This adds greatly to the original cost. In order to

1876

UNDERGROUND LINES AND PNEUMATIC TUBES IN EUROPE.

Under date of March 6th, a circular letter was addressed by Mr. George B. Prescott to the different telegraphic administrations in Europe, in which information was requested concerning the number of miles of underground lines operated by each, their location, the method of insulation, and the length of time they had been operated; also as to the extent of the pneumatic tube system for transmission of messages. The following replies have already been received:

SWITZERLAND.

SWISS CONFEDERATION,
DIRECTION OF TELEGRAPHS,
BERN, 1st *April*, 1876.

GEORGE B. PRESCOTT, *Electrician Western Union Telegraph Company:*

SIR.—We hasten to give you the information about the cables in Switzerland, requested in your favor of March 6th.

The Swiss cables are of four classes, viz., Underlake cables, cables on the dangerous passes of the Alps, to avoid the avalanches, cables in tunnels of railroads, and cables in cities.

The under-lake cables are laid only in the Lake of Constance, where, by mutual consent with the Bavarian and Wurtemberg administrations, we have one-wire cables between Romanshorn and Nonnenhorn, and between Romanshorn and Friedrichshafen. One-half only of these cables belong to our administration, and in the following statement of the length of our entire cable system, only one half of their total length is included. These cables were constructed by Felton & Guillaume, in Cologne, and are similar to the underground cables.

Our lines cross the Alps in several places, either to make communication between the different sections of Switzerland situated on both sides of the Alps, or to connect Italy with Switzerland and the neighboring countries. These lines in some cases are at a height of 2,400 metres (7,900 feet) above the level of the sea, and consequently reach the region of eternal snow. Owing to avalanches, these passes are dangerous, yet they cannot always be avoided; consequently, at these places we have constructed underground cables, especially on the Simplon, on the Saint Gothard and the Fluela. The cables used came from Rattier & Co.'s works in Bezons, near Paris. Each cable is composed of three or five wires, according to the number of the wires in the line. Each copper core consists of seven wires of one-half millimetre (one-fiftieth of an inch) twisted together.

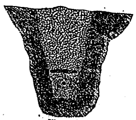


Figure 1,

This wire is covered by a double guttapercha sheath, and wound around the guttapercha is a hemp covering, soaked in Chatterton's compound. The different cores of the cable are united in one single strand, which is enveloped in three layers of hemp soaked in Chatterton's compound, the first and last in the shape of ribbons, and the one in the centre in the shape of wires or strands. The whole is enclosed in a leaden tube hermetically closed.

These cables are buried in the ground to a depth of from two to three feet. The cable is surrounded by sand, and covered with flat stones, and the trench is filled up with ordinary gravel (Fig. 1). In some places, especially in Fluela, it has been found necessary to dig the entire trench in the rocks.

In all the railroad tunnels which are about 300 metres (1,000 feet) and upward in length, the overground wires have been replaced by cables of three, five, or seven wires. If there are more than seven wires in a line, two or more cables are used. Some of these cables are of the same manufacture and come from the same works as those of the Alps. Still, in the Cornallaz, Vanderens, St. Maurice, Mayats, Haut de la Tour, de la Combe, Mont Lagne, des Loges, de la Zimmeregg, and Bözberg tunnels, we have made experiments with the other cables manufactured in the St. Aubin works in Switzerland. The insulating material of the latter cables is purified asphalt. The construction of the copper cores and the outside leaden tube is similar to that of the Rattier cables.

With regard to the manner in which the cables in the tunnels are laid, we have used different systems. In some tunnels they are buried in the ground, in a similar manner to those across the Alps. In some places they have been fitted with cement in a groove in the rocks, in other places trenches of cement blocks have been used, as illustrated in Fig. 2; but latterly they have almost all been laid in saturated wooden tubes fixed on the walls of the tunnel, about 1½ metres (5 feet) from the ground (Fig. 3).

Fig. 2.

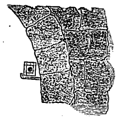


Figure 3.

We have used, with regard to cities, underground cables in every instance where it was difficult to reach the stations by means of aerial lines, or where the airlines would have looked unsightly in the streets through which they had to pass. There are cables laid in the following cities: Geneva, Lausanne, Bern, Zürich, Schaffhausen, Winterthour, Altorf, and St. Gall. With the exception of Schaffhausen, all the cables laid in the cities are manufactured at Rattier & Co.'s works, and are of the form heretofore described. In Schaffhausen we have made use of a cable made by the India-rubber Company in Silvertown (England). This cable differs from those made by Rattier mainly by the fact that the leaden tube is replaced by a tarred hempen sheath.

The cables in the cities are sunk into brick trenches, or in the sewers, or in Zores-iron tubes. We have no testing boxes, the portions of line not being long enough to make the experiment necessary.

The following is a list of all our cables and wires, their length, and the date when laid:

1. *Submarine Cables.*

PLACE WHERE BUILT.	LENGTH IN FT.		WHEN LAID.
	CABLE.	WIRE.	
UNDERLAKE CABLES.			
Romanshorn-Friedrichshafen.	21,340 (4 miles)	21,340	1856, (1)
Romanshorn-Nonnenh'rn	38,376 (7¼ miles)	38,376	1863, '66, '69, '70, (2)

2. *Alps Cables.*

PLACE WHERE BUILT.	LENGTH IN FEET OF		WHEN LAID.
	CABLE.	WIRES.	
On the Simplon.	9,348	28,044	1873-4
" " St. Gothard.	16,400	82,000	1871 and 1873
" " la Fuela.	7,872	23,616	1871

3. *Tunnel Cables.*

Cornallaz	1,640	11,480	1872
Vanderens.	18,083	21,581	1872
St. Maurice.	1,640	11,480	1872
Combe.	836	4,180	1873
Mont Lagne.	4,444	22,220	1873
Loges.	10,693	53,465	1873
Brot.	1,460	10,220	1872
Mayats.	1,060	7,420	1873
Fleurier.	1,791	12,537	1872
Haut de la Tour.	10,000	7,000	1873
Pierre-Pertuis.	4,221	29,547	1874
Aarau.	1,525	21,350	1867
Gutruh.	1,043	21,003	1870
Zimmeregg.	3,992	27,944	1875
Bozberg.	8,298	58,086	1875
Bommelstein.	656	4,592	1872
Oteneck.	2,296	16,072	1872
Standenhorn.	984	6,888	1872
Tiefwinhelstutz.	984	6,888	1872
Wipkingen.	3,149	59,827	1867
Rutf.	853	4,265	1867
Paradiso.	2,624	18,368	1875

4. *Cables in Cities.*

Geneva.	5,576	61,664	1866—'72 (3
Lausanne	4,264	59,696	1873
Neuchatel.	1,312	18,368	1867
Bern.	3,772	93,316	1872
Zurich.	7,167	220,238	1865
Schaffhouse	377	5,281	1871
Winterthour.	558	11,710	1869
Altdorf.	574	4,018	1873
St. Gall.	328	10,496	1866

NOTE 1.—This is only one-half of the entire cable.

2.—The cable, being laid in 1863 near the mouth of the Rhine, in the lake, has been deranged by pebble stones.

It was found necessary to take it up in 1866, and to lay it farther from the mouth. In 1869 and 1870 it had to be removed further from the mouth.

3.—Partly laid in 1866, partly in 1872.

The entire length of all our cables is 33 English miles, that of all the wires in the cable tubes separately 213 miles.

You want also to know the length of the overground lines. We do not know whether you want to know the length of the wires in the cities or those in the entire system. The length of all the wires in our system is 9,575 miles, but the length of the wires only in the cities is pretty hard to give. Often it is hard to tell where the city ends, and the country commences.

With regard to the duration of our cables it is very difficult to give you any definitive answer. The majority of the cables have not been laid long enough to give, as yet, any conclusive results. The cable from Romanshorn to Nonnenhorn had to be repaired several times, owing to pebble stones, coming from the Rhine, as we have mentioned before.

The actual cables in the Cornallaz, Vanderens and St. Maurice tunnels are the second cables which

92

have been laid in the tunnels. The first did not last for more than two years. They were cables insulated by means of asphalt, and manufactured in the St. Aubin's works. The cable of Neuchatel, laid under unfavorable circumstances also is suspended, the leaden tube being assailed both by gas and rats. A cable on the St. Gothard has considerable defects, probably caused by a defective laying. The other cables are in good condition, and do not give rise to any complaint, but it may be possible that one of the conducting wires is not as perfectly insulated as it was when laid.

The cables are crossed by comparatively speaking strong currents. The effects of charging and discharging, and of induction of one wire on the other are not felt, the cables being too short.

All the cables are shielded from the influence of atmospheric electricity by means of special lightning arresters.

Pneumatic tubes are not used in Switzerland.

Hoping that this will be the information required, we beg to assure you of our profound respect.

The Director of Swiss Telegraph,
F. Vey.

NORWAY.

Royal Telegraph of Norway,
Christiania, 29th March, 1876.

George B. Prescott, Esq., *Electrician of the Western Union Telegraph Company:*

Sir,—I beg to acknowledge receipt of your honored letter, dated 6th this month, and have the honor to inform you that underground telegraph wires are not in use in this country. The strength of climate and the rocky ground will generally be a serious objection for applying underground wires to any extent in this country; and, in fact, we have so few wires that we find no serious objection over in towns to go over the houses.

I have the honor to be, Sir,
Your Obedient Servant,
C. Pierson.

ITALY.

Ministry of Public Works,
Florence, Italy, 26th March, 1876.

Mr. George B. Prescott, *Electrician Western Union Telegraph Co.:*

Sir,—In answer to your letter of 6th inst., I beg to inform you that we do not make use of any underground wires nor of any pneumatic tubes, and that our system now contains 45,677 miles of aerial or overground wire.

Accept the assurance of my distinguished consideration.

The General Director,
E. d'Amico.

ROUMANIA.

Ministry of the Interior,
General Direction of Telegraphs and Posts.
Bucharest, March 27th, 1876.

Mr. George B. Prescott, *Electrician W. U. Telegraph Company:*

Sir,—I have the honor to acknowledge the receipt of your letter of March 6th, and beg to give you the information asked for.

1. We have no underground lines as yet, but in the city of Bucharest they are going to be built in the course of this year. The length of the cables when laid will be 1½ miles. There will be three cables of seven wires, and two others of one wire each, in all a length of wire of thirty-six miles.

The cable has been constructed by the India-rubber Guttapercha and Telegraph Works Company of London, and consists of two guttapercha layers, and a stout wrapper of galvanized iron rods. The cable will be buried under the sidewalk in wooden tar-covered boxes, one yard deep.

2. With regard to the overground lines, we have in our entire country a length of 2,347 miles of poles, and 4,223 miles of wire.

I hope very soon to be enabled to send you a statement of my administration for 1875, in which you will find all the details, which will be of interest to you.

Please accept the assurance of my profound respect.

The Director General,
G. Lahonary.

BAVARIA.

Kingdom of Bavaria,
Munich, March 30th, 1876.

Mr. George B. Prescott, *Electrician W. U. Telegraph Company:*

Sir,—Your letter of the 6th inst. is duly received. I beg to answer as follows:

We have underground lines only in a few of our larger cities, also submarine cables at Lake Bodensee connecting the Bavarian station Lindau with the Swiss station Romanshorn, and at Lake Tegernsee with Gmund. The first-named are cables with from seven to eight wires, the last each of one wire. The total length of the underground lines is thirty-two miles, and the total length of the submarine cables eighteen miles.

The underground lines are, as has been above said, in use mostly in our larger cities, where reaching telegraphic offices could only be done with much difficulty by aerial wires. Such underground lines are:

(*a*) At Munich, firstly, to connect the Central Station, situated in the Telegraph building (*Bahnhofplatz*), with the branch offices, situated in the center of the city; and secondly, to connect this station with all land lines running together at the Central Railroad Station. The first connection consists of a cable nearly one mile in length, with eight wires; the latter of seven cables with seven wires, each of them 410 feet long, and of a similar cable 561 feet long.

(*b*) at Augsburg, where the connection of the Telegraph Office with the land lines is made in two different ways, by means of three cables, each of seven wires, about 410 feet long, and three others, each of 1,650 feet length.

(*c*) at Numberg. The underground cable here is only needed for a short distance, viz., to overcome the obstacles offered in a large open and much frequented place before reaching the telegraph station; five cables are in use here, each of them measuring 765 feet, and ending in 35 city lines, mounted on double-poles.

All our cables, both submarine and underground, are bought from the Telegraph Cable works of Felton & Guilleaume at Cologne on the Rhine. Each wire of the cable consists of three copper wires, twisted together, and three-one hundredths of an inch thick; they are enclosed with a concentric layer of the purest india-rubber. This india-rubber has twenty-two-one hundredths of an inch diameter, and in cables of 7 wires twenty-eight-one hundredths of an inch; the insulated wires are covered with a tarred hempen layer; in cables with more than one wire the spaces between the insulated wires are also filled up with hemp.

The outside covering of the one wire cables consists of 11 galvanized iron wires one-tenth of an inch thick; in cables of 7 wires, of 16 such galvanized iron wires sixteen-one hundredths of an inch thick.

The underground cables are covered with asphalt, and sunk about 3½ feet into the ground. The 8 wire cable, laid in 1856 at Munich, has worked perfectly since, and the india-rubber just as flexible as ever; the other cable at Munich has been in use since 1871; the cable at Augsburg from 1870, and that of Numberg from 1872.

The connecting of the branch office, Munich (Post Building) with the Central Station (Telegraph Building) is projected, but not yet started.

Very respectfully, Yours obediently,
Gumbart.
Secretary to the General Director of Telegraphs.

AUSTRIA.

Ministry of Commerce,
Vienna April 5th 1876.

George B. Prescott, *Electrician Western Union Telegraph Company:*

Sir—In reply to your favor of 6th March last, I beg to answer your questions for information about our underground lines and pneumatic tubes as follows:

1. *Underground and Submarine lines.*

After an experiment made as early as 1850 and 1851 to construct underground lines of any considerable extent, which resulted in failure, owing to the very defective technical knowledge of construction, our administration has preferred to build air lines, and now only construct underground lines when overground lines are absolutely not allowed.

The length of the system in Vienna is 1,617 feet, and consists of twenty cables of seven wires; the line in Brünn has a length of 1,574 feet, with six wires; the line in Prague 1,476 feet, with nine cables of seven wires.

The first mentioned of these three lines was constructed in the Fall of 1873; both of the others are only recently made.

All the cables used hitherto were made by Felton & Guilleaume in Cologne on the Rhine. Each line consists of a three-wired copper string covered with two layers of Chatterton's compound, and two layers of guttapercha, all the wires are twisted to one single string, covered with a layer of tarred hemp, and protected by an armor of 18 galvanized iron wires of ¼ inch diameter. In Vienna the cables are buried 6 feet deep in a wooden tube, the tube being filled with a mixture of tar and bituminous lime. In Brünn and Prague, it is only at particularly dangerous places that an outside protection of a similar kind is given. The connecting of the cable with the line is done in a little pavillion, where a lightning arrester is placed between the cable and the air line, and where, also any examination of the separate wires can be made.

Of 140 under ground wires of the city lines in Vienna up to the present time, not a single one has suffered any injury or weakening of its electrical capacity. Besides the cables for the city lines, there are in Austria, along the coast of the Adriatic Sea, submarine lines, with an aggregate length of 96 miles, to connect the Dalmatian and Istrian Islands with each other and with the mainland. Usually Hooper's india-rubber cables are used for this purpose. The copper strand consists of three wires of about one thirtieth of an inch in diameter, and with Hooper's insulating material has a thickness of ¼ of an inch.

This is provided with a tarred hemp covering and an armor of galvanized iron wires, which for the coast cables have a diameter of one-fifth of an inch and for deep sea one-sixth of an inch. They also receive a coating of Clark's compound for protection against the corrosive action of salt water. The connecting of underground with overground lines

93

Le Pres July 19 1879

Transatlantic Cable.—The cable ...day, left Millwall at an early hour and during the forenoon was safely ...ast of Messrs. Siemens' works at ...e *Faraday* is a powerful steamer of ...ilt at Newcastle in 1874 for Messrs. ... designed specially for laying cables. ...se of the afternoon she was sur... ...arges; those on the outside supply... ...kers with coal, and those next to ...mployed in passing the cable into ...s tanks. The new company, the ... of which is, "La Compagnie Fran... ...graphe de Paris a New York," has ... in London for the transaction of ...siness at 100 and 101, Gresham ...oad street. The *Faraday*, having ... shore end and the Brest-Scilly ...e new cable, was cleared at the ...om-house on Tuesday night for ...d sailed for Brest the following ...r departure had been delayed, the ...aving interfered with the work of ...ble in the bunkers.—*London Iron,*

D. ... Le Pres July 19

African Cable.—The telegraph... ...nect the European and Asiatic ...ystems with the Cape of Good ... 4,000 miles long, extending from ...able, of Aden around Cape Guard... ... the east coast of Africa to Port ...it made a junction with the pres... ...o Cape Town. The cable will be ...coast, the depth being moderate ... of the continent and the facility ...ossible breakages has been care... ...ed. The cable will touch at Zanzi... ...que, Sofala, Delagoa Bay, and ...ban as the submarine terminus, ...int the land telegraph becomes ...mplete the circuit to Cape Town. ...struction and laying the cable is ... 7,500,000. The line from Durban ... to be finished in July, and the ... the middle of November.

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NORWAY.

Royal Telegraph of Norway,
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I have the honor to be, Sir,

Your Obedient Servant,

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ITALY.

Ministry of Public Works,
Florence, Italy, 26th *March*. 1876.

Mr. George B. Prescott, *Electrician Western Union Telegraph Co.:*

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The General Director,

E. d'Amico.

ROUMANIA.

Ministry of the Interior,
General Direction of Telegraphs and Posts.
Bucharest, *March* 27th, 1876.

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The cable has been constructed by the India-rubber Guttapercha and Telegraph Works Com-

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this serves to deliver the messages which ar[e] outside, of forwarding the dispatches receiv[ed] various Telegraph and Post Offices to the Telegraph Station, and to forward pneumati[c] between the City and its suburbs.

The entire system of tubes has an exte[nt] miles, and consists of a closed circuit with sev[en] matic stations, also three single branch lines one connects with the circuit in station I., th[e] in station II., so that altogether there are te[n] matic stations in operation.

The line of tubes consists of wrought ir[on] 16½ feet long, and 2½ inside and 3 inches diameter. The single tubes are provid[ed] soldered and properly fitting flanges, which ed in the middle by means of a screw, additional caoutchouc packing ring having ed there.

The tubes laying in curves are previously cold, bent to the required radius (minimum of and buried an average depth of 3½ feet in the at the deepest points cast-iron supports are as to let off the water condensed in the tubes.

The propelling power for the entire system nished by two horizontal engines of respect[ively] and 12 horse power, which are set up in Sta[tions] and V. Each of these machines sets a coupl[e] pumps (for condensing and evacuating purp[oses]) motion, by which the air in 12 wrought iro[n] voirs becomes respectively compressed and The cubic contents of the six reservoirs for co[mpress]ed air amounts to 380 feet, and of the six re[servoirs] for rarified air 295 feet. Four of these reserv[oirs] put up in Station I., four in Station II., and Station V.

The reservoirs of Stations I. and II. are fed taneously by the machine of Station I., and purpose, between the Stations I., and II. in a to the pneumatic tubes, properly speaking, a tube conduction of 1½ miles in length is mad[e] same material, and according to the same sy[stem] above described. The length of this doub[le] duction is not taken in account, when summ[ing] the aggregate extent of our system of pne[umatic] tubes. The over pressure in the compressio[n reser]voir usually amounts to 60 or 70 centimetres 27½ inches) mercury, whilst in the other re[servoirs] the air is rarified at an aggregate pressure of centimetres (12 to 15¾ inches).

The pneumatic apparatus of the ten stati[ons] very similar to those which are made use of Paris system; its construction allows the con[nection] of the tubes leading to the next station either or backward alternately according to requi[rement] and the movement of the pneumatic train the whole of the tube system, hence follows, u[...] ly, either under the over pressure of the com[pressed] air against the atmospheric or under that of mospheric against the rarified air.

The pneumatic train in the closed circuit of some seven boxes with one piston. The boxes are made in one piece of wrought sh[eet] steel, and are closed by means of a leather They will hold from 20 to 25 messages or letter[s]. train, consisting of seven boxes and piston, from 7 to 9 pounds, and runs with an averag[e] of 1,100 yards a minute. At present the pn[eumatic] tubes in Vienna are operated only between 8 and 9 P. M., so as to have a train from the

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Mining & Sc. Press July 19 1879

The New Transatlantic Cable.—The cable steamer, *Faraday*, left Millwall at an early hour on Monday, and during the forenoon was safely moored abreast of Messrs. Siemens' works at Charlton. The *Faraday* is a powerful steamer of 4,000 tons, built at Newcastle in 1874 for Messrs. Siemens, and designed specially for laying cables. In the course of the afternoon she was surrounded by barges; those on the outside supplying her bunkers with coal, and those next to shore being employed in passing the cable into the steamer's tanks. The new company, the official style of which is, "La Compagnie Francaise du Telegraphe de Paris a New York," has opened offices in London for the transaction of executive business at 100 and 101, Gresham house, Old Broad street. The *Faraday*, having on board the shore end and the Brest-Scilly section of the new cable, was cleared at the London Custom-house on Tuesday night for New York, and sailed for Brest the following morning. Her departure had been delayed, the wet weather having interfered with the work of coiling the cable in the bunkers.—*London Iron, June 21st, 1879.*

Mining & Sc. Press July 19

The South African Cable.—The telegraphic cable to connect the European and Asiatic telegraphic systems with the Cape of Good Hope will be 4,000 miles long, extending from the Red Sea cable, of Aden around Cape Guardafui and along the east coast of Africa to Port Natal, where it made a junction with the present land line to Cape Town. The cable will be laid along the coast, the depth being moderate along that side of the continent and the facility for repairing possible breakages has been carefully ascertained. The cable will touch at Zanzibar, Mozambique, Sofala, Delagoa Bay, and thence to Durban as the submarine terminus, from which point the land telegraph becomes available to complete the circuit to Cape Town. The cost of construction and laying the cable is estimated at $7,500,000. The line from Durban to Zanzibar is to be finished in July, and the whole cable by the middle of November.

Hardware July 18 79

Telegraph Wires.—American cities are insisting upon underground telegraph wires, and this has occasioned a demand for a new kind of wire. Into glass tubes made in 14-foot lengths decarbonised steel wire is inserted. The glass tubes are then encased in a prepared iron pipe, and the whole heated in a furnace to a welding heat, which reduces the size and makes a solid mass of the iron, steel, and glass. It is claimed that this makes a conductor not only durable, but perfectly insulates it, and renders it proof against the influence of induced currents. Hardware July 1879

Telegraphic Journal July 15 1879

The French Atlantic Cable.—Some 345 knots of the Brest to Nova Scotia section of this cable have been successfully laid by the *Faraday*, which has returned to Brest after buoying the sealed end at Scilly.

Leakage Faults in Cables.—In the *Philosophical Magazine* for July, there is an interesting mathematical paper on this subject by Mr. Oliver Heavyside.

94 Operator Aug 15 1879

Operat. Cable Dividends. Aug 15 1879

The fourth ordinary general meeting of the Direct United States Cable Company was held in London, August 1st. From the report it appears that for the half-year the revenue, after deducting out payments, amounted to £87,706 3s. 2d.; for the corresponding period of 1878 the amount of revenue, after similar deductions, was £79,852 11s. 5d. The working and other expenses (exclusive of cost of repairs), interest on loan, and income tax, etc., amounted for the half-year to £20,523 5s. 10d., leaving a balance of £67,182 17s. 4d. as the net profit for the half-year. In the corresponding half-year of 1878 the expenses and payments above mentioned (also exclusive of cost of repairs) amounted to £20,065 17s. 9d. The cost of repairs for the half-year amounted to £8,965 9s. 11d.

Three quarterly interim dividends of 1¼ per cent. each, amounting to £45,532 10s. 0d., have been declared and paid at the usual times during the financial year, and a final dividend of 5s. per share was declared at the meeting, making, with the three interim dividends, 5 per cent. for the year, being a total distribution of £60,710. £34,756 4s. 3d. was added to the reserve fund, thereby increasing it to £100,000. £2,345 1s. 5d. was also carried forward to next account.

At a meeting of the board of directors of the Anglo-American Telegraph Company, held in this city July 11th, it was resolved (after reserving £37,500 for the renewal fund) to declare an interim dividend, for the quarter ending June 30th, of 1¼ per cent. on the consolidated stock, and 2½ per cent. on the preferred stock, both free of income tax. This leaves an estimated balance of £10,000 to be carried forward to next quarter's account.

The agreement with the Dominion Telegraph Company of Canada, referred to in the last report, has been completed, and came into operation as from the 1st January, 1879.

The particulars of the Award in the Arbitration between the Liquidators of the Old Company and Mr. Leoffler, were fully stated at the ordinary general meeting on the 21st March last.

The break in the Company's main cable which occurred on the 4th January last, was repaired on the 20th March, and the interruption on the 12th February last of the short section was repaired on the 22d April. Both sections of the cable are in good working order.

Telegraphic Journal Aug 1 1879

Tel. Jour. Aug 1 1879

Old Broad Street, July 24th, 1879.

ANGLO-AMERICAN TELEGRAPH COMPANY (Limited).—In anticipation of the meeting of this Company the report has been issued. It says: "With £3,587 brought forward, the total receipts of the half-year were £298,393, showing an increase of £25,120 compared with the corresponding period of last year, while the expenses were £54,592. The sum of £75,000 has been added to the renewal fund, and a quarterly dividend of 2 per cent. on the Preferred, and at the rate of 4 per cent. per annum on the ordinary stock has been paid. A second quarterly dividend of 2½ per cent. on the former, and at the rate of 5 per cent. on the latter stock, will be paid on the 1st proximo, leaving £11,300 to be carried forward. In view of the approaching competition of the new French Company, and to facilitate the increased number of messages expected from a lower tariff, it has been determined to lay a new cable next year, for which the shore ends and part of the intermediate types of the 1865 and 1866 cables will be available; while the deep sea section, which will be of the latest improved type, will be paid for out of the renewal fund. The duplex system of telegraphy, invented by Mr. J. B. Stearns, and applied to the cable laid in 1874, has been taken over by the Company as from the 1st March, 1879. The royalty to be paid to Mr. Stearns during the life of his patents, for their use upon the whole of the Company's system, amounts, at present, to £1,300 per annum, the maximum payment being limited to £1,500 per annum. The system will be gradually extended to the whole of the Company's cables."

Iron Aug 1879

UNDERGROUND WIRES IN GERMANY.—A subterranean telegraph wire has just been laid down between Hamburgh and Bremen, and Oldenburgh and Emden, with branch lines to Bremerhaven and Wilhelmshaven.

Iron Aug 1 1879

TELEGRAPH RATES TO AUSTRALIA.—It is said that the efforts made by the Royal Commissioners of the Australian Exhibition to obtain a reduction of telegraphic rates in favour of exhibitors at Melbourne and Sydney have failed of success, solely by reason of the uncompromising opposition of Lord John Manners, who holds "that as the telegrams in question would be sent with the view of facilitating the arrangements of manufacturers and tradesmen who are exhibiting for trade purposes, and because of the pecuniary advantages they are expecting to derive, he can see no reason why the Post-office Department should forego its revenue for their benefit."

LEASE OF THE DOMINION TELEGRAPH COMPANY'S LINES.—It is reported that the lines of the Dominion Telegraph Company of Canada have been leased to an American company on the following terms:—The American Company take up all unissued stock of the Dominion Company ($289,000), at 80 per cent., $140,000, of which is to be applied to pay off floating liabilities, leaving $90,000, to be used in extending the lines, &c. The lessees are to pay for interest on Dominion telegraph bonds $30,000 annually, and at their maturity pay the same off, and pay quarterly in advance 5 per cent. on the capital of $1,000,000, the first quarter's interest being now in hand. They also pay $2500 per annum for the maintenance of the company's organisation, such as board, secretary, &c. The Canadian Board is to be maintained. The lease is for 99 years from the first of July ult., and should the lessees in any way fail to carry out their agreement to pay over quarterly dividends, interest on bonds, &c., the Dominion Company, at the expiration of thirty days, are empowered to terminate the lease.

Telegraphic Journal Aug 1 1879

Tel. Jour. Aug 1 1879

DIRECT UNITED STATES CABLE COMPANY.—The report of this Company, to be presented at the fourth ordinary general meeting, to be held at the City Terminus Hotel on August 1st, says: "With this report the directors, submit the usual statements of account for the half-year ending 30th June, 1879, which, with the half-year's accounts to the 31st December last, presented at the ordinary general meeting on the 21st March last, show the financial result of the second year's working of the Company. For the half-year the revenue, after deducting outpayments, amounted to £87,706 3s. 2d.; for the corresponding period of 1878 the amount of revenue, after similar deductions, was £79,852 11s. 5d. The working and other expenses (exclusive of cost of repairs), interest on loan, and income tax, &c., amounted for the half-year to £20,523 5s. 10d., leaving a balance of £67,182 17s. 4d. as the net profit for the half-year; making, with £5,273 8s. 4d. brought forward from the previous half-years, a total of £72,456 5s. 8d. In the corresponding half-year of 1878 the expenses and payments above mentioned (also exclusive of cost of repairs), amounted to £20,065 17s. 9d. The cost of repairs for the half-year, amounting to £8,965 9s. 11d., has been paid for out of, and is charged against the reserve fund. Three quarterly *interim* dividends of 1¼ per cent. each, amounting to £45,532 10s. 0d., have been declared and paid at the usual times during the financial year, and a final dividend of 5s. per share is now proposed; making, with the three *interim* dividends, 5 per cent. for the year, being a total distribution of £60,710. The appropriation of the above balance of £72,456 5s. 8d. on the revenue account is thus shown:—*Interim* dividend for quarter ending 31st March last, £15,177 10s.; final dividend now proposed, £15,177 10s.; carried to reserve fund, thereby increasing it to £100,000—£34,756 4s. 3d.; written off preliminary and arbitration expenses, £5,000; carried forward to next account, £2,345 1s. 5d.; total, £72,456 5s. 8d. The agreement with the Dominion Telegraph Company of Canada, referred to in the last report, has been completed, and came into operation as from the 1st January, 1879. The break in the Company's main cable, which occurred on the 4th January last, was repaired on the 20th March, and the interruption on the 12th February last, of the short section, was repaired on the 22nd April. Both sections of the cable are in good working order.

Journal of Tel Aug 16 1879

The International Telegraph Conference.

The action of the International Telegraph Conference, as has been before stated, will not be authoritatively known until ratified by the Governments which the delegates represent. Although the English telegraphic journals have made no report of the proceedings or the conclusions arrived at, some of these are made known in speeches of the delegates at the numerous entertainments which are given them.

Journal of Tel. Aug 16 1879

The Telegraphic Journal of August 1st, says:—"The delegates, despite the unseasonable weather, are still diversifying their business with sight-seeing and entertainments. On Saturday, July 12th, they were shown over the West India Docks, by invitation of the East and West India Dock Company. The ships were dressed in their honor, and luncheon was served in one of the large wool warehouses. On Friday, July 18th, the delegates paid a visit to the Camp at Wimbledon, where they were entertained at lunch in the Refreshment Pavilion, by the Joint Reception Committee of the Post Office and Telegraph Companies. And on the following Wednesday they went to Liverpool, and were entertained at a banquet given by the Lord Mayor, and a luncheon on board one of the Inman steamers. From Liverpool they then proceeded to Edinburgh and Glasgow."

At Edinburgh the members were entertained by the Lord Provost, Magistrates and Town Council to a cake and wine banquet in the Council Chambers. The Lord Provost presided, and a large and brilliant assembly were invited to meet the delegates.

Mr. C. H. B. Patey, Assistant Secretary, General Post Office, London, a member of the Conference in proposing the toast of "The Edinburgh Chamber of Commerce" said, speaking of the work of the Conference, "In regard to the tariff with Europe, that also would be found to be lowered in some instances very considerably, more especially to the four countries with which England had its greatest intercourse—France, Belgium, Holland, and Germany. In regard to these there would be a decrease, but that was not to be wondered at when he told them that of the messages to foreign countries 80 per cent. were to those he had named. In connection with the word code a change was brought about by the Conference at St. Petersburg, which preceded that of London. The only difference now was that in the number of languages allowed for code messages the Turkish had been excised, leaving eight languages."

At the banquet given to the delegates at Manchester by the President of the Manchester Chamber of Commerce, Mr. Patey proposed "The Manchester Chamber of Commerce," and gave an account of the labors of the Conference. He said they had come to the conclusion that a word rate should be introduced, and he hoped that in the course of the next year or two that rate would be in operation for the European telegraphs. The differential rate between London and the country would be done away with, and next year there would be only one rate to any part of the United Kingdom or the world. He thought they had been able to hit upon a tariff which would continue to pay dividends, and still give satisfaction to the public. It would be found that a great reduction had been made in all the rates. With regard to European code messages scarcely any alteration had been made. Another alteration had been made which he also thought would be for the benefit of the merchants. Heretofore they had been permitted to send five figures as one word, and some difficulties had arisen in connection with this. The Conference had decided that the extra payment for figure telegrams should be altogether abolished, but that, on the other hand, the number of figures allowed to count as one word should be reduced to three.

95

Telegraphic Journal Aug 1 1879

Notes.

Tel. Jour. Aug 1 1879

THE INTERNATIONAL TELEGRAPH DELEGATES.—The delegates despite the unseasonable weather, are still diversifying their business with sight-seeing and entertainments. On Saturday, July 12th, they were shewn over the West India Docks, by invitation of the East and West India Dock Company. The ships were dressed in their honour, and luncheon was served in one of the large wool warehouses. On Friday, July 18th, the delegates paid a visit to the Camp at Wimbledon, where they were entertained at lunch in the Refreshment Pavilion, by the Joint Reception Committee of the Post Office and Telegraph Companies. And on the following Wednesday, they went to Liverpool, and were entertained at a banquet given by the Lord Mayor, and a luncheon on board one of the Inman steamers. From Liverpool they then proceeded to Edinburgh and Glasgow.

Engineer July 25 1879

SOCIETY OF ENGINEERS.—Arrangements have been made for a visit of the members and associates of the society, on Wednesday, the 30th instant, to the telegraph cable works of Messrs. Siemens Brothers, at Charlton, by their kind permission. The visitors will there have the opportunity of inspecting the various processes connected with the preparation of the materials used in the manufacture of telegraph cables, and the manufacture of the cables themselves as well as that of various kinds of electric telegraph apparatus and instruments. The telegraph cable ship Faraday will also be open for inspection, through the kindness of Messrs. Siemens Brothers. Members and associates, who are requested to state their intention to attend, will assemble at Messrs. Siemens's Works at 11.45 o'clock. A convenient train leaves the Charing-cross Station at 11.0, and the Cannon-street Station at 11.10, for the Woolwich Dockyard Station. Arrangements will be made for those members and associates who wish to do so, to dine together, at the Guildhall Tavern, Gresham-street, at 6 o'clock.

Engineer July 25 1879

 Telegraphic Journal Aug 1 1879

THE EASTERN TELEGRAPH COMPANY (Limited).—At the fourteenth ordinary general meeting of this company, held on July 14th, the chairman, having moved the adoption of the report, an abstract of which appeared in our last issue, and the same having been seconded by the Marquis of Tweeddale, said in answer to questions by shareholders: Is there any other question to be put? Well, then, I may say to Mr. Newton, in the first place, that I think we have shown you that there is an increase in the stations alone of 12 stations, and I think that the gross increase that we shew you is £6,000 odd. Then there is —— Mr. Newton: £6,160 in the half year; that means £12,320 per annum. The Chairman: Yes; quite true. Well, if you take 12 stations, and take them at an average of £500, you have £6,000 to begin with, and if you take the loss of £7,000 on exchange you have the net amount without any difficulty. As to fluctuations in the exchange it is very difficult for me to give an opinion. The wisest men at the present moment are baffled by this question of silver, and if there is any hon. gentleman who can throw any light on the subject I am sure that it will not only be acceptable to me and the Board generally, but also acceptable to a great many others who are deeply interested in the trade; but I may mention to you that we have not been idle and have not been thoughtless on this particular question, and we have entered into an arrangement now with the Indian Government which will give more favourable terms to the company as regards the value of the rupee. Mr. Newton: That leads me to another question. Have you some arrangement with the Government that they take any risk of the fluctuations in the price of silver and in the value of the rupee? As I understand it you collect your revenue in Calcutta in rupees. We cannot take any benefit from the Government in that respect; we must take the chance if the exchange is 1s. 6d. And I do not think that we ought to consider that we make a loss on exchange unless you, for convenience in the accounts, take the value, say at 20d., which is 1s. 8d. in our money, but received abroad in the rupee. We certainly must take the risk of it being remitted home, like any merchant, unless the Government is so kind as to give us an increase on the value to that prevailing in the markets abroad. That is what I mean—not that we take any benefit from anyone, but that we take our chance like any merchant. The Chairman: I think that if you asked any merchant who sends out goods to Calcutta he will tell you that it is a question of the exchanges where he makes a loss where otherwise he expected a profit. But the Indian Government forms part of our joint purse; and in future we have arranged with the Government that it is to be taken at about 1s. 7½d., and, therefore, any variation below that must be to our detriment; but above it, as it is now, it is in our favour. Now, gentlemen, I think those are the only two questions I have been asked, and I hope that I have answered them satisfactorily. The resolution for the adoption of the report was then put to the meeting and carried unanimously. The question of the Cape cable was then discussed at considerable length, Mr. Newton remarking on the want of a limit to the increase of preference and debenture capital when compared with the ordinary capital of the Company. He also said, "Seeing the tremendous influence of our directors, I am amazed that, as to that part of which so much is made, the influence of the directors with the Government has not produced us a better bargain; and it would seem that the influence is not worth so much, seeing the results of this new undertaking; and the sooner you get on your board two or three more gentlemen of consummate mercantile capacity (hear, hear), the better will it be not only for you, sir, and your Company, but for every member of telegraph property." The chairman then proposed the following resolution:—"Resolved, that the several provisional agreements referred to in the directors' report, and submitted to this meeting with the Lords Commissioners of Her Majesty's Treasury, the Colonial Governments of the Cape of Good Hope and Natal, the Portuguese Government, and the Sultan of Zanzibar, with respect to a line of submarine telegraph between this Company's station at Aden and Natal, and the arrangements mentioned in the report as to the making, laying, and working of the cables, be and the same are hereby approved and adopted so far as the same relate to the matters and things to be done by this Company, and that the board of directors be and they are hereby authorised on behalf of this Company to complete and carry into effect the said agreements and arrangements, with or without any modifications or alterations from time to time required or approved by the board; and also to make and carry into effect any other agreements and arrangements with reference to the said cables which the board may think desirable; and also to subscribe for and accept on behalf of the Company shares and debentures of the proposed Eastern and South African Telegraph Company; and to raise, by the issue of debentures of this Company or otherwise, such moneys as may be required for those purposes or any of them, and apply the same accordingly as the board shall from time to time deem expedient." Sir James Anderson seconded it, and, after some further critical remarks by Mr. Newton, it was put to the meeting, and carried with one dissentient. The usual vote of thanks then brought the proceedings to a close.

The Eastern Extension Telegraph Company (Limited) notify that the Six per Cent. Debentures, due on August 1st, will be paid on or after that date, on presentation at the Consolidated Bank.

The Eastern Extension Telegraph Company (Limited) notify that their Java-Darwin cable is now repaired, thus restoring direct telegraphic communication with Australia and New Zealand.

The *Faraday*, steam screw cable ship, has returned to Messrs. Siemens Brothers' Telegraph Works, Charlton, after having successfully laid 200 miles of the shore end of the new French Atlantic cable in course of being laid down from St. Pierre to the United States. The *Faraday* will shortly begin to take on board the first portion (about 1,000 miles) of the deep sea cable, and is expected to make three voyages before France and America are placed in direct and independent communication.

The following are the final quotations of telegraphs:—Anglo-American, Limited, 53¼-53¾; Ditto, Preferred, 82¼-82¾; Ditto, Deferred, 26¼-26¾; Brazilian Submarine, Limited, 6¾-7¼; Cuba, Limited, 7¾-8¼; Cuba, Limited, 10 per cent. Preference, 15¾-16¼; Direct Spanish, Limited, 1¾-2¼; Direct Spanish, 10 per cent. Preference, 10¾-11¼; Direct United States Cable, Limited, 1877, 10¼-10¾; Eastern, Limited, 7¼-7¾; Eastern, 6 per cent. Debentures repayable October, 1883, 105-108; Eastern 5 per cent. Debentures repayable August, 1878, 103-106; Eastern, 6 per cent. Preference, 11½-12; Eastern Extension, Australasian and China, Limited, 7¾-8; Eastern Extension, 6 per cent. Debenture, repayable February, 1891, 108-111; German Union Telegraph and Trust, 7½-8; Globe Telegraph and Trust, Limited, 4¾-5¼; Globe, 6 per cent. Preference, 10¾-11¼; Great Northern, 8½-8¾; Indo-European, Limited, 20¼-21¼; Mediterranean Extension, Limited, 2½-3; Mediterranean Extension, 8 per cent. Preference, 9-9½; Reuter's, Limited, 9-10; Submarine, 229-234; Submarine Scrip, 2-2¼; West Coast of America, Limited, 1-1½; West India and Panama, Limited, 1¼-1¾; Ditto, 6 per cent. First Preference, 7½-8¼; Ditto, ditto, Second Preference, 7¼-7¾; Western and Brazilian, Limited, 2¾-3¼; Ditto, 6 per cent. Debentures "A," 96-100, Ditto, ditto, ditto, "B," 89-94; Western Union of U. S. 7 per cent., 1 Mortgage (Building) Bonds, 118-123; Ditto, 6 per cent. Sterling Bonds, 107-109; Telegraph Construction and Maintenance, Limited, 30-30½; Ditto, 6 per cent. Bonds, 106-108; Ditto, Second Bonus Trust Certificates, 2¼-2¾; India Rubber Co., 12¾-13¼; Ditto, 6 per cent. Debenture, 106-109.

TRAFFIC RECEIPTS.

Name of Co., with amount of issued capital, exclusive of preference and debenture stocks.	Anglo-American Co. £7,000,000.	Brazilian Sub. Co. £1,300,000.	Cuba Sub. Co. £160,000.	Direct Spanish Co. £116,379.	Direct U.S. Co. £1,213,900.	Eastern Co. £3,697,000.	Eastern Ex. Co. £1,997,500.	Gt. Northern Co. £1,500,000.	Indo-Euro. Co. £425,000.	Submarine Co. £338,225.	West Coast America Co. £300,000.	Western and Brazilian Co. £1,398,200	West India Co. £883,210.
	£	£	£	£	£	£	£	£	£	£	£	£	£
June, 1879 ...	45,000	11,021	2,400	1,025	15,000	36,635	26,485	19,618	... ...	10,661	... ...	9,379	5,057
June, 1878 ...	41,480	11,124	3,175	793	12,840	31,118	23,269	18,582	... ...	10,350	... ...	... ...	3,884
Increase	3,520	... ...	... ...	232	2,160	5,517	3,216	1,036	... ...	311	... ...	... ...	1,173
Decrease	... ...	103	775	... ...	... ...	... ...	... ...	... ...	... ...	... ...	... ...	... ...	... ...

(*The figures in this Table are as accurate as it is in our power to make them, but we do not guarantee their correctness.*)

Journal of Tel Aug 1 1879

The Telegraph.

ANGLO-AMERICAN TELEGRAPH.

THE report states that the total receipts for the past half-year, including a balance of £3,587 brought over from the last account, amount to £298,393, being an increase of £25,120 as compared with the corresponding period last year. The total expenses amount to £54,592. Out of this sum the directors set apart £75,000 to the renewal fund, leaving a balance of £168,800. One quarterly interim dividend, of 2 per cent. on the preferred stock, and at the rate of 4 per cent. per annum on the ordinary stock, was paid on May 1, 1879, absorbing £70,000, leaving a balance of £98,800, from which a second quarterly dividend of 2¼ per cent. on the preferred stock, and at the rate of 5 per cent. per annum on the ordinary stock, will be paid on August 1, 1879; leaving a balance of £11,300 to be carried forward to next account. The 1869 cable, laid down by the French Atlantic Telegraph Company between Brest and St. Pierre, and taken over by this company in 1873, was broken on February 22 last. The necessary repairs are now being proceeded with. The short section of the same cable, laid between St. Pierre and Duxbury, has been broken twice during the half-year; both breakages have been repaired, not without considerable difficulty and delay. The *Minia* has been engaged in the restoration of the main and short sections of the cables belonging to the Direct United States Cable Company. The policy to be pursued, in view of the approaching competition with the new French company, "La Compagnie Française du Télégraphe de Paris à New York," of which M. Pouyer Quertier is the president, is occupying the constant attention of the directors; and it has been determined that, in order to preserve for the Anglo-American Company the position and prestige they have hitherto enjoyed, and to facilitate the transmission of the increased number of messages which may be expected from a lower tariff, a new cable should be laid by this company next year. The shore ends, and a considerable portion of the intermediate types of the 1865 and 1866 cables, will be available for this purpose; the deep sea section will consist of new cable of the latest improved type, and will be paid for out of the renewal fund. The duplex system of telegraphy, invented by Mr. J. B. Stearns, and applied to the cable laid in 1874, has been taken over by the company as from March 1, 1879, and will be gradually extended to the whole of the company's cables. It is proposed to establish a fund for the benefit of the officers of the company, to which the company will subscribe half the annual premiums. This fund will, to a great extent, stand in place of a periodical augmentation in the salaries of the staff, and will, besides, make the service more popular.

Times July 26 1879

THE DIRECT UNITED STATES CABLE COMPANY.

THE report of the Direct United States Cable Company (Limited), for the six months ending 30th June last, states that the revenue for the half year, after deducting out-payments, amounted to £87,706; the amount of revenue for the corresponding period of last year, after making similar deductions, being £79,852. The working and other expenses (exclusive of cost of repairs), interest on loan, and income tax, &c., amounted for the half year to £20,523 5s. 10d., leaving a balance of 67,182 17s. 4d. as the net profit for the half-year, making, with £5273 8s. 4d. brought forward from the previous half-year, a total of £72,456 5s. 8d. In the corresponding half-year of 1878 the expenses and payments above mentioned (also exclusive of cost of repairs) amounted to £20,065 17s. 9d. The cost of repairs for the half-year, amounting to £8965 9s. 11d., has been paid for out of, and is charged against, the reserved fund. Three quarterly interim dividends of 1¼ per cent. each, amounting to £45,532 10s., have been declared and paid at the usual times during the financial year, and a final dividend of 5s. per share is now proposed, making, with the three interim dividends, 5 per cent. for the year, being a total distribution of £60,710. The appropriation of the above balance of £72,456 5s. 8d. on the revenue account is thus shown:—Interim dividend for quarter ending 31st March last, £15,177 10s.; final dividend now proposed, £15,177 10s.; carried to reserve fund, thereby increasing it to £100,000, £31,756 4s. 3d.; written off preliminary and arbitration expenses, £5000; carried forward to next account, £2345 1s. 5d.

Times July 26 1879

98 Engineering Aug 1 1879

Engineering Aug 1 1879

NEW SUBMARINE CABLES.

AFTER a period of stagnation extending over five years, there is again a revival of submarine cable enterprise; and cable electricians, who have been for that time deprived of their legitimate occupation, are now experiencing brighter prospects. There are no less than four distinct cables in course of being manufactured or laid; and others are projected. Last year the Eastern Telegraph Company completed the duplication of their Oriental lines from England to Bombay; and the Eastern Extension Telegraph Company, which prolongs the Eastern Company's system to Australia *viâ* Madras, Penang on the Malay Peninsula, and the East Indian Islands, are at present engaged in duplicating their lines also, a work which has been somewhat delayed, however, by their giving up 1400 miles of ready-made cable to form a portion of the cable to the Cape. The latter important line of communication is, of course, the chief cable operation now in hand, and we regret to see that there was some delay in the furtherance of the work, for the s.s. Kangaroo, belonging to the Telegraph Construction and Maintenance Company, who are the contractors, although she arrived at Durban on May 21 with the Natal to Zanzibar section on board, had not begun to lay her cargo up till June 17. For some unaccountable reason a valuable month was lost by this cable steamer, although the need for the cable is, or at least was, so urgent. It is to be hoped that the difficulties in the way, whether due to bad weather, or faults in the core, or to the rumoured refusal of a subsidy by the colony of Natal, on the ground that the terminus ought to be within the Natal borders, have by this time been smoothed away, and that the line is now laid as far as Zanzibar. The second section is on its way out in the s.s. Seine, and the s.s. Calabria carried the remainder.

The agreement between the Eastern Telegraph Company and the Government requires that the entire cable shall be capable of transmitting fourteen words a minute, and that the company shall, save in case of *force majeure*, have the portion of the cable between Durban and Zanzibar opened for traffic by July 31, and the entire line by the last day of this year. The company agrees to keep a repairing ship properly equipped in the Red Sea or Indian Ocean for maintaining the line. All Government messages, whether imperial or colonial, are to have priority to all other traffic, at one-half the rate charged to the general public. The public rate is not to exceed 5s. per word between Durban and Aden; 4s. per word between Zanzibar and Aden; and between Aden and London, by the Eastern Telegraph Company's lines, the sum of 3s. 9d. per word. The total charge for a message from Durban to London must not, therefore, exceed 12s. 9d. per word. Her Majesty's Treasury may nominate an official director on the boards of the companies owning and working the line, to whom every information must at all times be afforded. On the completion of the line between Natal and Zanzibar, the Treasury agrees to pay, during a term of 20 years, an annual subsidy of 17,500*l*., and a like sum on completion of the line between Zanzibar and Aden, provided always that the line is kept in good working order. In case of war, rebellion, or other emergency, the Imperial Government or the Government of any British colony or possession duly authorised by her Majesty's Government so to do, may take possession of the cables, stations, offices, and apparatus on the line, and keep possession of them for as long as they may think fit. For this privilege the Government agrees to make a reasonable compensation to the company. The last clause provides that the agreement shall not be binding until it has been approved by a vote of the House of Commons. It is, we think, a wise foresight on the part of the Government to arrange for taking possession of the lines themselves if need be; and the day is perhaps not far distant when not only the Cape cable, but also the Indian cables of the Eastern Telegraph Company, may become the property of the nation.

The second great cable enterprise now in progress is the Pouyier-Quertier scheme for two Atlantic cables from Brest to New York. This project was ostensibly put forth as designed to gratify the *amour propre* of the French people, who wished to have Atlantic cables of their own. But the offer of the Anglo-American Company to sell or lease them a cable was declined, and the original plan adhered to. It is probable that the ultimate aim of the new company is to compete with the existing Atlantic cables for English as well as Continental traffic, a supposition which is borne out by the fact that the Scilly Islands off the coast of Cornwall have been chosen as an intermediate landing-point for the cable. The new cables are being made by Messrs. Siemens Brothers at their Charlton works, and the s.s. Faraday, which laid the direct United States cable, has already submerged the Brest to Scilly section of the first line.

Within the limits of Europe itself a short cable made by Mr. Henley for the Russian Government was recently laid across the Caspian Sea; and there is now in process of manufacture a new German-Norwegian cable intended to connect Scandinavia direct with Germany. Hitherto the latter power has been obliged to send all her telegrams to Norway through Denmark and Sweden, a course which was irksome to her owing to the uneasy political relations which have for a long time existed between her and Denmark. The agreement entered into between the representatives of the German Empire and the Governments of Norway and Sweden stipulates that Germany shall lay the new cable at her own cost. It is to be a three-wired line and will be laid from Romoe, an island off the west coast of Schleswig, and the Norwegian peninsula, at a point near Arendal. At the latter place it will be connected to the whole Scandinavian telegraph system. The cable is estimated to cost 95,000*l*. and will belong to Germany, who will also repair it. All telegrams from Norway to Germany are to pass through the new line, and also three-fifths of the Norwegian traffic with other countries (excepting Russia, England, and Denmark), unless the new route should prove more expensive than the old ones. It is obvious that this arrangement will materially reduce the inland telegraph revenue of Denmark, for hitherto all the German-Norwegian traffic has passed through that country. The new cable is, we believe, being manufactured by Messrs. Siemens and Halske, of Berlin, and it is expected to be laid some time in August.

Besides these actual performances, there are at least two projects for new submarine cables afloat; one by the American Cable Company to lay a line from New York to Flores, an island of the Azores, with one connecting line from Flores to France, England, and Holland, and another from Flores to Fayal (Azores), San Miguel, and Lisbon. These will comprise 7300 miles of line, if they are ever executed. The other scheme is for the long-talked-of Pacific Ocean cable from some point on the western coast of the United States to the Sandwich Islands, and thence to Japan and China. Mr. Cyrus W. Field, the cable veteran of Atlantic fame, is the chief promoter of this undertaking, and he is now in England for the purpose of investigating the subject of making and laying the cable in question. He holds, it appears, an exclusive concession from the Government of the Sandwich Islands for such a cable; a fact which was first announced at the recent Cable Jubilee or celebration of the twenty-fifth anniversary of the organisation of the first Atlantic Cable Company. Similar concessions have yet to be obtained from China and Japan, but as the Celestials are now awake to the advantages of the telegraph, it is expected that these will be obtained without difficulty. On the return of Mr. Field to America a company will be formed to carry out this work, and Mr. Field has, we understand, agreed to contribute 100,000 dols. as a subscription to the capital stock. The establishment of this cable would complete the telegraphic circuit of the world, and we can only hope that Mr. Field will be as successful in carrying the electric wire across the Pacific Ocean as he was in spanning the Atlantic.

99

ELECTRICITY & TELEGRAPHY

Aug 2 1879

INTERNATIONAL TELEGRAMS.

Iron

THE *Daily News* takes a discouraging, but not wholly incorrect, view of the work done in London by the recent International Conference. A general demand for cheap telegraphy, it says, has been met, not by a general reduction of tariffs, but by concessions as to the form of messages; and the word-tariff has, with certain modifications, been adopted for general use. The old idea of a minimum message has been given up, and what may be called a fixed or constant charge made instead; and the method of charging for long messages has naturally undergone alteration. It will be recollected that, under the system now existing, a minimum message, including name and address, is fixed at twenty words, which must be paid for whether as many words be required or not; and that the charge increases by so much per ten words. Thus, if a message be, including names and address, only five words, twenty must be paid for, while if it require twenty-one words thirty will be charged, as the rate of increase is at so much per ten words. The system of a high initial charge has been throughout defended by the argument that a message is a message, whether it be short or long, and that the same prefixes and terminal charges are required for both. It has, however, been found possible to combine a fixed initial charge with a simple word-tariff in such wise as to relieve the senders of short messages of considerable expense. It is understood that the submarine companies expect to sustain a certain loss by this modification, which, so far as short mercantile telegrams are concerned, amounts to nothing less than a reduced rate of charges, but hope to recoup themselves by a large expansion of this part of their business.

The solution of the difficulties between the advocates of a simple word tariff and those who clung to a minimum message of such length as to prove remunerative to the lines has been found in a first charge at the rate of five words for a telegram, and after that at so much per word according to the existing tariff. To make this clear in intention, it may be mentioned that the telegraph companies consider the "prefixes"—that is, the preliminary messages exchanged between the clerks before the actual message is dealt with—equivalent, with the trouble of collection and delivery, to five words. In practice, it makes it possible to send a short message at a very low rate. To take the example of a telegram from England to Italy. To begin with, the shilling extra from English places other than London is abolished, leaving the minimum telegram of twenty words. For this the charge is now seven shillings and sixpence, with increase by ten words at the rate of fourpence per word. Taking this rate as the basis of calculation, the new telegram would be computed thus. An initial charge of five words, one shilling and eightpence; message of, say, eight words, 2s. 8d.—in all 4s. 4d. This is a very great reduction. But it may be objected that a message of eight words is a very short one. It is in fact much longer than it appears at first sight. To persons accustomed to correspond by telegraph the address only consists of three words—for instance, Brown to Black, of Rome. Brown does not need to send his address, and the full name and address of Black at Rome are kept in a private directory at the telegraphic office—a privilege costing him about a guinea per year. He has, therefore, five words left free—often more than enough, inasmuch as Brown to Black, at Rome, "Yes," would often be sufficient, and would be charged as only four words in addition to the initial five; making a message of simple assant cost no more than 3s. This, then, is the effect of the new scale of charges on inter-European telegrams. It is hardly necessary to state that the simple word-tariff without initial charge has been in use since the Convention of St. Petersburg on extra-European lines.

The regulations laid down by the Conference of London as to the definition of a word are minute in the extreme, and would appear amusing if the artful devices of "packers" were not well known. Great ingenuity has been expended upon the concoction of words conveying the meaning of a sentence, and a species of duel has been going on for some time past between the "packers" and the companies—the latter protesting against the use of "words of learned length and thundering sound," obviously intended to defraud them of what they consider their lawful dues. Code-makers have carried the art of building up sentence-words to such a pitch at last that the companies have turned upon them and obtained from the London Conference a definition of what a word, telegraphically speaking, is. For inter-European purposes a word may contain fifteen characters according to the Morse alphabet, but beyond Europe ten characters only. Thus, "responsibility" is one word for European, but two for extra-European telegraphy.

By the abolition of the signature previously required, a concession has been made which almost compensates for the insistance on a telegram being properly directed. This latter provision, however, is not very exacting. Two words only are actually obligatory, and these must be the name and address of the person to whom the telegram is sent. It is, perhaps, well that the name, signature, and address of the sender should not be required. Many bickerings have arisen over the question of signature, and probably would have occurred again, had it not been determined not to ask for it at all. Still the telegraph officers retain the right of compelling the sender of a telegram to establish his identity whenever they think fit. The remainder of the work of the International Telegraph Conference has been in the direction of minute but necessary regulations for the adjustment of the order in which messages shall be sent, and other arrangements for the more perfect management of international telegraphy. Government telegrams take precedence of all others, and are followed in the order of transmission by service telegrams and the "urgent" private telegrams, for which a triple rate is charged in the countries—all except India and England—in which "urgency" is recognised. These "urgent" private telegrams, which take precedence of ordinary messages, appear to pass mainly between operators on the various Continental money markets, to whom the cost of a message is probably of slight importance.

The effect of the Conference of London will unquestionably be the destruction of any hope of cheap and popular international telegraphy being introduced for some little time—at least till after the Conference to be held in Berlin in 1884. The concessions made in form and price are all, it will be observed, to regular customers, merchants, and others whose "code," name and address are kept at the terminal office. Senders of telegrams who are compelled to write name and address of sender and destinee at full length will profit but very little, if at all, by the revised code of 1879, which may be regarded rather as a politic concession than the initiation of a new system. It must, however, in fairness be recognised that the great submarine lines are commercial speculations working for a profit, and therefore hardly to be discussed on the same principle as land telegraphs, managed by the Governments of the countries through which they pass. The latter may be regarded by any Government so disposed as part of the machinery of national life, and not therefore compelled to return a profit; but so long as the ocean lines remain in private hands, these theories are obviously inapplicable to them. Merchants, however, have cause to thank the delegates to the London Conference for relieving them of most of the ignominious necessity and opportunity for getting the better of the telegraph companies. It may be added that the amendments of the Conference have yet to receive the formal ratification of the several Governments concerned, and that they are not intended to take effect before April, 1880.

100

THE NEW CAPE CABLE.

from July 26/1879

THE works of the Telegraph Construction and Maintenance Company, on the riverside just below Greenwich, present just now rather a decided contrast to a great many factories and business places down the river below London Bridge. Very unmistakeable are the symptoms of dulness and stagnation that are here everywhere visible—warehouses and wharves to let, workshops closed, and one fancies a good deal less than the average of shipping in the river, the general depression in appearance being very much enhanced by the unfortunate ferry between Rotherhithe and Wapping, which, after a chequered career, appears to have finally broken down, and now lies a conspicuous and particularly dreary representative of the hard times. It is an ill wind, however, that blows nobody any good, and the mischievous breezes that have blown up for us the expense and anxiety of a vexatious war in South Africa have wafted to the Telegraph Construction Company a good substantial contract for a new line to bring our distant and troublesome possessions at the Cape into ready communication with us. The line is now in rapid construction, and this, together with another submarine cable for connecting Germany with Norway, a duplicate line from Penang to Australia, and one or two others, keeps the wheels spinning merrily at the Company's works; which are just now, therefore, particularly well worth visiting, more especially as the manufacture is of a kind at once pretty and simple enough to be readily comprehended by any one unfamiliar with such operations.

The actual conducting wire, which, of course, is really the telegraphic line, is not made at the works now under consideration, but is imported from the company's establishment just off the City Road, where the heart of the whole cable is formed by encasing a seven-strand copper wire in a coating of gutta-percha. When completed it is wound on huge reels, in lengths of about three miles, the copper conductor and its insulating covering being somewhere about the thickness of a lead pencil, the copper and gutta-percha bearing, in point of bulk, about the same relation to each other as the "lead" and the cedar. On their arrival at Greenwich from the City Road the reels are immediately plunged into circular tanks of water, from which, as they are required, they are drawn by a crane and deposited in a trolly running upon a tramway laid throughout the length of the large machine-room in which operations are commenced. Each reel is rolled from the trolly on to the floor, lifted by means of screws placed under the ends of its axis, and the line may now be spun off as rapidly as desired. The whole process from this starting point until it is coiled on board the vessels that are to pay it out into the ocean is a process of protection and strengthening. It is first incased in a covering of cotton tape by a method which will be familiar enough to anybody who has seen ropemaking, a reel of the tape being made rapidly to revolve round the insulated wire as it is paid out. This is the manner in which every succeeding layer is applied and it may serve to render it more intelligible to any one who does not happen to have seen rope, making if we say that the process may be very fairly illustrated by drawing a wire slowly through the axle of a wheel with a reel of cotton fixed on one of the spokes. The reel, of course, will revolve round and round the centre, and if the end of the cotton be attached to the wire it will be gradually unwound from the reel and twisted spirally round the wire as it passes along.

The early deep-sea cables suffered terribly from the ravages of a minute marine insect, which ate its way through the insulating materials. To guard against this enemy the next covering—applied in precisely the same way, only that the winding is done in a direction opposite to that in which the cotton tape is twisted—is a brass tape which covers it so completely that the insects can find no way to the materials within. Next comes a similar sheathing saturated with marine glue—this, again, being twisted round in the direction contrary to that of the brass. Several reels of jute yarn are now spun round the whole, thus completing the case of the cable. The rapidity and beautiful simplicity of the whole of the work may be gathered from the fact that all this is done while the line is merely passing from one side of the room to the other. On this side the room is the reel of insulated wire, just as it comes into the factory; on the other are the "core tanks," in which is coiled the telegraphic line perfectly complete and capable of conveying messages and resisting all the ravages of marine animal life, and the effects of prolonged immersion at great depths of sea water, only that it requires to be strengthened.

From this point the proceedings vary somewhat according to the position for which the line is intended. The shore ends, which are to be exposed to the action of tempests and jagged rocks, are encased in solid thick galvanised wires, which bring up the weight of the completed cable to some 19 tons a mile. The deep sea cable is wound round with a slighter wire of homogeneous iron, which is first heated in a furnace to expel any air that it may contain, and then plunged into cauldrons of a boiling black varnish, calculated to effectually exclude the action of the water. The winding of these homogeneous wires, and the similar proceeding with the stouter wires for the shore ends, is in principle precisely the same as in the operations already described, but of course on a much more gigantic scale, and presents one very pretty feature. The core around which the strengthening wires are to be wound passes up through the room, coming in by a hole in the floor, and passes out by a hole in the ceiling directly over. As it moves up, a considerable number of reels of wire of any required kind or thickness revolve round it like the horses in a "merry-go-round," or like children round a may-pole, with their ribbons attached to the top of the pole. Just according to the speed with which the "core" is drawn up through the ceiling, their revolutions around it are performed, and the wire they pay out is wound round with a regularity and compactness simply perfect. The very pretty feature alluded to is a mechanical arrangement known in the engineering world as the "sun and planet" system, which keeps the reels always with the same side presented to the line around which they are so merrily spinning. The floor on which a number of those urchins are at work is a particularly lively one, inevitably suggesting the idea of a number of "merry-go-rounds" at a fair, an idea which is further sustained by the clanging of bells with which each machine is provided to stop or start. On the floor above, the apex of each maypole, so to speak, is seen protruding through the floor. The core as it passes off from this apex is found to be sheathed in iron, and very little remains to be done with it. First, another tape is wound round, and then a stream of what looks like tar is copiously poured upon it; then another tape and another stream and finally it passes out of the building through two sets of wheels, one running against another, and grooved so as to exactly fit the cable as it passes between them. Two of them run horizontally and two perpendicularly. Thus the whole is well squeezed in a perfectly circular form. Tanks as big as small houses, and capable of holding 200 miles of deep-sea cable, are ready to receive it as the completed line squeezes its way between these wheels. As it passes through, a couple of men coil it down in regular layers, each layer being whitewashed over, to prevent sticking together, and the whole receptacle being filled up ultimately with water, until the vessel is ready to receive it into similar tanks on board.

Of course it has to be tested, and for this purpose each section of cable is put in communication with the sanctum of the electrician. Every now and again a current is passed through it, and observation made of its effect on a tiny magnet. The way this is done is very curious. The magnet has a little mirror at its back, and this mirror is made to reflect a ray of light on a graduated scale. The most trivial movement of the magnet is thus shown, and the position of the little slit of light on the scale tells at a glance whether all is right. About 50 miles a day is the rate at which this, we believe the largest manufactory of the kind in the world, can turn out completed cable, and it is expected that by the end of the year the line completing our communication with the Cape will be laid. A portion of cable originally intended for the duplicate Australian line has been appropriated to this more urgent contract, and already three out of the four sections have been despatched. From Natal to Delagoa, a distance of about 350 knots, thence to Mozambique, a distance of 1000 knots, and from there on to Zanzibar, some 650 knots, are the sections already completed; and the remaining 2000 knots required to connect Zanzibar with Aden are being rapidly proceeded with.

101

mauvais temps impriment au navire de forts mouvements de tangage et forcent le frein à laisser dérouler par soubresauts, selon que le navire monte sur la lame ou descent avec elle!

Les efforts sous lesquels ces ruptures ont lieu, sont de 7,800 kilog. au maximum; mais sans atteindre à une pareille traction, on peut craindre tout au moins des avaries notables.

Ce sont là probablement les causes déterminantes de la variation de la durée des cables; car il y en a qui ont besoin de réparation au bout de très peu de temps, d'autres au contraire n'en ont subi aucune depuis leur pose qui date de près de vingt ans; cela tient évidemment aux conditions dans lesquelles ils ont été immergés.

Le premier cable posé a cessé de fonctionner au bout de vingt-quatre jours.

Si on laisse le câble se dérouler naturellement, son poids l'oblige à descendre suivant une ligne D presque verticale (fig. 1), et il est certain que cette position le fatiguera beaucoup plus sérieusement que la ligne ABC; or, c'est pour parer à cette fatigue démesurément augmentée dans les mauvais temps, que M. Dronier, un ingénieux industriel scientifique, a eu l'idée d'appliquer à l'immersion des câbles un parachute, offrant absolument la forme d'un parapluie (fig. 2), dont l'axe est une corde terminée par une boule de plomb.

Au commandement, un homme tenant d'une main le parachute, de l'autre lancerait la corde munie de plomb, par un mouvement qui peut être comparé au coup de fronde, de manière à ce que la corde s'enroulant autour du câble puisse l'amarer solidement. Le parachute occuperait successivement les positions A, B, C, et par sa résistance dans l'eau obligerait le câble à descendre doucement et sans danger pour lui.

Si l'on suppose la vitesse de descente de 2 mètres par seconde, le poids soutenu par le parachute serait de 600 kilos environ; supposons que 1,000 mètres de câble pèsent 370 kilos, on voit qu'avec un parachute par kilomètre, le câble ne descendrait pas dans les profondeurs de la mer avec une vitesse de plus de 2 mètres par seconde; mais en tenant compte de la traction opérée par la rapidité du navire, on peut dire que la descente se ferait alors suivant une ligne se rapprochant de l'horizontalité, qui non-seulement atténuerait beaucoup les effets de tangage, mais encore soulagerait presque complétement le frein dans le poids qu'il a à supporter.

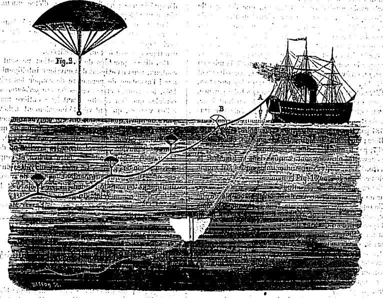

Fig. 2.

Fig. 103.

Si nous passons maintenant de la théorie à la pratique, nous trouverons que le prix d'un parachute en toile à voile, d'un mètre superficiel, peut revenir à 3 francs.

Nous avons parlé ci-dessus d'un parachute par kilomètre, pour obtenir une descente de 2 mètres par seconde; mais, par les temps très calmes, il pourra se faire que l'on n'ait pas besoin d'avoir recours au parachute, ou bien qu'on n'en utilise qu'un par 2 kilomètres. Pour ne pas avoir de mécomptes, supposons que l'on ait à en employer un par kilomètre. Si le câble a 6,500 kilomètres, comme celui dont l'immersion est à l'étude, il suffirait donc de 6'500 parachutes, soit une dépense de 19,500 francs,

over

somme bien peu considérable si l'on tient compte du capital consacré à l'entreprise. Selon toute probabilité, cette dépense se changerait en une grosse économie immédiate, sans parler des garanties qu'elle donnerait pour sa durée.

Le transport des parachutes à bord ne peut être une question ; pliés, jusqu'au moment de leur emploi, ils n'occuperont qu'un emplacement des plus restreints.

Il n'y a aucuns frais accessoires à faire ; M. Dronier n'a pas pris de brevet et abandonne à tous son idée et le résultat de ses travaux.

Ce projet, du reste, n'est pas nouveau ; *les Mondes* en ont dit quelques mots en 1865. Depuis cette époque, aucune objection, aucune critique ne sont venues affaiblir la confiance de l'auteur du projet dans la facilité et l'efficacité de son application.

Nous avons cru devoir appeler de nouveau l'attention sur cette question, parce que l'idée nous paraît simple, pratique et toute d'actualité.

THE SUBMARINE TELEGRAPH COMPANY LIMITED.—Since writing the above notes, the half-yearly ordinary meeting of this Company has been held, Sir James Carmichael presiding. The report of the directors for the half-year ending 30th June last recommended a dividend at the rate of 17½ per cent. per annum, and to add the usual proportion of the receipts to the reserve fund. It also stated the directors had established, in concert with the German Union Telegraph Company, a duplex system of telegraphy on a wire between London and Emden for the transmission of messages passing over the special wire erected by the company between Emden and Vienna.—The Chairman, in moving the adoption of the report, congratulated the shareholders on the balance sheet, which, while showing a slight increase in traffic, did not show a corresponding increase in the expenditure. With regard to the alteration of tariff contemplated, the shareholders were aware that the directors had from the commencement of the company always been advocates of reasonable rates. Many years ago, he (the Chairman) endeavoured to obtain a reduction of the present rates from the French Government, and an assimilation of the differential rates from Liverpool, Glasgow, &c., to the Continent. The French Administration did not see their way to meet the wishes of the company. At a late telegraph conference in London there was an almost general expression of opinion in favour of a word tariff. Personally speaking, he would have preferred taking a more medium course, commencing with a ten-word rate. This was advocated by the French delegates, but the general opinion was in favour of a substitution of an actual word rate. Such being the case, it became their duty to endeavour to carry out that intention in the most efficient manner for the interests both of the public and shareholders. He had only just returned from France, where he found that the operation of the word-rate had led to a considerable increase, both in receipts and in the number of messages sent. With an increase of business they must, of course, look to an increase in the expenditure, as a large additional number of messages would mean an increased number of clerks and instruments, and the probable use of the duplex instrument for many of their lines. In any case, they were not likely to require new wires for many years to come, and, when they did, there was an ample reserve fund to supply them from.—Mr. Capper seconded the motion, which was carried unanimously.—After the re-election of the retiring directors and auditors, the meeting closed with the usual compliment to the chairman and directors.

THE NEW ATLANTIC CABLES.—The *Faraday* is at Messrs. Siemens Bros.' Works, Charlton, taking in 1,000 miles of the ocean section. She is expected to make three trips before France and America are directly connected by wire. Telic Journal Aug 15 1879

THE West Coast of South America cables on either side of Iquiqi, have been cut by orders of the Chilian Admiral. Telic Journal Aug 15

THE Cape cable has been buoyed at Delgoa Bay. 1879

THE RESERVE FUNDS OF THE CABLE COMPANIES.

Telic Journal Aug 15 1879

RECENT occurrences in connection with submarine cable enterprises have had the effect of directing the attention of all thinking men, interested therein, to the future of our submarine cables, and also to the present state of the reserve or renewal funds of the various companies.

It is thought by some of our leading practical electricians, that, in a few years, nearly all existing deep-sea cables will have become useless for telegraphic purposes; and others estimate that the life of these electrical conductors will endure for ten or even twenty years yet. Whatever length of time they may last, and this will vary according to the kind of cable and the ground on which it is laid, it is certain they are at present anything but permanent property. Many hundreds of miles of cable have already become totally useless, and without going much into details we may mention that of the seven cables laid across the Atlantic some are quite defunct, while as we are writing, two are in need of repair, and only two are left to do the whole message traffic from Europe to the United States and the Dominion of Canada.* As a general rule, cables laid in shallow waters are very liable to breakage, but, on the other hand, they are easily repaired. With deep-sea cables, although faults are comparatively unfrequent, the repairing is almost impossible owing to the outer covering and sheathing becoming weakened by decay. Last year an expedition composed of the s.s. *Seine* and s.s. *Calabria* failed to repair the 1866 (Atlantic) cable, and returned to this country on the 27th July, 1878. "The failure was caused by oxidation of the iron wire and decay of the hemp of which the outer covering of the cable consisted." So stated the report of the Anglo-American Telegraph Company.

It may be urged that cables will eventually be made more lasting, or that they may be made much cheaper, so as to permit of total renewals at comparatively frequent intervals, or it may be possible to obtain more sensitive instruments to enable work to be done after faults have shown themselves; but so exquisitely sensitive are the instruments now used that we fancy little can be hoped for in this direction.

Having considered to some slight extent the durability of the cables, the next point which demands notice is that of the reserve or renewal funds of the various companies. Taking the amount of the capitals together of four of the principal companies, having mostly submarine cables rather than land-lines, and the bulk of whose capital is invested in the sea, we find it to reach the considerable sum of over £15,360,000, whilst the reserve funds of the same companies also added together, amount to £731,659.

It cannot be said that directors are to blame for paying excessive dividends; for, with the exception of three companies, two of which pay 6 per cent., and the remaining one 17½ per cent., none of the companies pay over 5 per cent., and two or three pay nothing at all on the ordinary shares.

Nor can it be maintained that the reserve funds are at all adequate to complete renewal, for, doubtless, directors see as well as we do that, unless the receipts increase very remarkably, there is little likelihood of their being able to add any adequate amounts to the reserve funds, and at the same time satisfy their respective shareholders with dividends. The question then arises,—if the traffic returns do not increase, what is to become of those enterprises where no sufficient allowance has been made for renewal? Are they to lapse, or will the Government step in, and, for the sake of retaining our telegraphic communications with the rest of the world, and particularly with our colonies and foreign possessions, subsidize and sustain them, or, purchase existing rights, and, relaying the cables where necessary, work them itself?

The question is one of vast and ever increasing interest, alike to directors, shareholders, electricians, and all engaged in connection with submarine telegraphy—to the whole world, we may say—and the more the directors are aided in their difficult task, by the shareholders, the better will it be for all concerned, and particularly for the shareholders themselves. It would be living on in a Fool's Paradise not to look this serious matter boldly in the face. The Trust companies holding telegraphic securities must also necessarily be affected by whatever affects the success of those companies whose securities they possess.

* Since writing these lines, communication by a third cable has been restored.

THE NEW CABLE STEAMER.

Telic Journal Aug 15 1879

A FINE new cable steamer, built to order for Messrs. Siemens Brothers, was launched from the yard of the makers, Messrs. C. Mitchell and Co., Low Walker, Newcastle, on Tuesday, August 5th, in presence of a large number of spectators, including a distinguished company of ladies and gentlemen from France. The vessel is named the *Pouyer-Quertier*, after the well-known French statesman, who occupies the position of Chairman to the New Compagnie Français du Telegraphe à New York, in whose service she will be for the future engaged as a repairing ship.

Although much smaller, the new vessel bears in many respects a resemblance to her predecessor, the well-known cable steamer *Faraday*, also built by Messrs. C. Mitchell and Co., for Messrs. Siemens Brothers, about five years ago, and which has gained the reputation of being one of the most successful vessels afloat. Like the *Faraday*, the new steamer has twin screws, is fitted with rudder at each end, and has bilge keels of a special kind. There are on board two principal cable tanks, and sundry small supplementary tanks for coiling and stowing the different descriptions of cable. Her whole form and structure are unusually strong; and although bearing the highest class both of the English Lloyd's and the French Veritas, she is even stronger than required by these societies. The vessel is built with a curved bow, on which will be fitted a projecting girder with a swivel cable sheave, a similar sheave being also fitted at the stern. On the deck will be placed very powerful machinery of the latest and most improved description for "laying" and "picking up" cables. Arrangements will also be made for steering the vessel both by steam and by hand, and throughout she will be fitted with a complete system of telegraphs. This is an appliance indispensable for such a ship, as it enables those in charge to handle her in the promptest possible manner—a consideration of such vital importance in cable-laying. Taking it as a whole, the *Pouyer-Quertier*, embracing all improvements suggested by the extensive experience of Messrs. Siemens Brothers and their staff, may be considered as complete a vessel of the class as it is possible to produce. The machinery consists of a pair of compound surface-condensing engines, manufactured by Messrs. Thomas Clark and Co., of Elswick, including all the latest improvements in marine engineering, and capable of propelling the vessel at the speed of 10 knots per hour on the most moderate consumption of fuel. The dimensions of the steamer are: Length over all, 260 ft.; beam, 36 ft.; depth, 24 ft. 4 in.; and she will have a burthen of 1,800 tons. As the vessel left the ways, the christening ceremony was gracefully performed by Miss Siemens, daughter of Mr. Carl Siemens, who himself was present as the representative of his firm.

aux docks de Keesham à Plymouth ce qui reste du câble embarqué avec tant d'enthousiasme deux mois plus tôt.

Des hommes d'un génie vulgaire auraient essayé de sauver l'entreprise en vendant les débris du câble transatlantique à quelque compagnie sous-marine. Mais M. Cyrus Field trouve des arguments énergiques pour ranimer l'esprit des actionnaires qui lui avaient confié leur capital. Il les décide à faire une nouvelle émission d'actions.

Pendant toute la durée de l'hiver, M. Witehouse et les électriciens s'occupèrent nuit et jour à expérimenter les moyens d'accélérer la vitesse des signaux transmis à travers les restes du câble et à perfectionner les moyens de recevoir les messages. Mais, hélas! on ne put arriver, malgré les plus grands efforts, qu'à une vitesse de quatre mots par minute. Encore, pour obtenir ce résultat si important, il fallait avoir recours à l'étincelle d'induction!

Il était certain que l'accident si funeste qui avait interrompu la grande opération était uniquement dû à un défaut dans l'appareil destiné à servir de frein.

Les efforts que l'on fit, après avoir constaté ce fait capital, conduisirent à imaginer le frein automatique d'Appold, appareil dont les services ont été si bien appréciés qu'il est encore en usage et ne sera point sans doute remplacé.

La machine pour lâcher le câble et toutes les parties du système des mécanismes à vapeur dont le concours est nécessaire, reçurent également les plus notables perfectionnements.

Aucune des péripéties ni des accidents de cette nouvelle campagne n'avait été perdu.

Le *Niagara* et l'*Agamemnon* partirent de nouveau pour se séparer du milieu de l'Océan.

Mais avant de faire voile l'un vers Valentia, l'autre vers Terre-Neuve, les deux steamers devaient avoir été rattachés par une soudure unissant les deux bouts du câble dont chacun portait une moitié.

L'idée était simple et fort rationnelle, mais lorsqu'il s'agit de la mettre à exécution, les opérateurs rencontrèrent des difficultés inouïes dont le détail nous occupera une autre fois.

On eût dit que la nature accumulait à ce moment solennel tous les obstacles, et que le génie de ces solitudes déchaînait les tempêtes avec autant d'acharnement que celui qui cherchait, suivant Camoëns, à arrêter Vasco de Gama.

Il fallut s'y prendre à trois reprises pour que la soudure fût faite d'une façon, hélas! bien peu solide, et que les deux navires s'éloignassent l'un de l'autre comme il avait été convenu.

C'est le 6 août 1858, grand jour dans l'histoire de la civilisation, que les premiers messages furent échangés entre l'Angleterre et l'Amérique. La joie qu'excita le succès d'une entreprise qui semblait tellement dépasser les forces humaines, ne se borna point à la race anglo-saxonne. Elle s'étendit même aux nations qui n'avaient pris aucune part à la grande entreprise.

La France, qui ne connaît même point le sentiment de jalousie, si développé chez une nation voisine, se distingua par son enthousiasme. Si l'on en excepte certains physiciens de l'Académie des sciences, un élan pour ainsi dire universel s'empara du public parisien.

Mais ce triomphe n'était pas destiné à durer; il devait être bientôt troublé.

En effet, après avoir parlé pendant vingt-six jours d'une façon de plus en plus lente, de plus en plus pénible, le câble de 1857 refusa de dire un seul mot.

Le nombre des télégrammes échangés avait été de 400, chiffre insuffisant pour assurer autre chose qu'une recette dérisoire, mais assez important pour que le succès fût complet au point de vue scientifique.

Quelque redoutable que fût l'autorité de M. Babinet, elle n'était pas suffisante pour contrebalancer celle des faits accomplis.

Heureusement les progrès de la télégraphie sous-marine avaient été si grands que les objections des savants n'avaient plus de valeur sérieuse, même en présence d'une interruption qui semblait donner si complétement raison à leurs adversaires, d'autant plus redoutables qu'ils se bornaient à prétendre que le câble qu'on avait tant de peine à poser ne durerait pas, qu'il serait même brûlé infailliblement par les courants de grande tension que l'on serait obligé d'employer.

M. Cyrus Field parvint à faire comprendre aux capitalistes qu'il fallait réunir un second capital pour sauver le premier. Il faut ajouter qu'il appuyait ses raisonnements sur l'étude sérieuse, approfondie, complète des causes qui avaient amené le sinistre et qu'il présentait en même temps des moyens qui paraissaient sûrs pour triompher de si grandes difficultés.

Il insistait sur la marche irréprochable de câbles qui avaient déjà un développement assez considérable pour que les critiques de MM. Babinet et consorts pussent s'y appliquer si elles étaient fondées. Il faisait comprendre que l'énergie des courants employés n'avait rien que de très-relatif, et qu'il était excessivement facile de concevoir que leur faiblesse diminuerait au fur et à mesure des progrès de l'électricité. Il ajoutait même qu'en augmentant la conductibilité du câble on arriverait à diminuer les résistances et par conséquent l'énergie du courant nécessaire pour faire parler les appareils connus.

Enfin, il avait eu l'idée d'employer à la nouvelle pose le *Great Eastern*; ce navire géant qui pouvait porter dans sa cale le câble électrique tout d'une seule venue, et qui semblait avoir été construit providentiellement pour permettre aux deux moitiés de la race humaine de se réunir d'une façon définitive, malgré la profondeur des abîmes de l'Océan.

La réussite de cette opération gigantesque, aussi importante pour l'humanité que les conquêtes de César et d'Alexandre, restera comme un exemple mémorable des résultats que peut obtenir l'énergie persévérante quand elle est appliquée à une noble et grande pensée. Cette épopée scientifique n'est-elle pas digne de trouver son Homère tout aussi bien que le siége de Troie?

Le touage par câbles, sur les canaux américains.

Tout le monde connaît le touage tel qu'il s'opère sur la Seine, par exemple, au moyen d'une chaîne noyée au fond du fleuve et accrochée aux deux bouts, sur laquelle se hale le bateau-toueur, au moyen de treuils à noix ou de tambours à encoches.

Un système de touage analogue est en usage en Amérique, particulièrement sur le canal Erié, au moyen d'un câble métallique noyé au fond du canal sur toute sa longueur et attaché à ses deux extrémités. Les remorqueurs, dont chacun a à traîner une flotte de bateaux, sont pourvus de machines qui donnent la puissance à l'organe moteur. Celui-ci a la forme d'un grand tambour dont la circonférence est pourvue d'une série de collets mobiles qui forment une gorge continue pour y loger le câble; ces collets mobiles sont construits de telle sorte qu'ils se ferment sur le câble lorsque le tambour tourne et le tiennent serré avec une force proportionnelle à celle qui agit sur le câble, par suite de la tension que lui imprime la charge traînée. Le câble qui se lève du lit du canal entre sur le bateau par la proue et est conduit par des poulies-guides jusqu'au tambour moteur monté sur le pont du remorqueur : si la machine est mise en train, le tambour tourne et la flotte de bateaux est traînée. Le câble redescend à l'eau par l'étrave de derrière.

Le rapport fait sur le trajet assez court de 42 milles (70 kilomètres), qui sépare Buffalo de Middleport, constate les bons résultats obtenus par ce système.

La vitesse était trois fois plus grande que celle que peut procurer la traction animale et on menait, sans plus de dépense, sept fois plus de marchandises. La plus grande charge fut de sept bateaux de canal, chargés de 1.499 tonnes de charbon, ce qui correspond à la charge de 150 wagons. Le fonctionnement du mécanisme était très convenable.

La Compagnie fondée pour l'exploitation de ce système sur le canal Erié se nomme *N. Y. Steam Cable towing Company*, et on dit qu'elle a déjà traité pour la construction et la mise en place de 300 milles (500 kilomètres) de câble d'acier fondu et pour la construction d'une flotte de 13 bateaux remorqueurs (1).

Ces excellents résultats développeront rapidement en Amérique ce système que les ingénieurs du Nouveau-Monde ont emprunté à la Belgique, où il est depuis longtemps en usage. — (*Engineering and mining Journal.*) La Correspondance Scientifique Sept 16 1879

Iron, Sept. 1881.

ELECTRICITY, TELEGRAPHY

New Cable between Trieste and Corfu.—Messrs. Erlanger, of Paris, have just obtained the necessary authority for laying the submarine cable between Trieste, in Austria, and the island of Corfu, as well as the proprietary right of the said cable for a period of twenty years. The new cable will facilitate telegraphic communication between Austria and Egypt. The cost is stated to be estimated at one million florins.

The Electric Light for Rivers.—Among the latest uses to which it is proposed to put the electric light on the other side of the Atlantic is the illumination of rivers to permit the rafting of logs at night. The Muskegon Boom Company will be the pioneer in this direction. In Baltimore experiments have been made with a view of illuminating water at night to a depth of 200 feet. Such a means of illumination, it is believed, would be of great service in searching for lost treasure and drowned persons, in raising wrecks, removing torpedoes, and in other subaqueous labours.

The Jamin Candle.—M. Jamin has made a considerable advance in the arrangement of his electrical candle. He encloses his carbon loop in a carefully closed vessel containing air. The electric action at first produces the combination of the oxygen and nitrogen of the atmosphere, and the usual coloured vapours are seen; these are soon destroyed by the oxygen combining with the carbon, nitrogen and carbonic oxide alone remaining in the glass globe. The phosphorescent arc then becomes quite fixed, giving light of a greenish-blue tint. Each candle by this arrangement lasts 160 hours.

Telephonic Communication.—The use of the telephone has been adopted on the system of the London, Chatham and Dover Railway Company, and the office of the superintendent at Victoria has now been placed in immediate communication with the Holborn Viaduct, with Loughborough Junction, where there are large sorting and make-up sidings, and with Wandsworth Road, where are the head-quarters of the locomotive and other departments. The goods manager's office at Victoria has also been connected with the goods depot at Blackfriars. The instruments in use are constructed on the Gower-Bell principle, which for some time have been used satisfactorily to connect the Victoria Station with the residence of the chairman, at West Wickham, near Beckenham.

The Electric Light at Scarborough.—The Brush electric light has been utilised at the Scarborough Spa, and the lamps were put into circuit on Saturday last, the start being a brilliant display. The wide Esplanade was illuminated from end to end with seven 2000 candle-power Brush lights, suspended from iron posts, placed at intervals down the centre. It is stated that in each of the bandhouses a 2000 candle-power Brush light was hung from the canopy and replaced at a cost of 2d. per hour, gas costing 10s. per hour. The large concert hall was lighted by a central chandelier, consisting of five 2000 candle-power Brush lights. Altogether 16 lights were run on the one circuit, and from the one dynamo machine, which was driven by a Robey's semi-portable 12 nominal horse-power engine. The whole apparatus has been erected by Messrs. Hammond and Co., of London.

Guide pratique du télégraphe, par M. Louis Houzeau, commis principal des lignes télégraphiques.

Ce volume, publié par l'auteur-éditeur, 11, rue Rousselet (faubourg Saint-Germain), est arrivé rapidement à sa troisième édition. Il est orné de 70 figures et se compose de plus de 200 pages in-8°.

Les personnes qui veulent se former à la pratique des manipulations y trouveront tous les détails nécessaires à la manœuvre des appareils et notamment de ceux qui sont employés par l'administration.

Nous y trouvons un excellent tableau résumant les causes de troubles électriques et les moyens d'y remédier.

CHRONIQUE

M. Avrillon nous fait part d'une mésaventure qui lui est arrivée et qui mérite d'être signalée. Un de ses ouvriers manifesta le désir de voir le fonctionnement d'une petite bobine fabriquée par M. Loiseau, actionnée par une pile au bichromate du plus petit modèle. Après avoir reçu une commotion, cet homme n'a cessé de se plaindre, déclare qu'il ne pourra jamais plus travailler, fait des démarches en ce moment pour arriver à poursuivre son patron, et présente à l'appui de sa réclamation une épaule démise.

Il est matériellement impossible qu'une commotion donnée avec un appareil si faible produise le moindre désordre organique, et nous sommes certain que les tribunaux feront justice d'une pareille réclamation.

Si l'épaule de l'ouvrier s'est trouvée démise, si un docteur l'a envoyé à l'hôpital, c'est évidemment par suite de circonstances dans lesquelles l'électricité n'a rien à voir.

On donne depuis assez longtemps des secousses et des commotions sur les places publiques pour que M. Avrillon n'ait point à redouter les suites d'un si ridicule procès.

Nous signalons cette circonstance afin d'attirer l'attention de nos lecteurs sur le danger d'électriser des personnes de mauvaise foi.

NÉCROLOGIE

On nous annonce à la dernière heure la mort de M. Lamont, directeur de l'Observatoire de Munich, un des pères de la météorologie électrique. Nous donnerons dans un de nos prochains numéros une étude sur les travaux de cet homme célèbre et sur sa vie. Nous dirons déjà que les appareils qu'il employait étaient des *espèces de télégraphes électriques* dans lesquels les manipulateurs étaient absents.

CORRESPONDANCE

Nous recevons de M. Buchin, mécanicien à Bordeaux, la lettre suivante que nous nous empressons de reproduire :

Cette lettre intéressante peut être ajoutée à ce que nous disons d'autre part sur la multitude d'applications dont l'électricité est susceptible.

« Je viens vous signaler une application des machines Gramme ou autres qui, dans l'état actuel, peut trouver de nombreuses applications. M. Ferdinand de Lesseps pourrait trouver à cette application un auxiliaire très-puissant pour le percement de l'isthme du Panama.

« Je lui conseillerais, dans le cas où il réunirait son capital, de prendre comme moteurs des machines Gramme qui conviendraient très-bien pour actionner ses perforeuses.

« L'emploi de l'arbre flexible, appliqué directement sur l'arbre des machines dynamo-électriques, ferait de cet appareil un instrument très-précieux, surtout par la facilité de son maniement : des moteurs fixes enverraient à grande distance le courant nécessaire pour actionner les perforeuses électriques. »

L'électricité se prête à merveille à obtenir ce résultat.

Si les travaux de percement de l'isthme de Panama doivent s'exécuter, ce qui est devenu douteux, en ce moment, nous aurons occasion de revenir sur les moyens pratiques de le réaliser à peu de frais et d'une façon absolue.

Nous recevons, en ce moment, un excellent traité par M. Barbe, officier d'artillerie, qui s'occupe exclusivement de cette importante question.

Pour juger des développements qu'elle est susceptible de prendre, nous nous contenterons, aujourd'hui, d'indiquer le sommaire de différentes applications dont s'occupe le savant auteur : la culture à l'aide de la dynamite, la destruction du phylloxera par son intervention, l'abattage des arbres et la rupture des pièces de fer, la destruction des ailes de pont, le creusement des bassins dans les ports de mer, la construction des galeries de mines, l'ouverture de la banquise du Pôle Nord, etc., etc.

La Cage de Faraday

Malgré l'efficacité incontestable des paratonnerres, l'expérience prouve que la protection qu'ils donnent n'est pas radicale et absolue. En effet, des effets électriques peu dangereux, mais sensibles, se manifestent dans leur voisinage.

Il n'y a qu'un moyen d'être complétement à l'abri, c'est de s'enfermer complétement dans une cage en cuivre, dont les barreaux sont suffisamment rapprochés et qui est en communication avec le réservoir commun.

L'efficacité absolue d'un pareil abri a été démontrée il y a longtemps par Faraday, à l'*Institution*

Ocean Telegraph Cables.

Se. Am. Nov 22 1879

In a recent lecture by Mr. Wm. H. Preece, he says: The deep sea portion of the Cape cable, while it differs to a certain extent from the Atlantic types, is still deficient in that absolute durability which all cables ought to have. In fact there is room for invention in this direction. Generally, one notices that, where there is a want, some one will spring up with an invention to meet that want. Here is a want that has existed for many years, but no one has invented a cable which can be said to be perfectly adapted for its purposes; so that, if any one here is of an inventive turn, let me recommend him to try his hand at inventing a cable which will give us all the requirements needed.

This cable to the Cape has one peculiarity in which it differs from any others. Now, among the various accidents to which cables are subject, there is one due to the existence of life at the bottom of the sea. We know that in different seas there are certain little insects, sometimes *Teredos*, sometimes *Xylophaga*, sometimes *Limnoria*, and others of very hard names, which have a peculiar liking for gutta percha. These little *teredos* attack us on sea as well as on land, and the trouble they cause us is sometimes immense. We suffer from them very much on the Irish coast, where the little wretches have found their way to the gutta percha, and have there scored and figured it in a very curious way, samples of which you will see on the table.

To put a check to their boring instinct, the Telegraph Construction and Maintenance Company, who made the cable which is being laid to the Cape, but which was originally intended for Australia, have surrounded the gutta percha with a wrapping of brass; and if any of these boring insects abound in any portion of the line where this brass wrapping is used, I have no doubt that the brass will be too much for them, and that they will find themselves terribly beaten in making any attempts to get at the gutta percha.

It is found that these little animals do not exist at greater depths than 100 fathoms, and, therefore, in the deep sea portion of this cable the brass wrapping will not be found.

There are a great many accidents to which submarine cables are subject. One of the principal is that of a ship's anchor, and it was the disturbing element of a ship's anchor that prevented me from having the pleasure of being before you last Monday. On the table is a piece of cable which has been taken out of that crossing the River Humber. The cable which crosses this river is one of the most important that we possess, and for that reason one of the strongest kind of cable ever made was laid down. In the Postal Telegraph Department we have no less than 62 cables, and their aggregate length of 1,224 miles contains a total of 3,809 miles of wire. To cross rapid streams and important rivers strong cables are used, and to cross the Humber, which during spring tides runs at the rate of six to seven knots an hour, a cable of the strongest type was used; yet it had not been down six weeks when a ship got hold of it, and the cable was caught by its anchor. The heavily laden schooner riding on a strong tide, with its anchor attached to the cable, brought to bear an enormous force, and, perhaps owing to the construction of the cable, this force would not be equally divided among the outside protecting wires, and thus one wire, bearing the greater strain, gave way, followed by the snapping of a second, and so on till the whole cable was severed in the straggling and tangled manner that you see, which is very different from its symmetrical form when first laid. This break occurred in a very nasty stream, where the cable was so buried in mud that I could not find it; and I was despairing of being able to give even a second lecture here, when a happy thought occurred to me. I had spent a whole day in grappling after this cable, trying over and over again, and yet never getting near it, when it suddenly came into my mind that Shakespeare makes Bassanio say: "In my school days, when I had lost one shaft, I shot his fellow of the self-same flight, the self-same way, with more advised watch, to find the other forth; and, by adventuring both, I oft found both." So, knowing that a ship had dropped its anchor over the cable, I thought we would drop our anchor too, and we did, and waited a whole tide, and when we hauled the anchor up there was the cable.

The chief cause of accidents to cables, next to that of anchors, is probably due to abrasion of the cables on rocky bottoms. The bottom of the sea is frequently of an undulatory nature, and the cable remains suspended from point to point, and at such points the wire becomes chafed and worn away, and speedily decays. I am sorry to see that the time at my disposal has gone so rapidly that I cannot particularize to you many of the different causes that lead to the destruction of cables, not only abrasion, not only accidents in paying out, but accidents that exist afterward; for instance, a whale once caught a cable in the Persian Gulf and broke it; a shark's tooth has been found embedded in a cable, and a sinking ship has caused damage to a cable.

Sometimes the cables rest on corrosive stones, copper ores, and ironstone, when corrosion sets in and causes the cable to speedily fail. Volcanic action sometimes damages cables, as also rock slips. In the Bay of Biscay, which is crossed by the Direct Spanish Company's cable, there is no doubt that such a cause has interfered with the cable on two occasions, curiously enough, interrupting the wire each time on the same day of the year. There is a peculiar shelving of the rock, and slips exactly equivalent to our landslips take place at intervals.

Icebergs, too, from the North Atlantic, frequently carry large pieces of rock, which fall to the bottom when the iceberg thaws, and in their descent are liable to fall across a cable and damage it.

There are also faults due to imperfect joints, due to accidents that pass inspection during the process of manufacture, but which slowly develop themselves after submersion or lapse of time.

Lightning, earth currents, and things of that kind affect cables, but, nevertheless, the eye of the telegraph engineer is constantly watching these circumstances as they happen, and he tries to bring to bear upon them all the power and thought he possesses; and the result is that, by slow experience, the cable of the present day is very superior to that used in the early days, and the improvement has been equal to the advance, which, I hope I have been able to show you, has been made as regards the insulators and iron wire.

NOTES ON MR. WILLOUGHBY SMITH'S PAPER UPON "THE WORKING OF LONG SUBMARINE CABLES."

(CONTINUED FROM P. 238.)

Electrician. Oct 11 1879

Mr. Willoughby Smith gave in his paper five diagrams, which we here reproduce, referring to arrangements for signalling through long cables which were patented by Mr. Varley in 1862. In Fig. 4, it will be seen that the receiving end of the line is con-

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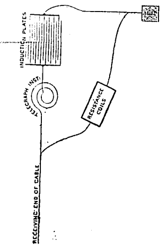

nected to earth through a resistance coil (which was stated by Mr. Varley to be more effective when wound on a large iron core) and that it is also connected, through the receiving instrument, with one side of a condenser of which the other side is connected to earth. This arrangement is of interest as being, we believe, the first in which the use of condensers for cable signalling was suggested, and also from the fact that in it an evident attempt is made to utilise the "inverse current on making contact," and also the coil current, or "direct current on breaking contact." It should be borne in mind that, when these arrangements were devised, the impression everywhere prevailed that an Atlantic cable could be worked only by very powerful currents of electricity. And an ingenious mind, acquainted with the facts in relation to what Faraday termed "the induction of a current on itself," might readily suppose that the arrival current would be retarded, or arrested for a minute space of time, by the resistance coils indicated in the figure, whilst it would freely pass through the receiving instrument to charge the condenser, and thus give a signal; and further, that this signal would be "sharpened" by the subsequent discharge of the condenser through the coils in question, serving also to discharge the cable. But, as the writer of these notes discovered to his cost, in a lengthened experimental trial of some proposed improvements in signalling which appeared *primâ facie* to be very efficacious, the effect of electro-magnetic retardation is not exhibited when a coil is placed, as shown, at the receiving end of a long submarine line. This is due to the very *gradual* rise of tension at the distant end of a conductor of high resistance and charging capacity, when such a conductor is charged from a source at the near end. For the effects of electro-dynamic induction to be strongly manifested, the current must be suddenly produced and suddenly arrested—a fact which the makers of dynamo-electric machines, as well as the makers of induction coils, would do well to keep in view. Moreover, by the introduction of Sir W. Thomson's mirror galvanometer as a signalling instrument, cables became readily worked by what Mr. Varley once termed the "ghost of a current;" and such a current, as Mr. W. Smith pointed out, is totally inadequate to produce perceptible electro-magnetic induction effects.

In Fig. 5, we have the same arrangement at the receiving station; whilst at the sending station the line is insulated from earth by a condenser. Here Mr. Varley comes very near indeed to the present system of working long cables, in which the line is normally insulated from earth. We learn from Mr. W. Smith's paper that Mr. Varley was, somewhat unaccountably,

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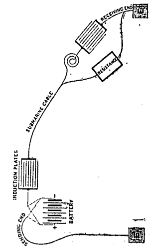

under the impression that the condenser would be useless without the adjunct of the resistance through which, together with the receiving instrument, it is circuited.

In Fig: 6 the condenser at the sending end is circuited through

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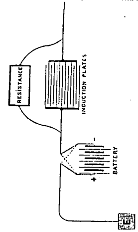


a resistance, presumably possessed of electro-magnetic inertia. We must confess that we cannot perceive the object of this arrangement, the results of which would appear to be from every point of view undesirable. In effect, the resistance would in no wise facilitate the sending of a current to line; whilst the coil current would oppose the discharge of the latter, by contact with earth at the sending end, or the reversal of the current.

In the next figure the object seems to be the sending of a current to line for a very short period of time, *i.e.*, until the magnetic inertia of the induction coil is overcome, or its inverse cur-

Ailkaud's Schreib-Telegraph für submarine-Kabel.

Der [illegible] Nov 1879

Die Spiegel-Galvanometer, die bis jetzt fast ausschliesslich auf langen unterseeischen Kabeln zum Telegraphiren benutzt werden, haben den Uebelstand, dass sie die übermittelten Schriftzeichen nicht bleibend wiedergeben. Im Interesse des Dienstes ist es aber sehr wünschenswerth, dass die Zeichen nicht allein sichtbar, sondern auch dauernd lesbar ankommen.

Die ersten Versuche zur Construction wirklicher Schreibapparate, welche auf den langen unterseeischen Leitungen Verwendung finden konnten, sind nach Zetzsche's Geschichte der elektrischen Telegraphie (S. 148) von Siemens mit dem elektro-dynamischen Relais auf dem Kabel des Rothen Meeres angestellt worden. Ein ganz origineller Apparat für Unterseekabel ist der Heberschreibe-Apparat von Thomson, welcher auf dem englisch-amerikanischen Kabel benutzt wird. Dieser Apparat hat seinen Namen von einem kleinen Heber, welcher mit dem kurzen Ende in ein Tintenfass eintaucht und mit dem langen Ende dem Papierstreifen gegenübersteht. Durch eine Reihe elektrischer Entladungen wird die Tinte in Form feiner Tröpfchen auf den Papierstreifen abgesetzt und dadurch die Morseschrift wiedergegeben. Die Schrift ist spitz, zickzackig, oberhalb, beziehungsweise unterhalb der Mittellinie des Papierstreifens und es bedeuten die oberen Spitzen die Striche, die unteren Striche die Punkte des Morse'schen Alphabetes, bezw. umgekehrt. In ähnlicher Weise sucht Siemens mit seinem Russschreiber die Morseschrift wiederzugeben.

In neuester Zeit nun hat Ailkaud einen Schreibe-Apparat konstruirt, der in einfacherer Weise die Schriftzeichen dauernd erzeugt. Derselbe besteht nach "Ann. Télégr." aus zwei hintereinander geschalteten Elektromagneten mit je zwei Rollen, welche so gegen einander stehen, dass zwischen je zwei Rollen ein kleines Magnetstäbchen den Polen der Kerne gegenübersteht. Diese Magnete werden von einem Aluminiumdraht getragen, dessen unteres, mit einem eisernen Knopf versehenes Ende in ein eisernes Quecksilbergefäss mündet.

LE TÉLÉGRAPHE DE LA RÉUNION

L'Électricité

La ligne télégraphique du Cap

Nous apprenons par le journal le *Temps*, si bien renseigné sur toutes les questions électriques, que le gouvernement anglais a passé un contrat avec la compagnie de l'*Eastern Telegraph*. La garantie accordée est, paraît-il, d'un minimum de recette annuelle de 60.000 livres sterling (1.500.000 francs).

La Compagnie, maintenant, est chargée de la fabrication de la ligne sous-marine d'Aden à Zanzibar.

La fabrication en sera poussée avec une si grande activité que la pose doit être terminée au 1er novembre.

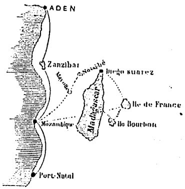


Diagramme montrant le réseau télégraphique des Iles Mascareignes (1).

Comme nous l'avons déjà dit, le réseau colonial s'étend de la ville du Cap à Port-Natal, autrement dit Durban, port important de l'océan Indien.

Le câble qui rattachera cette ville à Zanzibar s'est trouvé heureusement disponible.

En effet, les colonies autrichiennes l'avaient fait contruire pour assurer une seconde communication avec l'Europe.

Elles ont eu le patriotisme de laisser ce magnifique câble à la disposition du gouvernement britannique, de sorte que la pose sera terminée au premier juillet. Cette ligne nouvelle ira de Port-Natal à Zanzibar en passant par Delagoa Bay et Mozambique, capitale de la capitainerie générale du même nom. Il en résulte que la perspective à laquelle nous avions fait allusion se trouve réalisée. Le câble sous-marin passe à proximité de nos établissements des Comores. Il peut être rattaché à l'île Bourbon d'une façon simple et sûre, si nous formons un établissement permanent au cap Diego Suarez où existent déjà, si nous ne nous trompons, des factoreries françaises.

(1) Aden est en Asie et non sur la côte d'Afrique comme l'indique par erreur le diagramme.

Un des résultats de cette initiative serait de mettre en valeur nos établissements dispersés sur les flancs de la grande île qui appartient théoriquement à la France! On pourrait également rattacher par un câble spécial l'île Bourbon à l'île de France, dont la population créole est encore de cœur toute française.

Une autre voie pourrait être construite comme on le comprendra en jetant les yeux sur la carte qui accompagne cette notice. Qu'est-ce qui empêcherait par exemple de poser hardiment le câble dans l'île de Madagascar, où l'importance de nos intérêts commerciaux s'accroît de jour en jour?

En effet, la Chambre des députés est saisie en ce moment d'un projet de loi rédigé de concert par le ministre des affaires extérieures et le ministre de la marine pour établir à Tananarive une juridiction consulaire au profit de nos nationaux.

La résistance des Hovas, si elle se produisait, est du genre des obstacles qui doivent être surmontés par les armes, car le *droit au câble* existe pour toutes les nations civilisées, et l'on ne doit laisser sous aucun prétexte la barbarie opposer un stupide *non possumus* à la civilisation.

Les journaux de Londres nous apprennent que le câble destiné à cette grande opération coûtera environ 20 millions de francs. Le premier navire destiné à opérer la pose de Zanzibar à Port-Natal aura quitté l'Angleterre au moment où ces lignes seront sous les yeux de nos abonnés.

La subvention de la Compagnie Orientale sera payée en partie par le gouvernement impérial d'Angleterre, par le gouvernement de Natal et par le gouvernement Portugais intéressé à l'établissement des deux stations de Mozambique et de Delagoa Bay.

La ligne étant posée le long des côtes, on suppose que l'entretien sera excessivement peu coûteux.

W. de Fonvielle

A New Irish Cable.—In consequence of the frequent failures of existing cables and the expected increase of Irish telegraphic business, the Post-office authorities have determined upon increasing the means of communication by the laying of a new cable, containing a core of four wires. Operations have already commenced, and it is anticipated that the new line will be completed early in January next.

The French Atlantic Cable.—M. George Van Chauvin is at Ottawa on behalf of the new French Cable Company, with a view to ascertaining what steps are necessary in order to effect a landing on Canadian territory. The Dominion law provides that any British company shall have the right to land cables upon taking out letters patent for that purpose. This appears to preclude the French company; but should it be so interpreted by the Ottawa authorities, no obstacle is likely to be put in the way of conceding the privilege by fresh legislation. As soon as the application for power to effect a landing in Canada is granted, the company propose to lay a cable from the Island of St. Pierre de Miquelon (which is the only vestige that remains of French domination in North America) to a point either on Cape Breton or the Nova Scotia mainland, near the Gut of Canso, and thence to connect with the telegraph systems of the Dominion. M. Van Chauvin is accompanied by Baron de Cambrey.

11 112

CHRONIQUE

L'Electricite

Le steamer *Dacie* vient d'arriver à Alger, apportant dans ses cales le câble destiné à rattacher une seconde fois Marseille à la métropole de nos établissements sur la côte septentrionale de l'Afrique.

Nous devons féliciter de nouveau M. le ministre des Postes et Télégraphes d'avoir organisé une expédition si nécessaire au développement des relations télégraphiques avec la colonie.

Ajoutons que l'intention de l'administration est de réduire à 10 centimes par mot le tarif des dépêches, aussitôt que ce second câble aura été posé. Nous sommes certain que le trafic augmentera dans une proportion suffisamment rapide pour récompenser l'administration du courage avec lequel elle applique, dans cette occasion importante, les principes les plus sages de l'économie politique.

La pose a commencé à Alger, le 10 août, en présence de M. Albert Grévy. Un punch a été offert à l'honorable gouverneur de l'Algérie, à bord du navire anglais.

Il n'est pas inopportun de rappeler à nos lecteurs l'histoire des mésaventures de l'ancienne administration algérienne, lorsqu'il s'est agi de la pose du premier câble algérien; mais pour éviter des redites nous nous bornerons à les renvoyer à nos Tablettes historiques publiées à la fin du volume de l'an dernier.

Mais parmi les singulières fantaisies de l'administration à cette époque, il est impossible de ne pas citer l'acquisition, moyennant un quart de million, d'un steamer anglais, qu'on destina à la pose du câble, et que l'empereur Napoléon III baptisa lui-même du nom du *Dix-Décembre*, appellation qui lui porta bonheur, comme nous le verrons une autre fois.

M. Reginald Forster, de Sainte-Catherine's Point Niton, île de Wight, publie dans le *Times* une lettre fort curieuse.

Il nous apprend que le second dimanche de septembre, à 6 h. 30 du soir, le steamer *Charles W. Anderson* fut obligé de jeter l'ancre pour éviter d'échouer. Sa position était excessivement critique et il fallait à tout prix faire venir de Coywe un remorqueur. Mais comme ce naufrage avait lieu un dimanche, le télégraphe postal ne marchait pas. Ne pouvant vaincre la résistance de l'employé, qui était un bon *sabbatarien*, on fut obligé d'envoyer un homme à cheval pour chercher le remorqueur, qui n'arriva qu'à une heure du matin.

Pendant tout ce temps, les marins du *Life-Boat* furent obligés de veiller dans le cas où un sinistre se produirait.

Une pareille marque d'ineptie de la part d'un télégraphiste ne saurait être trop énergiquement signalée.

La direction du câble transatlantique français a reçu d'Amérique une dépêche annonçant que le steamer *Faraday*, appartenant à la maison Siemens, a heureusement terminé l'immersion de la partie comprise entre les îles Scilly et le banc de Terre-Neuve.

L'opération a duré juste le nombre de jours qui avait été calculé, avant le départ du *Faraday*, comme étant nécessaire à son accomplissement.

A la date du 4 septembre, le *Faraday* s'occupait à installer une bouée sur l'extrémité du fil qui est encore au large de la grande île américaine.

Cette opération étant terminée, il s'est rendu à Londres pour prendre le câble de terre et la ligne qui doit joindre Terre-Neuve à New-York. Ce sont les deux sections à la fabrication desquelles nous avons assisté dans l'usine de M. Siemens, à Charleton, ainsi que nous l'avons rapporté.

Il y est arrivé le 16 septembre au matin, après s'être triomphalement acquitté de cette grande et importante mission.

Il reprendra la mer dans la première semaine d'octobre pour terminer l'opération simple et facile qui doit la compléter.

Nous enregistrons avec d'autant plus de plaisir ce succès de la Compagnie du câble électrique français, que des gens malintentionnés avaient répandu en Amérique le bruit que la pose avait échoué à cause des gros temps, et que le *Faraday* avait été obligé d'abandonner son câble en pleine mer.

Nous trouvons ce stupide *racontar* dans l'*Operator* du 1er septembre publié, du reste, à New-York, à une date où l'on n'avait pu avoir de nouvelles de l'expédition; car c'était uniquement avec l'Europe que le *Faraday* se trouvait relié pendant cette opération.

Ces tentatives pour égarer l'opinion publique donnent une idée de l'importance qu'on attache par avance à l'intervention du câble français dans les relations télégraphiques entre les deux continents.

113

THE ENGINEERING AND MINING JOURNAL

[OCT. 15, 1881.

TESTING UNDERGROUND TELEGRAPH CABLES.*

By Dr. Brix.

In a paper read before the Electro-Technical Society of Berlin, Dr. Brix describes in detail the methods adopted in practice of testing the underground cables on the lines of telegraph under his direction. The tests are made once a week. In measuring what the author calls the "copper resistance," that is, the electrical resistance of the copper conductors, great advantages are found in having several wires in one cable. In such a case, the wires may be measured in continuous circuit, instead of making use of an earth return. The importance of this in obtaining exact measurements will be understood when note is taken of the disturbing influences of polarization of earth-plates, and the working of other lines having earth-plates at no great distance.

At the distant station, the several conductors of the cable are connected together; at the place of measurement, the testing-room of the home station, two of these conductors are connected with the Wheatstone bridge, and the resistance of this wire circuit is measured in the usual way. The battery is not in this case put to earth, but is in communication with the bridge, an arrangement which gives true results, even if one of the conductors has a fault of insulation, for no loss of current can then take place through the fault. When there is a fault of insulation in each of two conductors, the case is obviously different; for if these faulty wires were connected up to form a circuit, a leak would occur from one wire to the other through the earth, and a false indication would be obtained. In such a case, the wires must be connected up singly, care being had that a faulty wire be joined to a sound one. When dealing with three wires, the resistance of these singly may be easily found by the method of connecting-up in circuit here referred to. Connection is first made between Nos. 1 and 2, then between Nos. 1 and 3, and lastly beween Nos. 2 and 3. The last measurement deducted from the sum of the two others gives twice the value of No. 1, and this value deducted from the first two measurements gives the value of Nos. 2 and 3. In a cable containing seven conductors, seven circuits, made up in like manner, will be sufficient. But in practice nine are formed; the additional labor occasioned thereby is small, and more than compensated by the advantages gained. These nine combinations are so chosen that out of any three of them three circuits may be determined, and that a circuit, say No. 7, may be common to each of the three groups. From these nine measurements are thus obtained three values of No. 7. Each of these values is deduced from three independent measurements; and if these three values agree one with another, there is strong presumptive evidence of their being all correct. A further proof may be obtained by comparing the measurements one with another, when these have been taken always in the same order. The difference between two consecutive measurements must always be about the same in amount. From the copper resistance obtained in this way, after making a suitable reduction for the temperature of the room and the rheostats, the mean temperature of the underground cable is deduced. The measured resistance of the conductors is compared with a standard resistance at a normal temperature of 15° Centigrade.

contained in the old saying of it being a long lane that had no turning. They had travelled that lane for some time, and although they had thought they saw rays of light occasionally coming across their path, it must be admitted that all those bright hopes had gradually faded away, and they could only come to the conclusion that, looked upon as a field for telegraph enterprise on a commercial basis, the West India colonies were unprofitable. It was said that the man who waited long enough always got what he wanted, but, unfortunately, in their case, while they were waiting the cables on which they depended were running through their span of natural existence, and were approaching that decay which must end in the cessation of their operations, and, unfortunately, during their lifetime they had not been able to put by such reserves as were sufficient to relay or restore them when they ceased to work. With these facts staring them in the face, it was natural to ask, what was their policy? Were they to see their cables gradually dying out before their eyes, and to see the eventual loss—he did not say when it was to occur—of a great part of the capital sunk in the endeavour to connect the West Indian colonies with the rest of the world by telegraph, and were the colonies to be deprived—to lose, in fact, their communication with the home country, which in these days almost every colony of any size or importance thought it necessary to have? The only policy that they had—they had tried everything they knew of—was to continue their importunity with those who were so largely concerned in having a continuance of the system." He also remarked, "He had been struck with an article in the *Colonist* of Demerara, an article which contained, in the midst of a great deal of common sense and liberality of feeling, some reflections on the company which were not deserved. The article, he might say, did not entirely approve of the policy of the Government in this matter, but it traced the cause of their unfortunate position and their impecuniosity to their own folly and bad policy, and particularly in the matter of high rates. Now, those rates were fixed originally by the colonies themselves. The rate originally was for 20 words. Soon after the company was formed a very great concession was made by the company to the public of those colonies, for they diminished the minimum of 20 words to 10 words, charging only half the rate fixed for 20 words. It was very much less remunerative to carry a 10 word message at half the rate hitherto charged for a 20 word message. When the present board took office the 10 word rate was in force, and they found after working for two or three years with the system in complete order that there was not revenue enough to pay their working expenses, pay the small dividend they did on two or three occasions, and put by sufficient money for the renewal of the cables. They then applied for an increase of the rates, and the higher rates they were allowed to introduce had resulted in an increased revenue of £18,500 a year. If it had not been for that policy of theirs and that increase of rates, they would hardly have been in existence now, for there were many things they would have been perfectly unable to carry out. He thought it a pity, therefore, that people should have such an erroneous idea, and prejudice the minds of their fellow colonists in this manner." He then moved the adoption of the report and accounts, and the payment of the dividends recommended on the First and Second Preference Shares. Mr. William Ford, a director, seconded the motion. Mr. William Abbott thought that the Chairman had attached too much importance to the article in the paper he had referred to. He thought that the directors should go on and administer the affairs of the company as they considered best in the interests of the company. He would like to know, as the report was only to the 30th of June, whether the colony of Demerara had really deducted the subsidy. He thought it would be a very awkward time for that colony to be on bad terms with the company, looking at the very general rise which had taken place in everything the West India islands produced. The Chairman, in reply to questions, said they had entered into a contract for picking up the Investigator for £14,500, and it was expected that the vessel and its machinery would be picked up for £16,000. They had had no offers from the underwriters with respect to the vessel, and the claim for the amount of the insurance was awaiting settlement at law. They had received information that up to the present Demerara had withheld the subsidy. The motion was then put and carried unanimously.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY, LIMITED.—The twelfth ordinary general meeting of the shareholders of this Company was held on Wednesday, October 22, at the City Terminus Hotel, under the presidency of Mr. J. Pender, M.P. The report, an abstract of which appeared in our last issue, having been taken as read, the chairman said: Then before putting the resolution to the meeting for its adoption, I will, as usual, give you a few figures on the working of our system. As stated in the report, the gross receipts for the half-year ending the 30th of June, 1879, were £150,107, against, for the corresponding period of 1878, £135,482, showing an increase of £14,624. The expenses for the past half-year amounted to £65,509, against, for the corresponding period of 1878, £61,222, or an increase of £4,287. This is more than covered by the expenses of keeping three repairing vessels during the last half-year instead of two, as in the corresponding period of 1878, and by carrying an additional £1,000 to the maintenance ships' reserve fund. But for this a saving of about £2,300 would have been shown. The screw steamer, Edinburgh, has now, however, been sold, as stated in the report, for £10,000. The net revenue for the half-year under review was £84,597, in the corresponding period it was £74,260, being an increase of £10,337. Two interim dividends of 1¼ per cent. each, absorbing £49,937 10s., have been paid for the half-year, leaving a balance of £34,660 to be carried forward. As to the duplicate Australian cable, the first section of it was successfully laid and opened for traffic on the 16th of August last, and connected Malacca. This was done by arrangement with the Government of the Straits Settlements, who have to pay the company an annual subsidy of £1,000 for ten years. A considerable portion of the second section between Singapore and Java has been laid, and a vessel with the necessary cable to complete the section is now on her way to Singapore. We anticipate that the contractors will complete the whole work in the early part of next year. The articles of association state that in case of a vacancy in the auditorship it shall be filled up by an extraordinary general meeting. As, however, Mr. Ball's death took place so recently, the directors considered it unnecessary to call a meeting specially for the appointment of a successor, and therefore requested Mr. Ball's firm to complete the audit to the 30th of June. The vacancy will be filled up at the extraordinary meeting which is to be held at the conclusion of this meeting. Now, gentlemen, I have given you certain figures, or rather made certain comments, upon the report which you have in your hands. I may now say a few words, and those of congratulation, on the general improvement of our traffic. I have stated that up to the end of the half-year ending 30th June last we have shown a net profit over the corresponding period of the previous year of £10,000. From that time up to the present I am glad to say that our traffic has generally been very successful indeed—in fact, I may say that we are having now the best traffics we have ever had, and this may be to a certain extent accounted for in two ways. There is the Exhibition going on at Sydney for the present month, and there is a general improvement in trade. I have very often said at these meetings that our telegraph system is a very good barometer of trade. With bad trade we suffer, with good trade it is quite remarkable the buoyancy that takes place, and I hope that the improvement which is now pretty well acknowledged to exist will be maintained. You know that we have always been told that any improvement was to come from America. Well, America is very rampant at the present moment, and that is also testified by the returns on the Atlantic cable system. I have often also said that the importance of duplicating your cable was very great indeed; and I may mention that while our cable has no interruption at the present time, yet, had we not laid down our duplicate system—or that portion between Singapore and Penang—we should have been at a standstill. The original cable is now interrupted, and the whole system would have been interrupted. Fortunately this duplicate was laid down in time, and we are reaping the benefits of additional security and also of the improved traffic. I am glad also to tell you that, with regard to the duplicate cable which we are under contract to have completed by the end of February next, that we were enabled, without any loss or sacrifice on our part, with the sanction of the Australian Government, to give the home Government evidence of our desire to help them in having the Cape cable established; and I am glad to say this, notwithstanding our helping them in this object, the duplicate system will, I believe, be completed very early next year, or nearly two months before the contract time (hear, hear). I am also glad to tell you that Colonel Glover has visited all our stations. He was absent from London for something like eighteen months, and he has been able to give us a report of the working of our system, and I am glad to say that this visit has been of very great good, as you can well conceive. Our young men like to see their managing director among them, and I believe that Colonel Glover's visit has been productive of very great good. We were also able to avail ourselves of his presence in Australia to carry to a successful issue the negotiations with the Australian Governments. To do this Colonel Glover had to get them into a spirit of harmony for the benefit of the whole, which is rather a rare thing to get done. Each thinks that he knows better than his neighbour, but in this particular business of the duplicate cable they seem to be pretty well in accord. Colonel Glover has travelled during the time he has been away something like 40,000 miles. I am also pleased to say that up to the present time the experimental system of sheathing our cables with a brass coating has been successful. With these remarks, gentlemen, I think that I have pretty well exhausted all that I have to say to you, except this—that, as you are all aware, an important conference was recently held in London of the telegraph representatives of every Government, certainly of Europe, which laid down certain laws. We had not a seat at that conference, but so far we have always felt that we have been fairly dealt with by the conference. There is, however, a difference of opinion among some of the merchants at the present time, who think that they have been more or less aggrieved by certain alterations that have been made. But I will only make this remark—that we have no power to alter what has been done. We have certainly the power of receiving communications from merchants who feel themselves aggrieved; but I would say to those merchants that, looking to the history of submarine telegraph progress, up to the present time they have certainly had the best of it (hear, hear). They have dealt with the code system to an extent that was never contemplated. Had the original prospectus of this company been carried out, we should have been paying you to-day probably 35 per cent. instead of 5 per cent., and, therefore, the merchants have no cause to complain. They have done all they could—they have used their utmost ingenuity. I do not blame them for this. I think it quite reasonable that they should have the greatest amount of traffic carried at the smallest expense; but, on the other hand, they must take care not to kill the goose that lays the golden eggs (hear, hear). If any merchant feels himself aggrieved I shall be very glad to meet him and discuss the question, and I am satisfied that I will show him that the greatest benefit of the system has been with him and not with the shareholders. With these remarks I beg to move the adoption of the report. The resolution is—"That the report and accounts of the directors now submitted be received and adopted." The Right Hon. W. N. Massey, M.P., the Deputy-Chairman: I beg to second that. After some further remarks as to the appointment of an auditor in the place of the late Mr. John Ball, and the report and accounts having been adopted, the proceedings terminated.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY, LIMITED.—The twelfth ordinary general meeting of the shareholders of this company was held Oct. 28th, at the City Terminus Hotel, Cannon Street, under the presidency of Viscount Monck, chairman of the company. The chairman, in moving the adoption of the report, pointed out that the revenue for this period amounted to £75,083 13s. 11d.; the working expenses to £13,452 14s. 4d., leaving a balance of £61,630 19s. 7d. To this is added £23,301 16s. 9d., the undivided profits to 31st December last, making a total of £84,932 16s. 4d. After deducting income tax (£832 11s. 9d.), there remains a balance of £84,100 4s. 7d. A third interim dividend, amounting to £16,250, has been distributed since the last accounts were presented, leaving the sum of £67,850 4s. 7d. for appropriation. The directors now recommend the declaration of a final dividend of 2s. 6d. per share, free of income tax, making a total dividend of 5 per cent. for the year ending 30th June, 1879, which will absorb £16,250, leaving a balance of £51,600 4s. 7d. Of this amount £50,000 has been placed to the reserve fund, increasing that fund to £227,437 8s., and £1,600 4s. 7d. carried forward. Upon these figures he (the chairman) thought it was not necessary to observe at any great length. The report and accounts told their own tale. The object the directors had in view was to frame their report in a perfectly intelligible form so as to enable a comparison of one year with another to be drawn at a glance. The receipts of the past half-year, compared with the corresponding half-year of 1878, showed an increase of £5,000. But it should be remembered that the war in South Africa had brought grist to the mill, and they had carried a considerable amount of news from Madeira. Added to this, there was also an increase of 15 per cent. in ordinary messages. The speaker then referred to the unfortunate agreement which existed between this company and the Western Brazilian Telegraph Company, but with the assistance of the legal adviser of the board he hoped to be able to mitigate the evil of this unfortunate agreement. If they succeeded in getting rid of that agreement the profits of the company would largely increase. It would also be

116

A GRAND INVENTION

Lockport daily Union

The Atlantic Cables Knocked in the Head.

Feby 5 1880

A Hartland Frenchman the Inventor.

An Ocean Steamer Carries a Portable Telegraph, and at any Moment Can Telegraph Ashore, Even when in Mid-Ocean and Telephone Too.

EDISON BEATEN OUT OF THE MARINE FIELD.

Full, Special and Exclusive Details.

We have to announce a discovery or an invention perfected in Niagara County, that is destined to revolutionize the trade and commerce of the world; to give almost absolute security to life on the sea; and to practically annihilate time and space—in other words the practical application of the telegraph and telephone to moving vessels on the ocean, rendering certain the instantaneous communication between any ship or steamer, at any point of latitude or longitude with any port of the world.

THE INVENTOR.

The inventor, from whom we gather the information contained in this article, is Pierre Valcour, a Frenchman, 42 years of age. He was born in a small village in the *department du Rhone*, in France, of parents of the middle class, and at the age of 17, entered the Polytechnic school of Paris, and was subsequently graduated with high honors. He adopted the profession of mechanical engineer, but not prospering in France he came to the United States, resolved to master International Law and practice in the Admiralty Courts at New York. His success was intermittent,—at times making large fees, at other times being compelled to live on his small income of 6,000 francs, derived from his father's estate. His occupation threw him into perpetual contact with all classes of commerce, ship owners and captains, the great trans-atlantic companies, the Chamber of commerce, inventors, the Weather Bureau Service, the detective service, and other branches, making up Marine society, until he became intimately acquainted with, and had a passion for, all that relates to commerce and the sciences and arts governing its progress. M. Valcour, however, was a man of ease, and luxury as well, and up to forty remained a bachelor; and he might be frequently seen enjoying a dish of maccaroni at Moretti's on Fourteenth street, in New York, or lounging of an evening in the parlors of a fashionable up-town club. "Soon after meeting Madame Valcour," said the inventor to the writer, last Tuesday, "I began to take a more serious view of life. Our marriage happened about two years ago; but my French friends in New York made such demands upon my time that I concluded to leave the city, live on my income in a retired country house, and work out the invention you are now inspecting. But my wife, who was born in Copenhagen, would not consent until she had seen Niagara Falls. We made the visit, and while there learned that this house and these few acres could be reasonably rented, and here we are in Hartland."

THE INVENTION.

M. Valcour then took the writer to a large shed, which he said contained the principal apparatus for keeping up telephonic and telegraphic communication with a vessel going at the highest rate of speed in any weather, with the main shore. The entire machinery was encased in a cigar shaped, metallic float thirty feet long. A longitudinal section through the middle of this shell, presents a perfect ellipse, the greatest diameter being six feet, or one fifth of its length. This shell is one-eighth of an inch in thickness, made of the finest gun barrel metal, presenting, when water tight, a perfectly smooth, glazed surface. Within this shell are a series of reels mounted on axles, which are seated in sockets perpetually oiled by a powdered lubricator of the nature of talc, steatite, or soap-stone. It is on these reels that were coiled over 8,500 miles of perfectly insulated composition wire, the fine wire being made under the highests possible tests, of the best material known to electricians. But the wire does not appear to be the important feature at all. "You know," said M. Valcour, "that one of the chief problems in laying the Atlantic cable was perfect insulation, and you are aware what a many-stranded cable it is, covered with adhesive substances, variously compounded. Of course then, I sought to fabricate a single wire, so insulated that the electric fluid, and sound itself, could not be impaired by immersions, and I have succeeded, and this part of the invention I shall disclose to no one. Nor shall I patent it, for the reason, that in making my specifications I shall be obliged to name the process and the materials—and this could be made public, for you have only to enclose twenty cents to the Patent Office, and they will forward you any patent." M. Valcour then said if the writer would like to see the apparatus working, he would have his portable boiler fired up and we could see the wire reeled off at twenty miles an hour. The writer assented, and while the machinery was being put in readiness by James Andersen, a Dane, M. Valcour introduced the writer to his wife, and a plentiful luncheon was enjoyed in their joint society. Madame Valcour is a beautiful blonde, strongly betraying her Norse origin, both in feature and accent, and is evidently deeply interested in her husband's invention. "*Qu'il étonnera le monde encore!*" She exclaimed, with rapture, as we repaired to the shed to renew the inspection. The engine was now in readiness, and a large reel was placed on a horizontal shaft and turned rapidly, the bearings being carefully oiled. M. Valcour then placed the insulated wire leading from the metal shell over the engine reel fastening the end to it; so that as the reel in the shell fed out, it might wind up. The engine was started; the reel began to wind up while we noted the revolutions. Almost instantly the wire was being taken up at the rate of twenty miles an hour; and, to gratify the writer it was run up to thirty miles an hour, or twice the speed of ocean-going vessels. "Now," said the inventor, "you will note that when this wire is being paid out by the shell at sea, which is towed by the vessel, it will be put to no such violent strain or tension as here, when it is being literally wound up by machinery. Here everything is violence; there everything is mild." As the operation continued there was no break or flaw. M. Valcour then explained the practical adaptation of this shell to navigation, which, as will be seen below, has already been demonstrated. The float or shell is so weighted in the distribution of the metal that it will always sit on the water, with its slight keel down, and float like a boat. It is towed to the stern, say of an outward bound steamer, and to a large ring-bolt in the bow of the shell a chain cable is made fast, and likewise the other end to the stern of the vessel. This chain cable is one hundred feet long, to enable the float to keep out of eddies formed in the wake of the vessel. There are also side chain-braces secured to side bolts in the shell and leading to the vessel.

From the telegraph and telephone station on board ship the wire is led through a metallic pipe to the stern; it then enters a small perforation, carefully prepared at the bow of the shell, and enters the foremost reel in the shell. This wire, going over the combination of curiously placed reels by varying sizes, is uninterrupted throughout its entire length—hundreds of miles more than enough to traverse the usual pathway of ocean-going steamers to Europe. The shore end of the wire is connected with companies' offices in New York; and when the vessel drops down to Sandy Hook the wire from the sternmost reel in the shell is connected there. The vessel starts out to sea; the wire begins to release itself. When two hundred miles have been accomplished, an automatic connection releases a leaden sinker, weighing five pounds, and this as the vessel goes on, finds its way to the bed of the ocean. At the point where the sinker is attached, the wire is much heavier—for a distance of two hundred feet. Thus at every two hundred miles—this shell, which is full of automatic and clock-work machinery releases a sinker, thus fixing a telegraph wire on the bed of the ocean. The object of the shell is simply this that the wire shall not be at the mercy of the rolling and pitching of the ship, so that no great strain shall fall either on the apparatus or the wire;—and as the shell is kept in its place by braces and the tow-chains, ample slack of wire is had between the reels in the shell and the operating instrument on board ship.

SUCCESS DEMONSTRATED.

"Yes," said M. Valcour, in reply to the writer, "success is demonstrated beyond a doubt." "My wife's cousin, Ernest Ballonak, is master of a Danish ship which left New York on the 12th of December and connected with a station I established in Staten Island. He towed one of my shells out, and the wire and whole invention complete—all unknown to any one and not made public until I gave it to you to-day. Here is a letter which you see is in French—a copy; but here is the original in Danish. The writer extracts as follows:

QUARANTINE STATION.

NEW YORK, Dec. 26, 1879.

Mon cher Pierre:

* * * * * *

As you know when I left Staten Island all went well, and as we were in constant communication, until last night there is not much to tell—except this, that I gave the crew too much liquor without knowing its strength (I got it in Glasgow), to celebrate the great success, just as we sighted Sandy Hook; and could trust no one—not even my first mate, so I locked up the cabin and instruments and handled the ship with the pilot myself.

* * * * * *

We sailed in course S. S. E. pretty nearly all the time, averaging in the seven days, bound but 184 miles a day, running 1,288 miles. In returning to Sandy Hook I took a longer course making the run 1,856 miles. Thus we maintained telegraph and telephone communication in the heaviest weather over 3,644 miles.

Our little daily, written by my son, called the "Ocean Wave," I have sent to the Historical Society, as you desired. It contained on Dec. 23d, the London dispatch of the loss of the *Borussia*.

* * * * * *

THE GENIUS OF THE INVENTION.

The chief point about this invention is very simple—it is the *strength, small size, and absolute unimpaired conductivity of the wire for long distances when insulated and immersed in water*. This has been attained. The wire was made in Pittsburg, and has a core and envelope I am not permitted to describe. It may be said also, that there is an automatic repeater within the shell to use in case it were necessary for greater electrical force. Neither "Kerite" wire, nor wire made by the American compound wire company can equal this thin thread of Valcour. Nor is there any difficulty in the mechanism, as every practitical seaman will note. Mr. Valcour says that the only criticism he fears is in picking up the wire when returning from Europe. This will be done on the return voyage, when the vessel arrives a few miles from the first sinker. An ingenious *detachment* spring is operated by the electrical current so that the sinker releases the wire, and so the operation is continued, until it is reeled up on board again, for use in another voyage. This will keep the vessels to the well-known "Steam Lanes," or defined ocean routes, so often advocated in the New York *Herald*. The towing of the shell in no wise interferes with the steering of the vessel; but in a storm is an additional safe-guard as a jury rudder.

EXPENSE, INTERFERENCE AND EDISON.

M. Valcour says that the expense will be trivial compared with the advantages to be enjoyed, and would be little more than the cost of the wire, which he is prepared to furnish by contract at astonishingly low rates and also his shells. The query was made whether he anticipated trouble with Edison. He said hardly; that although this was an application of the telegraph and telephone, he did not see how he could be considered a poacher on the preserves of the great electrician. However, he would be glad to hear from Edison on the subject, and he thought he could give that inventor an idea or two. M. Valcour has not as yet parted with any of his interest, although sought after from all directions where the success has been made known.

TELEPHONING 3,500 MILES.

Before the writer left he maintained perfect telephonic communication with M. Valcour for over half an hour through 3,500 miles of wire coiled in the reels in the shell.

THE EFFECTS OF THIS WONDERFUL INVENTION.

The results of this invention, almost immediate, cannot be overestimated. Among the first, M. Valcour proposes to establish a small printing establishment and issue a little daily sheet on every ocean steamer plying the seas. This right he proposes to become the owner of and issue his journal called the *Ocean Wave*, so that no traveler by the sea will remain for an hour ignorant of the world's doings. Private messages will be taken and sent. Friends can hear each other's voices from mid-ocean to shore, and shore to mid-ocean. Instantaneous news of disaster can be flashed to the seaport left—say New York—and as the point of latitude and longitude is told, and as the other companies know the exact position of their ships or steamers, a hundred succoring ships or steamers can be sent with relief; and as the tracks of commerce are now known and followed no serious disaster can occur. Other results, will be the constant money speculations that can go on by wire. Criminals afloat can be apprehended, the march of storms be made known; deaths telegraphed. The entire shipping department of the New York *Herald* will be revolutionized. Cargoes can be bought and sold in transit; contracts made; marine insurance effected—and thus will life become almost perfectly cosmopolitanized on every sea and shore.

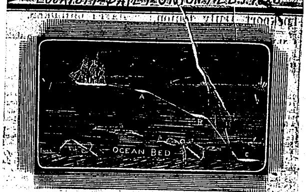
M. VALCOUR'S ADDRESS.

M. Valcour's address is Pierre Valcour, Lockport, N. Y., and he is willing he says to answers pertinent enquiries.

117

118

Lockport Daily Union Feb 3 1880



NOTE.—The Cut represents the Cunard Steamer Asia, bound to Liverpool. From the stern of the vessel to A, which is on the surface, is the chain cable towing A, the metallic shell, in which is contained 2,500 miles of wire and the apparatus. B and C should have been smaller, as they are only sinkers, finally anchoring the wire on the bed of the ocean. On the return of the vessel she carries another apparatus, in all parts like this, and while keeping up communication with Liverpool, she winds up the wire laid from New York, as explained below. A permanent wire can be laid too superseding the cables now in use.

THE CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The number of messages passing over the lines of the Cuba Submarine Telegraph Company (Limited) during the month of January was 2,891, estimated to produce £3,200, against 2,687 messages, producing £3,043 in the corresponding month of last year. The traffic receipts for the month of November, estimated at £3,000, realised £3,110.

Teleg'l Mech. News Dec. 1st 1881

THE system of underground telegraph wires has been adopted in Philadelphia, and a company is busy digging trenches and laying tubes. A trench is dug in the middle of the street, three feet nine inches in depth. The bottom and sides of the trench are lined with concrete. The tubes, two inches in diameter, are then put in place, five in a row, and four rows, one above the other. A composition of pitch and slag is then poured in, until the pipes are covered, after which the top is cemented with concrete. The ditch is then filled in and the earth rammed down. It is calculated that the twenty tubes will accommodate from 1,000 to 1,500 wires. A man-hole is placed in each square, and the wires will be forced through after the tubes are all laid. The work is mostly done at night.

Scientific American, Sept 4th 1881.

EXPERIMENTS WITH UNDERGROUND WIRES.

After a three months' test of their system of insulating telegraph and telephone wires underground, the national Subterranean Electric Company have applied for permission to introduce their system in Philadelphia. The company claim that when once introduced on their plan, telegraph, telephone, or other wires can be used in separate chambers, and that no disturbance of the pavement will be required for repairs or for additional wires. In the experiment referred to, in Camden, the telephone wires were, after three months' use apparently in as perfect condition as when first laid down. The plan embraces a system of terra-cotta cylindrical blocks, perforated lengthwise with several small holes, vitrified and lined with rubber. These blocks are laid end to end, cemented together, and form groups of pipes through which wires or cables are run. These pipes are laid in sections, at the end of each a sunken chamber affording workmen access to the pipes and wires for purposes of repairs or laying additional wires, which can be strung through the sections from chamber to chamber. The chambers are covered when not in use, and afford no obstruction to travel. The cost of the system is not given.

What is claimed as a cheap and durable system is under trial in Prospect Park, Brooklyn. The wires are strung in a trough of pine wood, into which is poured a mixture of pulverized glass, resin, and other ingredients made semi fluid by heat. In this compound, which becomes hard on cooling, the wires are hermetically sealed. It is claimed that the mixture has a very high insulating power, is durable, and sufficiently elastic to maintain its integrity under varying pressure. A bundle of wires of any length can thus be laid in sections without a break, and operated with a relatively small battery power, owing to the perfection of the insulation. The cost of the system is given at $1,500 a mile. The number of wires and the space between them are not given.

A more expensive and not altogether satisfactory system is used in London, where something like a hundred miles of underground lines have been laid. In this system the iron or earthen piping is in sections of 200 yards, separated by test and joint boxes. The cables are composed of 60 No. 18 copper wires insulated with gutta percha. The cost is given at about $7,000 a mile. The maintenance of perfect insulation is difficult, and when a fault occurs the whole cable has to be withdrawn and repaired.

Professor PERRY explained this action by the hydro-dynamical fact that the pressure is less at the centre of the mouth of the cup than at the edges.

Professor GUTHRIE said that he had tried a similar experiment with a funnel-shaped mouth and a glass cone, but failed. He surmised that perhaps the cohesion of the water for itself, as it formed a shell round the ball, might help to cause the success of the ball method.

Professor ADAMS pointed out that with the cup and ball there was less difference of head of water between the centre of the mouth and the edge where the water escaped than with the funnel.

Dr. STONE stated that he had been able recently to imitate many physiological sounds, such as the murmur of the heart, by means of constructions in tubes through which water and air were flowing. His demonstrations were made before the Royal College of Physicians.

Dr. C. W. WRIGHT then read an important paper

ON A DETERMINATION OF CHEMICAL AFFINITY IN TERMS OF ELECTROMOTIVE FORCE.

After giving a history of the subject, he described his original experiments. These consisted in performing electrolysis of sulphuric acid, and measuring the heat evolved in the process and by recombination of the materials. A voltameter with spade-shaped platinum electrodes soldered to stout copper wires, and sealed by a large plug of gutta percha, was employed for the electrolysis. An ordinary water calorimeter was used to measure the heat given off, as Bunsen's was found to contain sources of loss of heat. The strength of the current employed was varied from 6 Webers to $\frac{1}{20}$ Weber. The volume of gas produced was measured by Joule's plan. Radiation loss was corrected for by three methods. From an average of eighteen experiments the value of ϵ, the electromotive force was found to be 1·5038 C.G.S., or volts. Taking the formula $J = \frac{\epsilon}{(H + h)\chi}$, where J is Joule's equivalent, H is the heat actually evolved, h the heat evolved by the recomposition, and χ a constant, to which Kohlrausch gives the value of ·000105, Dr. Wright finds that Joule's equivalent should be $4{\cdot}196 \times$ by 10^7 instead of $4{\cdot}20 \times 10^7$ as given to answer the formula. The author thinks that Joule's water-friction experiments gave the truest value of J, and that his electric heating experiments gave a result about $\frac{1}{2}$ per cent. too low, owing to the B.A. unit of resistance being about 2 per cent. too high, and other causes.

Electrician March 6 1880

THE DIRECT UNITED STATES CABLE COMPANY (LIMITED).

Report of the proceedings at the fifth ordinary general meeting of the Direct United States Cable Company (Limited), held at the City Terminus Hotel, Cannon-street, on Friday, 27th February, 1880, at twelve o'clock noon; JOHN PENDER, Esq., M.P., in the chair.

The notice convening the meeting was read.

The CHAIRMAN: Gentlemen, as you have had the report in your hands for some days, I presume you will take that as read. I should like in the first instance to make a few remarks as to the figures in the report, in order, if possible, to make it so clear that there may be no difficulty in discussing it on its merits. It will be seen from the Company's accounts that our revenue for the half year to 31st December last, after deducting rent of land lines and payment to Anglo Company, amounted to £120,445 8s. 6d.; and the working and other expenses, including debenture interest and income-tax, absorb £25,001 3s. 6d., leaving a balance of £95,444 5s. as the net profit of the half year, making, with £2,345 1s. 5d. brought from the previous half year, a total of £97,789 6s. 5d., which has been appropriated as follows:—Two interim dividends of five shillings each per share for the quarters ended the 30th September, and 31st December, 1879, together requiring £30.355, have been paid; an amount of £48,942 2s. 9d. has been added to the reserve fund (which is thereby increased to £150.000); the sums of £1,900 on Preliminary Liquidation and Arbitration Account, and £914 7s. 1d., the cost of removing spare cable have been written off, and the balance of £15,677 16s. 7d, is carried forward to the next half year. Our revenue in the past half year, as compared with that in the corresponding period of 1878, has increased by the sum of £30,501 13s. 10d. This satisfactory result is mainly owing to the revival of trade between this country and America. The working and other expenses show a balance of increase of £3,250, which is accounted for as follows:—Compromise of Colgate suit, including law and other charges incidental thereto, £2,560. I think it is right I should explain to you that this Colgate suit is the reversion of an old patent which was obtained in America, and a claim in respect of royalty upon the covering of copper wire with gutta percha. That patent existed in this country, but expired many years ago. The American patent in some way or other had been in existence at a later date, and curiously enough the inventor, or rather, the trustee of the inventor, took the question up and gained a decision in more courts than one in America. Therefore, that involved a compromise; but, fortunately for us, we got out of the matter by that compromise at a comparatively small expense. I believe that the trustee of the inventor in America has got a very large sum of money from land lines in America in virtue of that patent. Then there is the opening and furnishing new stations in America and building in Ireland, £830; extra printing and stationery, £410; maintenance and renewal of instruments, £360; debenture issue and miscellaneous, £720; making a total of £4,880. But, as against this increase, there are many items of decrease, amounting to £1,630, leaving as an increase of expenditure £3,250. Omitting from these details the special expenditure *re* Colgate, it will be seen that the other items of increase were unavoidable, inasmuch as without the extra outlay it would have been impossible to earn the largely increased revenue. The above explanation of the increase in our expenditure, &c., having been given, no other item in the accounts appears to call for special remark [applause]. Now, gentlemen, I hope I have put before you very clearly the state of our finances, and I think I may congratulate the shareholders on their very satisfactory character. Therefore I need trouble you no further with these details. No doubt there are gentlemen in the room who may require to ask some questions on those accounts. If so, I shall be very glad to reply to any criticisms that may be made upon them. I may also congratulate you on the fact that since April last our cables have been working in every way satisfactorily, and the result has been the large return which your accounts show. I have no doubt that there are many gentlemen present who will be naturally anxious to know how we stand in relation to the new French cable [hear, hear]. It may be in your recollection that six months ago I gave you an outline of the French competing scheme. Since then the line has been completed, but I can scarcely say yet that it is open for general traffic. Messages have passed over the line, but at the present moment the telegraphing public know very little about it, and I suspect those who are immediately interested in the cable know a great deal more than it would be pleasant for them to communicate. So far they are very much in the position which I indicated—they are doing no good for themselves, but they are inflicting damage to a very considerable amount on telegraphy generally. I also stated six months ago, when those shares were at a premium in France, that in my opinion before twelve months were over they would be at fifty per cent. discount. I saw those gentlemen who formed the syndicate, for I went to Paris for the purpose of doing so, because I thought it was only right that those men, who must be ignorant of telegraphy generally, should be informed on the subject. I found one of them sitting at his desk with his pen in his hand, and I told him to make this note—that in twelve months, if I then returned to France, I should be able to sympathise with him on the loss of fifty per cent. of his property. To-day I can prove the truth of the prediction, for I now hold in my hand an official quotation from France, made only yesterday, which states that the shares have been sold at £11 each, which is close upon fifty per cent. discount. We may infer, therefore, gentlemen, that the cable manufacturers, the syndicate, and the French public generally, are in no way satisfied with their bargain. The contractors have pretty well exhausted England, as you who formed this Direct company know. For three years the shareholders got nothing out of this Direct company; and the syndicate lost £550,000. I have no doubt at all that if the new French cable were to fall into better hands, those better hands will probably by business-like arrangements be able to bring about the same result which has been brought about on our system; but then, gentlemen, it will be at a loss of about 50 per cent. on the original cost of the cable. As I have said they have exhausted England, I may say that they have pretty well exhausted France by this time also; and we are informed that they next propose to try Belgium, and, if that fails, Germany. But I should say that after the two attempts which have been made by the same parties, in which they have so signally failed, in carrying out the promises made in their prospectuses they will find out that other countries are not likely, particularly Germany, to engage in such a losing game. Schemes, such as the French cable scheme, are got up, as you are aware, by contractors and syndicates simply for the purpose of getting money upon the transaction, regardless of all consequences to telegraphy or to the investing public. Within a year they may get up a company, and within a year they may lay the cable, and hand it over to the Company; the public lose their money, the contractor probably puts something into his pocket, unless he has taken the amount of his contract in shares, and the result is that he goes elsewhere to find out another field for his enterprise. When telegraphic enterprise was first started, syndicates were a necessity, as it was almost impossible to get money from the general public; but now that telegraphy is established as a commercial necessity, and its real value ascertained, the public are not likely to subscribe for any enterprise unless they see a return commensurate with the risk. I have always held at public meetings of telegraph companies which I have had the honour of addressing that submarine telegraphy ought to pay from 8 to 10 per cent. dividend. I hold the same opinion now. It is a very curious fact, if you look at the telegraph companies generally, that the public estimate and value the telegraphic enterprises pretty much at that rate. No doubt in the early days of telegraphy 10 per cent. was necessary; but now that the public estimate the value of the telegraphs more accurately, and consider them more secure as a property, the returns are less. I may say that the telegraph returns upon the price which you can buy them at to-day give something like from 6 to 8 per cent. The amount of money at present invested in cables is about £25,000,000; the amount of reserve fund put aside by all the telegraph companies amounts to £1,630,000; but to replace the deep sea portions of these cables, an amount of £12,500,000 would be required, and until this amount is obtained it would not be wise in my opinion to consider submarine telegraphy in the sound position in which its friends would wish it to be placed. On this point I think it necessary to be very clear and distinct, so that there may be no misunderstanding betwixt shareholders and directors. The Direct Company's cable has been laid nearly six years; for three years, as you are aware, it paid no dividend, and put aside no reserve. It has been nearly three years under the present direction, and in that time we have paid you a dividend of 5 per cent., and have accumulated an amount of £150,000 for reserve. Had the proper course been pursued from the beginning, and a proper reserve laid aside, we should have at the present time £300,000 as a reserve fund. The average life of a cable is said to be ten years, but as to this much depends upon the bed on which the cable is laid. I believe it would be difficult, if not impossible, to raise a cable from 2,000

fathoms after being ten years under water; still, it is quite possible that a deep sea cable might live for twenty, thirty, or forty years, or even longer so far as the insulated core is concerned, because in all our raisings of cables that have been in the sea for a very considerable time, we find that the gutta percha is almost indestructible as far as sea water is concerned. As that is the life and heart of a cable, if you could only get armour plating sufficiently strong to resist the action of the sea water a telegraph cable might live for a very long period. However, let us assume the life at ten years. The reserve necessary to replace the deep sea portion of our cable in that time would be £52,300 per annum, but if we raise the life to fifteen years we should require £32,300 per annum. I think, gentlemen, the safer principle to go upon is to put aside the larger sum, and when we exceed the ten years and our cable is still living, and in a profitable working state, then the Company can afford to pay a very considerably increased dividend, or probably it would be better to give bonuses. I submit, therefore, that the policy, not only of this Board, but the policy of all Boards of submarine telegraph companies, should be to accumulate a large reserve. There is another point I must touch upon, and that is the often expressed desire in certain quarters for reduced telegraph rates. Now, I think I have shown you that a reserve fund is a necessity to secure permanency of telegraph property, I think I can now show you that the reduction of rates from the commencement of telegraphy has been very striking indeed. When the telegraph was first established, the tariff across the Atlantic was £20 a message; it has gone down steadily, and now an average message costs 30s., in fact, a message can be sent across the Atlantic for 9s. When we reflect upon the ingenuity of the code and packing systems, we find that the amount of matter that can be transmitted at this low rate is almost beyond calculation. I may repeat what I have often stated at these meetings—if we had now an open system, instead of the code system, to deal with, for the matter which is passed over our lines we should realise the most sanguine anticipations entertained in the early days of telegraph property as to dividend. I remember myself, in the very early days of telegraphy, talking with Mr. Cyrus Field, and his saying that nothing less than 50 per cent. would satisfy him as a proper return for these telegraphic cables. That was a very sanguine view; but, if the open system had been continued to-day, it would have proved pretty much what he stated. But the ingenuity of the coding and packing system has reduced us, as I will show you, to a very low dividend indeed. It is the public who have really got all the benefit of the telegraph. If we take the capital of all submarine cable companies at the present moment, we find that the amount is over twenty-five millions sterling, and taking all the dividends that are earned upon these twenty-five millions, we find it to come out at only 4-4ths per cent. It would therefore, I hold, be unsound policy both in the interests of shareholders and of the telegraphing public, to talk of reducing rates at the present moment. We must remember that a submarine cable can only carry a certain number of words, and, taking the working time of a cable, it requires 2s. a word to give but a very moderate return upon the invested capital in these Atlantic systems. So far as the Atlantic tariff is concerned, any reduction leading to an increase of messages would not lead to a larger return in money, because at a low rate it would be impossible for a cable to carry the number of words required to make it pay. To carry messages at a low rate additional cables would be required, which, of course, involves additional outlay of capital and reduction of dividends. The present tariffs are in no way checking telegraphy, as we may plainly see, if we take last year as an evidence, for there is a large increase in the return of telegraphs generally. As I have often said, telegraphy is the best barometer we have of trade. With good trade the returns rise rapidly. With bad trade they become correspondingly depressed. The increase in the telegraph companies' returns is one evidence, which I think we have all good reason to congratulate ourselves upon, at the present moment, that not only in America, but also in India, and, in fact, throughout the world, trade is getting into a brighter and sounder position; and that is an evidence which I believe will brighten many a home [hear, hear]. We must deal in this question of telegraph tariffs with averages, and I hold that the rates we are now charging are a fair average, and must be maintained until the reserves I have indicated are secured. Having now shown you by figures that it is desirable to largely increase the reserves, and that it is undesirable and impolitic to reduce tariffs, I will just say one word as to the position which submarine telegraphy occupies at the present moment, and what it has had to contend with. Telegraphy has had little or no support from governments. Governments have never hesitated to grant concessions to anybody who might apply for them, encouraging, as they say, competition. They even go so far as to prevent any cable landing upon their shores (I am speaking of England, France, and the United States) who hold any concession or special privileges, while they do this, throwing every obstacle in their power in the way of submarine telegraphy (and I should be glad to have an opportunity of proving this to the governments) becoming a remunerative enterprise, although they admit it has become a great necessity both for Imperial and commercial interests. But instead of dealing with it on the same principle that they deal with their own telegraph systems, which in every country is a vast and close monopoly, they are strict to a degree in upholding their own monopoly, but they lose no opportunity of destroying what they are pleased to term the monopoly of submarine telegraphy. I hope the governments will see these things in their proper light, and that they will consider well when concessions are asked for, whether they are sought in the interests of the public generally, or are meant to enrich speculative contractors, to the destruction of sound telegraph enterprise. Telegraphy does not admit of undue competition. It has had to be established at enormous cost, and is of a very speculative and uncertain nature. Until science has done more than it has yet done to render cables permanent, the greatest caution ought to be observed on the part of governments, and I may say also on the part of individuals, in order not to destroy the fabric which has done so much, not only to promote commercial interests, but civilisation to a degree more rapid than anything has yet been known in this or any other time in the history of the world [applause]. Gentlemen, I have felt it necessary to-day to give you a few details, which I dare say will be interesting to you, as showing the position in which telegraphy is at the present moment. I believe that the value and usefulness of telegraphy is only beginning to be felt at the present moment. Great as the benefits are which it has conferred upon mankind, there are still greater benefits to be conferred by it, and I think that all those who have been interested in telegraph enterprise from the beginning may congratulate themselves upon the fact that they not only have had a moderate dividend, but they also have the satisfaction of knowing that their property is an increasing property, and that they have conferred an enormous benefit upon the commercial interest and the public generally [hear, hear, and applause]. Gentlemen, having troubled you with these few remarks, I beg to move the following resolution:—"That the report of the directors, dated 13th February, 1880, together with the statement of accounts to the 31st December, 1879, annexed thereto, be and the same are hereby received and adopted."

Mr. W. FORD: I beg to second the resolution.

Replying to Mr. Jackson and Mr. Newton,

The CHAIRMAN said: Mr. Jackson has entirely endorsed the policy of the Board. He has asked the Board to stand on that policy; but he has stated that so far as our cable is concerned we are in a very uncertain and very unsatisfactory position. I do not agree with Mr. Jackson in that respect, because our arrangements with the Anglo-American Company are of a very satisfactory nature. We should have ample time to repair our cable if it were to break, without suffering in any way in our dividends. At the same time, were it to break in deep water there is no doubt at all that we should require to find a new cable. Our cable is still young and healthy and I think it is in that position which, if it were to break to-morrow, as we have got a very good nest egg to begin with, and plenty of time to repair it, and sufficient shallow water that would limit the amount required for the cable to a very small proportion indeed. I take, therefore, a much livelier and brighter view of our position so far as as our own cable company is concerned than Mr. Jackson does. We are, certainly, the junior partner; but we are supported by all the means, and all the powers of the Anglo-Company with regard to help in case of need. I do not go in for monopoly, I have always been opposed to monopoly. When we extricated this Company from its troubles we were most decided in that view; we felt that to be absorbed by the Anglo-Company was simply giving place for another cable to spring up. As long as I have the honour of being chairman of this Company, it will never be considered a monopoly, as I am opposed to monopolies altogether. I say that submarine telegraphy is a matter of enterprise, and is not ground to be poached upon by any other class of property. It is an uncertain property, as we all know, and that man who came forward to induce other people to find money to lay cables where they could get a better security for half the price at the same moment shows that the public are still what I will call very gullible indeed, but I hope that every day is opening their eyes in that respect. With reference to Mr. Newton's question, I was going to make the reply which Lord Monck did, which I think was a very sound and proper reply. Only last night in the House of Commons a question was put to one of the ministers, and the minister's reply was "During negotiations it would not be to the public interest that anything should be said about it." During the present stage of negotiations between the French and English companies, I think the less said about it the better [hear, hear]. All I can say is, that they are doing nothing, and with a large capital lying unemployed, every day is strengthening our position and weakening theirs. You may depend upon it, when it comes to close quarters, if a bargain is ever made, that the interests of the shareholders of this Company will be fairly protected.

The resolution was then put and carried unanimously.

Mr. JACKSON: I beg to move that the best thanks of this meeting be accorded to our worthy chairman for the way in which he has presided over the affairs of this Company. He is a gentleman who is not only A 1 as a telegraph director, but is ~~so devoted to our interest, that~~ I am sure we shall not hesitate for a moment to express the gratification we feel in having the opportunity once more of expressing our acknowledgments for the services of himself and his Board.

The motion having been seconded, was put by Mr. Jackson to the meeting, and carried by acclamation.

The CHAIRMAN: Gentlemen, we are very much obliged to you for this renewed mark of your confidence. I am sure there is nothing more gratifying to my co-directors and myself than to find that our shareholders are satisfied. I think that, looking to the affairs of this Company altogether, we have reason to congratulate one another at the respectable position in which we find ourselves to-day.

The proceedings then terminated.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).

The sixteenth ordinary general meeting of shareholders of the above company was held on the 2nd inst. at the City Terminus Hotel, Sir Daniel Gooch, Bart., M.P., presiding.

The SECRETARY (Mr. W. Shuter) read the notice convening the meeting, and subsequently the minutes of the last ordinary and half-yearly meetings, which were approved by the present meeting, and signed as correct by the chairman. The report, which appeared in *The Electrician* last week, was taken as read.

The CHAIRMAN, in moving the adoption of the report and accounts, and a dividend (tax free) of £1 16s. per share (making with the interim dividend 20 per cent. for the past year) said that he need not detain them very long, because the affairs of the Company were set out so fully in the report, which, no doubt, they had all read. During the past year they had manufactured 6,917 miles of cable. The result in money was that they showed a net profit during the year of £98,988, after deducting the interest charged on their debentures. They brought forward from the previous year an amount of £59,353, making together £158,341 to dispose of. Out of that they gave an interim dividend of 5 per cent. in July last, which absorbed £22,410, and now the directors proposed to distribute a dividend of 15 per cent. for the past half year, which would require £67,230, and leave to be carried forward £63,701. That he thought was a very satisfactory statement of their financial working in the past year. The work done had been the duplication of the Australian cable, which they began very early in the year, but the completion of it was postponed in consequence of the necessity which occurred for the carrying out of the contract for the Cape cable, and the Australian Governments were good enough to consent to the postponement of the completion of their cable, so that it might be used for the completion of the Cape cable. They did not complete the Australian cable, therefore, till the beginning of the current year. With regard to the Cape cable, they laid that cable of 3,845 miles during the year, and it was successfully laid. Unfortunately, a break had taken place close to the shore of Mozambique, and when it happened there was no ship nearer than Aden to repair it. They had, however, that day received information that the ship had arrived on the ground, and no doubt in a day or two that breakage would be put right. It was a very bad bit of ground where it was broken, and some steps must be taken by the Cape Cable Company to see if they could find a better piece of ground. They started a ship on Saturday with 555 miles of cable to lay a line between a point near Manilla, in the island of Luzon and Hong Kong, and that work would be completed in the month of May. That was for the Eastern Telegraph Company. They had carried out a contract for the German-Norwegian Telegraph Company to make and lay a cable between Arendal in Norway, and Hoyer, on the coast of Schleswig. That operation was completed in August, and the length of cable was 250 miles. Last December they entered into a contract with the Government of New Zealand to lay a cable of 120 miles in that colony, and they had heard that day that the cable was laid, and that the ship was on her return home. The total length of cable manufactured in the year was, as he had said already, 6,917 miles, and they were, he thought, indebted to the officers and others who had been engaged in laying these cables for the care and ability with which they had completed their work. It was a very large extent of cable to lay, and they had had no misfortune to report. The accounts were set out in full detail, and, therefore, he did not think it necessary to refer to them further, but he should be very glad to give any explanation which might be required relating to them. They hoped that the present prosperity of the Company would continue; perhaps it might not be quite so great as it had been hitherto, but, at any rate, as far as the directors were concerned, they would do their best to carry on the Company's work satisfactorily. He concluded by moving the resolution.

Mr. PHILIP RAWSON seconded the motion.

Mr. WILLIAM ABBOTT thought that every one would endorse the chairman's remarks about the shareholders' obligations to the officers of the Company for the skill and ability which they had displayed in carrying out the work of the past year. He was in the habit of asking the Chairman many questions at the meetings of the Company, but he was also in the habit of receiving very scant replies. He had no doubt that both the chairman and he had the same end in view—the welfare of the Company—and that no undue inflation might be stimulated in the minds of the shareholders as to what might take place in future, he had made a small calculation, and found they had laid 6,917 miles, and that the net profit amounted to exactly £15 per mile. Considering the risks they ran in cable laying, he did not think their customers could make any complaint at the amount of net profit made by the Company on the works they had carried out. He should be glad if the chairman would inform them whether the distribution of dividend, which was very satisfactory to him, though it might have been very much larger, was limited to the usual 20 per cent. on account of the fact that they had securities to the amount of £343,365. He presumed that they had to render a considerable amount of assistance to the Cape company, and also to the other companies for whom they had done work, and that when those securities were in a liquid state the profit would be fairly divisible among the proprietors. They did not live for posterity—posterity had done nothing for them, and, therefore, it was desirable that the shareholders should see a little of the return in their life time, and not wait for all their reward in the next world.

The CHAIRMAN said Mr. Abbott was wrong in supposing that the Company had laid 6,917 miles of cable during the year; they had constructed that amount of cable, but the whole was not laid. As he had said in his opening remarks, the Australian cable was not laid till the beginning of the present year, and the accounts connected with that work did not come into the accounts under consideration. As he had told the shareholders many times, the success of the Company hitherto had been owing to their having large funds in hand. Without large funds in hand they could not have undertaken the Cape cable. It was very well known that the Telegraph Construction Company had to take practically two-thirds of the capital of the Cape Cable company upon its own hands, the Eastern Company taking the other third; but if they had not had those large available sums in hand they could not have undertaken the Cape cable. Therefore, although it looked a large sum in hand, yet their success depended on it. He was as deeply interested as anyone in having a large dividend, but still he looked to the prosperity of the concern, not for one year, but as a permanent investment for their capital, and he was quite sure that the course they had hitherto taken was a wise one. He did not think anyone could complain of 20 per cent.; he only wished he had that rate or half of it from other companies he was interested in. He hoped the shareholders would not inquire too closely into the matter referred to by Mr. Abbott, but that they would trust the directors, who had hitherto not deceived them. He thought that the accounts placed before them showed pretty generally the state of the Company financially. He then put the motion, and it was carried unanimously. He next moved the re-election of Lord Alfred Paget to his seat at the Board.

Admiral Sir GEORGE H. RICHARDS, C.B., F.R.S., the managing director, seconded the motion, and it was carried unanimously, as was also a further resolution, proposed and seconded by the same gentlemen, for the re-election of Mr. George W. Campbell.

On the motion of Mr. W. ABBOTT, Mr. John Gane was re-elected an auditor of the Company, and Mr. James Glegg (of the firm of Quilter, Ball, and Co.) was elected the other auditor, to fill the vacancy caused by the death of Mr. John Ball, who, the chairman stated, had served the Company for many years, and paid great attention to their affairs. Mr. Glegg had been a partner of Mr. Ball's, and had lately assisted in the audit.

Mr. WILLIAM FORD said that notwithstanding that the directors had thought it prudent only to declare the normal dividend of 20 per cent., and notwithstanding that they had thought it prudent not to supplement it by a bonus of 20 per cent., notwithstanding, too, that they had thought it expedient to carry forward £68,000 odd, he still thought, in spite of those shortcomings on their part, that they were deserving of a hearty vote of thanks. He hoped next year that they would have a larger dividend; a bonus, and that they would carry forward more.

Mr. ABBOTT, in seconding the motion, thanked the chairman for the information he had given him. It was true it was not much, but it was all he required.

The resolution was carried unanimously.

The CHAIRMAN thanked them for the renewed vote of confidence which they had passed. He could assure them that the interests of the Company had the deep thought and attention of the directors, and he hoped that they would meet under such pleasant circumstances for many years to come.

Mr. FORD then said that the shareholders would concur in the remarks of the chairman as to the services of the officers of the Company's ships who had been engaged in the various expeditions the results of which had been so successful. He was sure that those shareholders who were acquainted, as he was, with the great difficulties of the various expeditions would appreciate as fully as he did how much they owed of their prosperity to the energy and skill of those officers. He was extremely glad to hear them mentioned. He was sure that the shareholders would concur in passing a vote of thanks to the various officers and the staff of the Company.

Mr. HANCOCK expressed his pleasure in seconding the resolution. He had known some of the men referred to for 20 or 25 years, and he was sure that the great success of the Company had been due as much to the great care, experience, and skill of the officers as to the straightforward and honourable conduct of the directors.

The CHAIRMAN put the motion, and it was carried unanimously, and the proceedings then terminated.

MEDITERRANEAN EXTENSION TELEGRAPH COMPANY (LIMITED).

The forty-fifth ordinary general meeting of the shareholders of this Company was held at the City Terminus Hotel, Cannon-street, on the 3rd inst., under the presidency of Sir James Carmichael, Bart., chairman.

The SECRETARY (Mr. E. Tombs) read the advertisement convening the meeting, and the report of the directors was taken as read. It stated th the last half-yearly balance sheet of the Company showed a slight improv ment over that of the previous half year. The cables were in good con dition. They recommended payment of the usual dividend at the rate of per cent. per annum, less income-tax, on the Preference Stock, and of a dividend at the rate of 3 per cent. per annum, free of income-tax, on th Ordinary Stock of the Company, on and after the 10th March, leaving a balance of £48 to be carried to the reserve fund. The revenue accoun showed that the receipts from messages during the half year ending th 31st of December last had been £2,281, and the amount due from th Government under the guarantee was £3,600.

The CHAIRMAN, in moving the adoption of the report and account expressed great regret at the delay which had occurred in holding th meeting, which was usually held in February, and, as they were aware, th dividend was usually paid on the 1st of March. The delay had not arise from any *laches* on the part of any of the officers or directors of the Com pany: but, unfortunately, the official auditor of the Treasury had demurre to the claim which the Company had made for payment of the guarantee at least, they demurred to a portion of it. They thought that they we entitled to it, and the matter was still under the consideration of th Treasury. They had endeavoured to get this settled before the meeting of the shareholders, but as that seemed to be impossible they thought better to leave the matter for the discussion of the Treasury, and he hope that at the next meeting they would be able to make a favourable report t the shareholders on the subject. Those were the only remarks he had t make on the report and balance-sheet, but he should be happy to answe any question or give any information which might be required.

Mr. HARRIS having seconded the motion,

Mr. C. ROBINSON thought they ought to have some little explanati as regarded the different matters which were going forward with respe to the Company—for their prospects for the future appeared to be n brighter than they were at present. When they found the Governmen objecting to pay what the Board considered the Company ought to receiv the shareholders ought to ask the question in what position the Govern ment stood towards them in respect to the guarantee, and, further, whethe the amount they objected to pay the Company was a sum which they cou legitimately claim back from them or not. Their solicitor was presen and he might tell them whether it was better to meet the dispute by a amicable arrangement, or whether they should insist on their rights. H thought they had very much truckled to the Government as to this matte The Treasury were imposing very onerous exactions on them, and th seemed to dictate to the Board what they should do and what they shou not do. He had several times made remonstrances with the Governme but they had not had the effect on their interests he could wish. Th must look to themselves and not to the Government. The diminution their expenses was considerable, and their cables were in perfect ord He thought a remonstrance from the shareholders would convince t Government that they must deal more liberally towards the Compa The Company had been in existence many years, and it was disgrace to the Government that they should ever have san tioned a competing line. Instead of promoting the interests of t Company, they promoted the interests of a company which was d metically opposed to it. He knew that many of the messages which t Government sent did not come to the Company, although it would thought that, as the Government had to pay the Company a guarantee, th would send all the messages they could through the Company, so as reduce the liability they were under to the Company. This question h been brought before them lately, and he understood that they had n more messages. At one time, however, they received scarcely any of Government messages. He thought the directors would be assisted v much by a large attendance of the shareholders at their meetings, and t some remonstrance should be made by the shareholders to the Governm Seeing the difficulty they now had in obtaining messages from the Gov ment, when the guarantee expired they would receive no messages f

that quarter. At present the shareholders seemed to think that because they received this interest each half year it was to last for ever, and, therefore, they took no heed of the position of the Company.

The CHAIRMAN thought the last part of Mr. Robinson's remarks almost answered the first, for the Government had a right to terminate the agreement. It had nearly four years to run. If they could end the guarantee it was surely not their interest to quarrel with their paymasters. They must do all they could to carry on their business in an amicable manner. He had never found the Government hard taskmasters. They had paid them he thought very fairly and liberally. They had now a question open as to which he entirely differed from them. It was a question open to discussion, though he thought it was a hard matter to press on the Company, but he hoped they would do all they could to carry their point. He certainly would not advocate taking legal proceedings against the Government. He thought the better way would be to leave the matter in the hands of the Board to negotiate. The present Government was not answerable for the competing line to which Mr. Robinson had referred, and which was, unfortunately, inimical to this Company.

Mr. CAMPBELL (the solicitor of the Company) thought the time had not arrived for entering into any legal discussion on the subject, and he hoped that an amicable arrangement would be made. Of course, if it could not be, legal proceedings must be taken, but he really hoped that that would not be necessary.

The CHAIRMAN said they must remember that legal proceedings were very expensive operations.

Mr. ROBINSON replied that he did not advocate legal proceedings, but suggested that as Mr. Campbell was present he might tell them whether the Government had a legal right to make the deduction in question or not.

Mr. CAMPBELL said they believed that the Government had not.

Mr. ROBINSON observed that there was another point in the Articles of Association which had, he thought, missed their notice. The only prospect of the Company becoming a valuable one to the present shareholders, or to their successors, was for them to endeavour to grasp some other line, or to make an arrangement with some other company, and at present he believed they had hardly any power to make arrangements or contracts with any company or government to make or lay any lines of telegraphic communication whatever.

The CHAIRMAN thought that Mr. Robinson was quite right.

Mr. ROBINSON held that they should have the power to grasp anything which might be put before them, and get the consequent advantage without delay. He thought the power should be provided in their articles.

The CHAIRMAN thought that was a very valuable suggestion, and he would be most happy, if the shareholders generally approved of it, to instruct Mr. Campbell to carry it out by suggesting a clause to be drafted into the Articles of Association. That could be done by two meetings, if it were the wish of the shareholders. He thought it might be very advantageous to have such a clause in their articles.

The Hon. A. PONSONBY observed that they had often discussed the matter at the Board, but they thought the time had not quite come. However, it seemed to him that it would be quite feasible, and at their next general meeting, six months hence, they could make the meeting special, for the purpose of considering the question, and then call another meeting to confirm it.

Mr. ROBINSON remarked that there was an old saying, that if a thing were worth doing, it was worth doing at once.

The Hon. A. PONSONBY thought it would do if the subject were considered at their next meeting.

Mr. CAMPBELL thought it might be left in this way: That if anything occurred which was likely to turn out well for the Company they could call a meeting, but if not they would make the next ordinary meeting special for the purpose. It was simply a question of saving money and time.

The CHAIRMAN said he had always regretted the power referred to was not in the Articles of Association originally, but nothing had been before them to necessitate taking the powers. Though he considered it was a very valuable power, he thought it would, perhaps, be better to leave the matter as suggested by Mr. Campbell.

Mr. ROBINSON acquiesced, and the report was then unanimously adopted.

The CHAIRMAN then moved the payment of the dividends referred to in the report.

Mr. DELFORCE seconded the amendment. He said that the amount available for dividend was £3,000, and on the other side they had £3,600 owing to them.

The CHAIRMAN said that the amount was owing by the Government, and it was available for the dividend.

The SECRETARY stated that by various conventions with the Italian Government three months were given to them in which to close their accounts. This amount was available for dividend.

Mr. DELFORCE said he thought it might, perhaps, be the sum in dispute.

The CHAIRMAN replied that he was glad to say that the sum in dispute was much smaller than that. The motion was then carried unanimously.

Mr. ROBINSON moved a vote of thanks to the chairman and directors. They knew the difficulties they had to deal with at the present moment, but he had no doubt that with the assistance of Mr. Campbell they would convince the Government that their claim on the Company could not be legitimately held. It was far better to close with the Government amicably than to throw down the cudgels. They knew that it was a very difficult thing to get a case against a Government. He thought that the suggestion of Mr. Campbell was a very good one.

Mr. LLOYD seconded the motion, and it was carried unanimously.

The CHAIRMAN, in returning thanks, said they would use their best exertions to obtain what they thought they had a right to, and if they failed it would not be from any fault of theirs.

TRAFFIC RECEIPTS FOR FEBRUARY, 1880.

COMPANIES.	Feb. 1880.	Feb. 1879.	Increase.	Decrease
...the Submarine Company	3,200 estd.	2,775	425	—
Eastern Telegraph Company	44,601	37,251	7,340	—
Eastern Extension Telegraph Company	[illegible]	[illegible]	[illegible]	2,781
Great Northern Telegraph Company	14,100	—	—	

TELEGRAPH SHARE LIST.

COMPANIES.	Closing Prices March 3.		Business Done Week Ending March 3. Highest.	Lowest.
Anglo-American Ordinary	59½,	60½	60	60
Do. "B"	88½,	½	89½	88½
Do. "A"	31½,	2½	32½	31½
Brazilian	7 13-16,	15-16	7½	7½
Cuba ... x d Feb. 27	8½,	9½	9 3-16	8½
Do. Ten per Cent. Pref. x d Feb. 27	16,	½	—	—
Direct Spanish	2,	½	—	—
Do. Ten per Cent. Preference	11½,	½	11½	11½
Direct United States	11½,	½	11½	11½
Eastern	8 15-16,	9 1-16	9 1-16	8½
Do. Six per Cent. Debenture	103,	6	—	—
Do. Five per Cent. do.	101,	3	102½	101½
Do. Six per Cent. Preference	12,	½	12½	12
Eastern Extension	8½,	9	9 1-16	8½
Do. Six per Cent. Deb.	105,	8	107½	107½
German Union	8½,	9	8 13-16	8½
Globe Telegraph and Trust	5½,	½	5 11-16	5½
Do. Six per Cent. Preference	11 5-16,	7-16	11½	11½
Great Northern	9½,	½	9 7-16	9½
Indo-European	24,	6	—	—
Mediterranean Extension	3,	½	—	—
Do. Eight per Cent. Preference	10½,	11½	—	—
Reuter's	10,	11	—	—
Submarine ... x d Feb. 27	223,	8	236	231½
West India and Panama	1 13-16,	15-16	1 15-16	1½
Do. Six per Cent. Preference	7½,	8	8	7½
Western and Brazilian	7½,	½	7½	7 1-16
West. Union Seven per Ct. 1st Mt.	120,	5	—	—
Do. Six per Ct. Sterg. x d March 1	102,	4	—	—

Scientific

ATLANTIC CABLES.

WHEN the first Atlantic cable was laid in 1858, each step in the operations was carefully reported in the daily press, and eagerly perused, owing to the novelty of the work and the intense interest it had aroused in the public mind. In the same way, though perhaps to a less extent, the operations of 1865 and 1866 were made public. In 1869 the cable laid between Brest and St. Pierre, known for some time as the French Atlantic, caused less interest. The cables of 1873 and 1874 were but briefly recorded, and the cables laid last year and this year have scarcely been noticed at all. This is partly due to the rivalry existing between the two telegraph companies, as well as between the firms who have made and laid the cables. Very little information is to be obtained on the subject from the principal persons concerned in the work, who, it would appear, wish to have as little made public as possible for fear of their adversaries gaining some advantage by it. This appears to us excessively childish, for any persons having sufficient interest in gaining particulars of either work, to be willing to incur a small expense and trouble, might easily obtain all the information he desired concerning the cables and operations. The rival parties themselves are not likely, therefore, to have any difficulty in knowing all that occurs in the enemy's camp, and it is only the public, and those who take an interest in the subject generally from a technical and scientific point of view, who are deprived of the information as to what is being done in this branch of engineering. There may be some slight advantage to contractors in thus keeping all experience and information as much as possible to themselves, but we doubt very much whether this exclusion of all, except those who are actually employed on the work, from any information as to the progress that is being made, is beneficial or will tend toward the advancement of telegraphic engineering generally. Improvements and new ideas do not always come from rich, conservative, and exclusive bodies or corporations, and unless what may be termed outsiders hear a little of what is on, it is unlikely that they will turn their attention to improvements.

That an improvement on the type of cable employed on the Atlantic in 1865 and 1866, and which is known among engineers as "Atlantic type," is required is proved by the fact that these cables had only lives of about 8½ years, and if cables will only last that time, even 10 per cent. dividends will not pay for them, whereas most cables at present only pay about 6 or 7 per cent.

The type we allude to consists in ten homogeneous iron wires, each separately surrounded with strands of Manila hemp, as the mechanical structure round the jute covered core. This type of cable when new is, of course, excellent for the process of laying. It has a low specific gravity and great friction from the roughness of the Manila hemp, and can consequently be laid with a given amount of slack with a very small strain during the operation of paying out. But as regard its durability it has little to recommend it. The wires being separated allow insects easily to enter. The hemp rots and the iron rusts away. The 1873 and 1874 cables had a little hemp and pitch and silica laid on round the whole, and have thus an additional protection, but the coating was meager.

The cable laid by Messrs. Siemens last year, we believe, consists of homogeneous iron wires touching one another, thus returning to what has been known as the Mediterranean type of cable, the iron being protected from rust by two coatings of yarn, pitch, and silica round the whole cable.

The cable laid this year by the Telegraph Construction Company has ten homogeneous iron wires, each covered with a thick coating of preservative compound called Clifford's compound, the composition of which is kept secret, and these are each separately further covered with tape. Between each wire a strand of hemp is placed. The whole cable thus formed has two layers of tape and pitch compound outside all. The mode of combining hemp and iron alternately round the core has been before largely adopted by the Telegraph Construction Company, and was first, we believe, employed on the cable between Sydney and New Zealand. We do not know what advantages are claimed for this plan, but it would appear to us to be principally a mode of saving first cost by substituting hemp for iron at the expense of durability. It does not seem possible that the hemp can take any strain properly with the iron, and when the cable gets old, we should think the hemp would not keep the wires in place when the cable is being strained or bent about in repairs so well as hemp round each wire. It is cheap, and that is all that can be said for it. The strong outer coating of tape and pitch no doubt keeps the wires in place when the cable is new, but we should look to what will be the state of the cable when this outside coating of hemp is gone. When the hemp has perished considerably it seems clear that the wires, with wide spaces between them like a bird cage, will not in the least fulfill the conditions of a wire rope, and we shall be very much astonished if after a few years of experience at repairing, this type of cable, with alternate wire and hemp, is not abandoned as a mistake. The attempt to preserve each wire with a compound, whatever it may be, is a step in the right direction. Gutta percha applied in the ordinary way round wires for protection was proposed and patented by Mr. Samuel Statham in 1857. We do not know what Clifford's compound is, but we doubt whether it is better than gutta percha, though perhaps much cheaper.

As regards the process of paying out there was one novelty in the Siemens expedition which we will describe. It is necessary, in order to distribute the slack of a cable uniformly or in such places as the engineer may decide on, to know at every half hour the exact position of the ship over the ground. To do this by observations even in fine weather is only possible once every twenty-four hours, and when the sky is overcast not even then. Dead reckoning is not to be trusted on account of currents. The following plan was adopted therefore, and forms one of the latest novelties in cable laying: a steel pianoforte wire was paid out throughout all the deep water passage with sufficient tension to insure its being laid without any slack, and thus the distance actually run was measured and known at every minute. The wire was, we believe, in 50 mile lengths on drums, and the lengths were rapidly joined by a hook joint.

In paying out the Anglo-American cable this year two ships were employed, the Scotia and Seine, and when the Scotia had nearly finished paying out her length, the cable was made fast to a buoy at some fathoms from the end, the stray quantity being coiled into a lifeboat, and the end thus handed to the bows of the Seine. We believe that in laying the Siemens cable last year there was a similar change from the Faraday to the Pouyer-Quertier.

It seems a pity that these operations are not published in detail, as they both no doubt reflect credit on those who have conducted them, and would be of great interest to all who follow up the important question of Atlantic telegraphy.

The laying of the Siemens cable, we believe, was under the superintendence of Mr. Loeffler, assisted by Mr. Brittle, Mr. Jacobs being the chief electrician. The cable laid this year by the Telegraph Construction Company was under the charge of Captain Halpin, assisted by Mr. London, Mr. Laws being the chief electrician. Captains Cato and Manning commanded the two ships.—*Engineering.*

120 Electrician July 31. 1880

NEW SUBMARINE CABLES.

Electrician July 31 1880 27

The India Rubber, Gutta Percha, and Telegraph Works Company have contracted to lay a cable between Marseilles and Algiers for the French Government during the present year. This will make the third cable the above firm will have made for the French Government for this route. The cable will be similar in pattern to that laid last year, the sheathing of the deep sea being 15 No. 13 homogeneous iron wires, with two tapes and compound. The length will be 500 miles of deep sea, 9 miles of intermediate and 16 miles of shore end, making a total of 525 miles, or 35 miles longer than the cable of last year. The steam ship Dacia belonging to the company is having water ballast tanks placed in her below her cable tanks. She will be employed in laying the Algiers cable. The operation of laying the cable will be conducted under the superintendence of Mr. R. K. Gray, the engineer of the company. The expedition will leave about the middle of September. A staff of French Government engineers test the cable every day at the works.

The same company are making the following cables for the Canadian Government:—Island of Anticosti to Griffins Cove, 2 miles shore end and 42 miles main cable—total, 44 miles. Prince Edward Island to the Magdalen Islands 4 miles shore end, 47 miles of main cable—total, 51 miles. Grosse Island to Bird Rocks, 4 miles shore and 15 miles main cable—total, 19 miles. Island of Grand Manin to Mainland (Maine) shore end 2 miles, main cable 9 miles—total, 11 miles, making a total of 12 miles of shore end and 113 miles of main cable.

These cables will be laid from the Dominion screw steamer Newfield, Captain Guilford. This steamer, belonging to the Dominion of Canada Government, is employed on the lighthouse and buoyage service in a similar capacity to our Trinity buoy boats. She will, however, be employed also to repair and maintain the cables, and for this purpose is being fitted at Silvertown with two iron tanks to receive the cable, and with bow and stern sheaves, with a machine for picking up and paying out cable, the one machine being constructed so as to perform both duties. Mr. F. N. Gisborne, C.E., has charge of the testing and laying of the cable and fitting of the ship on the part of the Canadian Government.

Mining Press Aug 21 1880

PROPOSED OCEAN TELEPHONE.—A Cincinnati company, says the *Iron Age*, is negotiating with the cable companies for the lease of a line for eight days for the purpose of testing experiments for telephonic communication with Europe. It is believed that the new French line will be secured. The arrangements, it is thought, will be completed in a few days. The process upon which the proposed work is to be done is based upon the Grangbough invention of 1868 and the recent Klemm patents. The tests will be made from New York city. Only the combination of the two systems mentioned will be tested, to the exclusion of the Bell, the Edison or any of the instruments now in active use, as the new company claim that they are actually infringing.

THE SS. Dacia, belonging to the India-rubber, Gutta-percha, and Telegraph Works Company, is now in the Mediterranean, employed in laying a third cable for the French Government between Marseilles and Algiers. The ship carries two electric lights, the current being supplied by two Gramme machines, worked by two separate engines. These lights light the deck for paying out, picking up, and sounding. Regnier lamps are carried for lighting the tanks. A sounding wire apparatus, with improved self-adjusting brake, is fixed permanently at the taffrail, on the starboard side, the cable stern sheave being on the port side. The machine is driven by a small engine fixed close to it, and connected by driving wheels with vulcanised india-rubber tires. The ship carries a buoy containing tanks filled with gas and carrying a lamp. Electric signals are fitted from bow, stern, and bridge to the engine room and helm, and there is a system of electric bells between all the cabins, chart rooms, deck-houses and saloon, to the stewards' pantry. 27 Engineering Oct 1 1880

27 Electrician Sept 4 1880

CENTRAL AMERICAN CABLES.—We hear that the Central American Telegraph Company intend to repair and put in working order their two disabled cables between Para on the Amazon and Cayenne (French Guiana), and between Cayenne and Georgetown (Demerara). These cables have long been out of use; but as they serve to connect the Western Brazilian Coast cables from Rio Janeiro to Para with the West India and Panama Company's cables from Demerara to Jamaica and Key West, they are important links in the chain of South American lines. The repairs will probably be undertaken by the ss. *Norseman* belonging to the Western Brazilian Company, and the electrician engaged for the work is, we hear, Mr. W. S. Seaton, late of the electrical staff of Sir William Thomson and Professor Fleeming Jenkin.

Electrician Sept 4 1880

CABLES.—In another column we give an article which appeared in a Boston contemporary. We have reason to believe that there is little new in Mr. Charles Work. At any rate, Mackintosh many years ago patented a method of having a relay in mid-ocean, whilst a few years ago Mr. FitzGerald patented an invention having for its object the increase of speed in cable signalling, and recently Mr. Blarney has obtained a patent for a somewhat similar object.

Scientific Amer Oct 9 1880

ELECTRICITY.

Scientific American Oct 9 1880

ST. JOHN, N. B., Sept. 14.—T. S. Gisborne, Superintendent of Government Telegraphs, has arrived here, and made arrangements for laying a cable from Grand Manan to the American coast. The cable will probably be laid from Long's Eddy to Liberty Cove, on Campobello; thence from Welchpool to Eastport, the whole distance being eight and a half miles. 27

Electrician Oct 2 1880

27 THE ELECTRICAL MACHINE IN TELEGRAPHY.—The state of the atmosphere it is well known has a very great effect on the conditions for the electrification of the ink by the "Mouse Mill," in the Thomson recorder, and at most stations where it is used this is more or less felt. At Portheurnow, the Eastern Company's station in England, where the damp fogs come up from the Atlantic, and saturate everything, causing the electricity to disperse, instead of being concentrated to the ink well, the trouble is sometimes very great. A lamp burning near is not effective. An electrical machine has been tried, a wire from the collector brought to the plate leading to the ink well, and it was found that a good and constant supply can be obtained, which causes the ink to flow well. Of course it necessitates labour to turn the machine, but this is compensated for by the fact that if the mirror were used this would also entail a writer, so that a greater number are not employed, and it does not generally last more than an hour or so.

THE MARSEILLE-BONA CABLE.—*L'Electricité* observes that, although the new cable between France and Algeria is termed "the third cable," there are already three cables, in tolerably good condition, uniting these countries. Of these two, between Marseille and Algiers, belong to France; the first cable laid, that between Marseille and Bona, belongs to England, and is exclusively reserved for the transmission of despatches between Great Britain and Malta, Egypt, or India. Originally, this cable was used only for messages between France and Algeria. Electrician Oct 9 1880

THE THIRD MARSEILLE-ALGIERS CABLE.—It appears that this cable has been laid between the two others; and *l'Electricité* urges that this position is an inconvenient one, and likely to lead to accident. On the occasion of the laying of the second cable, the buoyed end became detached; and, in dragging for it, the first cable was caught and broken, so that for some days the communication with Algeria was entirely interrupted. It was then found that the first cable had been shifted several miles by the action of currents; and our *confrère* apprehends that similar complications may arise in future. 27

121

13

THE UNDERGROUND TELEGRAPH IN VIENNA.—The cable, made by Messrs. Rattier and Co. of Paris, consists of a strand of seven copper wires 0·6 mm. in diameter, surrounded by a gutta percha covering 5 mm. external diameter, with a coating of tarred cotton-wool yarn. Seven of these cores form one cable, and protected with—1st, a tarred woollen ribbon; 2nd, a tarred hemp covering, dipped previously in a solution of sulphate of copper; 3rd, a second tarred woollen ribbon. Each core has a conductivity from 91 to 98 per cent. of that of pure copper, an insulation from 1,100 to 3,000 megohms per kilometre at 20° C., and a capacity 0·21 to 0·25 microfarads per kilometre. The weight of each core is, according to the contract, within 5 per cent. of 390 kilometres per kilometre. The tar was quite free from acid, but the hemp covering was slightly acid from being dipped in the copper sulphate solution. The cable was made in lengths of 500 metres, and laid at a depth of 1·3 metres in a box of red larch-wood, several such cables being stretched in the box, and separated from one another by a mixture of one part of Beocsimer cement and two parts of sand. Where the cable crossed the Franzensketten bridge, the wires, to avoid damage from the vibration, were not stretched tight, but laid simply in a layer of sifted coal ashes placed in the box. A channel 0·8 m. wide and about 1·4 m. deep was dug for the wires to lie in, and the bottom made quite smooth; the depth, 1·4 m., being always followed except when gas

pipes, &c., had to be avoided. The boxes in which the wires were laid were from 3 to 5 m. long. The cable, containing seven distinct conductors, cost about £112 per kilometre, and the complete cost of making and laying £4,202 kilometres of subterranean line containing 33,431 kilometres of cable was about £5,500.—Abstract of a paper by M. Zelli, in *Electrotechnische Zeitschrift*, in *Jnl. Soc. Tel. Eng.*

~~Scientific Amer~~ Sept 25 1880 27

Scientific Amer Sept 25 1880

PERHAPS the most remarkable operation hitherto recorded in the history of submarine telegraphy is that which has just attended the work of the Eastern Telegraph Company's ss. Chiltern. In 1870 a cable was laid running off the coast of Portugal in 2,000 fathoms of water, and recently persevering efforts have been made to grapple and raise this old cable. The general idea is that a cable after so long an immersion is rotten, and cannot be raised from such immense depths, but this success will do much to dispel these ideas. The cable has been successfully grappled and raised, and was found to be as good and as strong as when laid ten years ago. To grapple a mere thread in 12,000 ft. of water may well be termed a triumph, and great credit is due to the perseverance of the company, and the ability shown by Captain Goodsall and the chief electrician, Mr. Phillips.

Nature March 17 1881 27

THE work of laying subterranean cables is proceeding favourably from Nancy to Paris. This telegraph line is composed of twelve insulated wires placed in a large tube of cast iron. For each length of 500 metres doors have been arranged so that any section can be removed and replaced without having to open the ground, which is necessary in the German system of laying the cables in a solid bed of asphalte.

Mfg & Builder Sept 1880

Manufacturer & Builder Sept 1880

How Long a Telegraph Cable Lasts.

The life of a submarine telegraph cable is from ten to twelve years. If a cable breaks in deep water after it is ten years of age, it cannot be lifted for repairs, as it will break of its own weight, and the cable companies are compelled to put aside a large reserve fund in order that they may be prepared to replace their cables every ten years. The action of the sea-water eats the iron wire completely away, and it crumbles into dust, while the core of the cable may be perfect. The breakages of cables are very costly, and it is a very difficult matter to repair them in comparison with land lines. A ship has to be chartered at an expense of $500 a day for two or three weeks in fixing the locality and in avoiding bad weather, as cables can only be repaired in the calmest seasons. One break alone in the Direct Company's cable cost $100,000 to repair, and the last chance left to the company was to make an agreement with the Anglo-American, so that they should be protected and have the use of that company's line when their own was stopped.

Herald Aug 4. 1882.

Put the Wires Under Ground.

The successful laying under ground of the wires connecting the Central Office and Firemen's Hall is important in several respects. In the first place it affords an additional source of safety to the public—to life and property—and in the second it shows that the commercial telegraph companies can, if they choose, do away with the unsightly poles which disfigure so many of our leading streets and avenues. The only question involved is really one of expense, and as long as the companies are allowed to save money in this way so long will they continue to disfigure the streets. Even Washington is ahead of New York in this respect. Her authorities have put a stop to the erection of poles, compelling a company, which was recently given the right of way through the city, to carry their wires through the sewers. This is practicable in this city above Fourteenth street—at least so the Commissioner of Public Works says. We shall, of course, never have a reform until a stringent law is passed on the subject; but considering that the companies as a rule make the statutes to govern themselves the question is, How shall we get the law?

JOURNAL OF THE T...

VOL. XIII. NEW YORK, NOVEMBE...

27

Original Articles.

ATMOSPHERIC ELECTRICITY.

By DAVID FLANERY.

PROF. KIRCHHOFF relates two other cases of disruptive discharge, one where the lightning jumped from a rod across an air space of eighty metres to a water-pipe which it burst, by the mechanical effect of the stroke; the other in which the lightning followed the rod down into the earth and sprang to a gas-pipe a metre distant, damaging it considerably, owing, as he says, to the fact that the joints of the pipe were packed with hemp and tar instead of the usual lead. Father Secchi described similar accidents some years ago, and arrived at like conclusions, so the professor's idea is in accord with other distinguished scientists.

Consider the Stralsund church and these two cases together. If the generally accepted fact that the resistance of the earth in the telegraphic circuit is about 12[illegible] ohms be true, remembering that in overcoming resistance sparks do not follow Ohm's law, and not forgetting that they do follow the law of potential, how can one explain the passing of a spark through such spaces, the smaller of which has an infinite resistance, when that of the rod and earth circuit is so small? It seems more reasonable to think that the action was the reverse of that stated, as may appear from what follows; that the pipes conducted the electricity to the church, and more of it than the rod was able to discharge by its points, and hence the lateral strokes and damage. This view is supported by the well-known fact, stated by Prof. Kirchhoff, that the point whence electricity springs suffers most injury. The pipes were injured in both cases, nothing is said of damage to the rods.

There is another consideration: telegraphers know that there is great derangement of apparatus, more flashing and melting of lightning arresters when the storm is two or three miles off, than when it is actually overhead, and that the ground plate of the arrester often shows stronger marks of discharge than the line plate. If all strokes were from the clouds then, when the storm is overhead, we should, before the electricity has an opportunity to be diffused through the earth, receive most damage; but this is not our experience.

Furthermore, granting that all the discharges are from the clouds, what becomes of the electricity after it enters the earth? The reservoir theory is here suggested. But is the earth as a reservoir for electricity any way different from the ocean as a reservoir of water? Immense volumes of water are poured into the ocean daily, but it does not appear to increase, for evaporation on an equally great scale is going on at all times, and thus, what came from the atmosphere at one place goes back to it at another. So equilibrium is maintained, and so there is no more water or vapor in the world to-day than there was at creation. Does electricity move in a similar way, or is it dissipated in the earth... the question, what is electricity?... given an answer to that question al... dency of the day, however, is to r... tion of the luminiferous ether (Se... ture," by the Duke of Argyll, *Scie*... this as it may, let electricity be wh... certain that it cannot be created or... we know that it is not its nature to re... in excess at any one place, but that i... itself equally as far as possible, and... nature of surrounding bodies will p... not set up a positive tension und... stances without an opposite negative... panying it; and move the positive... will, the negative follows it, and soon... will inevitably come together, silently... Therefore, if the earth is a reservoir... is one only in the sense in which th... that is, it is constantly receiving and... tricity according to a law of nature, b... upon the whole is always the same.... when there is a discharge from the cl... tricity is distributed in some fashion... or, in another view, following the pa... sistance, the gas and water pipes... reaching a point of low potential, arik... its own descent, returns as best it m... tive. That it does this and restores t... sooner or later is not questioned; the... stantaneously I may be able to show.

Since the time of Franklin there... doubt of the identity of atmospheric e... that produced by galvanism, frictio... there is no difference between them,... urally the same, then we may reason... move according to the same laws.... JOURNAL OF THE TELEGRAPH may... views on the reservoir theory, partic... ence to the telegraphic circuit, which... that no electricity was transferred thro... from one ground-plate to another or th... into it at one point unless an equal... simultaneously taken from it elsewhere... has received the support of Count d... others. I am not, therefore, advanc... theory, but only developing one that... distinguished approval, and that is in... the well known laws deduced from... frictional machines, in saying that no... atmospheric electricity is set up unt... circuit is established; that lightning d... from the clouds until it has selected its... This, furthermore, is a reasonable co... everything in nature is governed by l... happens by chance.

But in either view of the reservoir... from what precedes, it appears that... scending by a rod connected with... pipes, which, being better conducto... earth, will follow them in their course in...

pany to join the Old World and the ... in communication, by means of a ca... lantic. After troubles which would... earnest men from the work, capit... and a cable made. On the 5th of ... operation of laying commenced; ... 335 nautical miles had been paid on... in 2,000 fathoms of water, and the ... time failed. The next year, howe... laid, and worked for 25 days, carr... period messages amounting in the... words. The loss represented £41... and new shares. The ardor of inve... and matters dragged on till 1864, ... tions of men at the present time ... positions in the domain of subm... more capital was forthcoming. ... made, another cable manufacture... made to lay it in 1865, but on Au... broke in 2,000 fathoms of water. ... ed, but for the time unsuccessful, ... to recover the cable. This was th... bly, that any endeavor had been ... cable from deep water. The reco... shallow water was an operation ... rence. To raise a cable from 2,00... cult, dangerous and, even when ... undertaking.

It will be best in the first plac... lize what is required to be raised... tion of the 1865 cable weighed 3... It had a breaking strain of 7·35 ... ter of 1·1 in. Fancy groping at ... that is 12,000ft.—below the sur... rope a little more than 1in. in ... thing to be done was to catch ... task by no means easy to t... This they accomplished. W... caught the cable, disaster follo... way, cable, rope, and grapnel g... Again and yet again, with cour... the operators sought to raise th... ond, third, and fourth breakag... tackle, and left them with no ... attempt. Another cable was m... known, was successfully laid in... fully laying this cable, the *Gre*... ed by Captain, now Sir James... ed to renew the attempt to re... If ever a writer requires to po... ple of perseverance, he cannot... count the work performed in t... ations commenced on August ... ber 2nd the cable was raised, ... perfect. The cable was spli... the American shore.

We have thus briefly referre... tory of cable grappling in dee... of the pioneers of 1866 was wor... the sanguine opinions previ... the possibility of such work... random; it also proved that i... spair because an accident hap... sea cable. The work of raisin... be arduous and costly, but ... This proof was of the utmost ... terests of submarine telegrap... feared total loss, and since 18... lions above referred to has ... work The apparatus used ... say crude and hardly adequat... called upon to do, or shall we ... worthy? Since then the pickin... board regular cable ships, su... tern Telegraph Company, or... struction and Maintenance C...

27 Tel. Jour. Nov. 15 1880

FAST SPEED WORKING ON CABLES.

Telegraphic Journal

PERHAPS at the present time no field of invention offers to electricians so rich a prize as that of submarine telegraphy. It is well known that the duration of a cable in good working condition is comparatively brief. It follows, therefore, as a matter of necessity that the profit on the large capital outlay, entailed in laying a cable, and the requisite reserve fund, be secured during a short period varying from ten to possibly twenty years. Now the carrying power of a submarine line being limited (although, thanks to the ingenuity of Mr. Stearns and the Messrs. Muirhead, less so than formerly), it follows that while the above conditions last, the tariffs must remain quite up to the existing rates if they are to be at all profitable.

It is, however, a matter well worth consideration whether the carrying power of cables cannot be increased by the employment of a quadruplex or multiplex system, or by the employment of automatic fast speed apparatus. The latter seems the more likely field for successful invention, and although we believe something has been attempted in this direction, no success has been attained as yet. The idea of the new American Cable Company recently organised in New York, to submerge a translator or repeater in mid ocean, is undoubtedly a correct one, but the practical feasibility of the project is more than open to question. It is hardly too much to say that no piece of mechanism has ever yet been devised which can be trusted to work with certainty to an indefinite period without human supervision. As is well known, the cause of the retardation of signals in submarine cables is the inductive effect, which causes the cable to hold a charge which has to be got rid of after each signal has been sent and before another can be transmitted. Could some arrangement be devised by which this charge can be "wiped out" at *both* ends of the cable simultaneously, a great advance would be made towards solving the problem of fast speed submarine telegraphy. It seems to us that there is considerable scope for invention in this direction.

Scientif Amer. June 25 1881.

Telegraph Cables in Sewers.

An important experiment looking to the disuse of telegraph poles in cities is being made in Washington, D. C., by the Mutual Union Telegraph Company. Having received permission to run their wires through the common sewers of the city the company began the work of placing the wires June 6. The wires which are needed for the city service and for connection with lines outside the city are twisted cable form and covered with a non conductor and waterproof coating. Outside the city limits these wires emerge from the sewers and join those placed upon poles. The cable made of the twisted wires is attached firmly to the arched roof or top of the sewer, and thus raised above all interference from water, except in case of floods. The cables are laid by men enveloped in rubber clothing and provided with safety lanterns, provision being made for conducting fresh air to the workmen by means of India-rubber tubes attached to their rubber suits. The wires are passed down through the man holes of the sewers.

Jour. Tel Oct 1 1880

Journal of ~~Telegraph~~ Oct 1 1880

The Marvels of the Telephone.—The Telephone discovering Faults in Submarine Cables.

[From *L'Electricite*].

WE have received from a correspondent in India the description of a truly marvellous experiment, to which we cannot too earnestly direct the attention of our readers. The original idea belongs to Mr. Allen, assistant to Mr. Schwendler, the skillful director of the Anglo-Indian system; but the application of it has been made by Mr. W. P. Johnston, employed in the active service.

The officers of a telegraph ship having to repair a submarine cable, belonging to a line which possessed several cables, found themselves very much embarrassed to choose the faulty one. They had, in fact, raised one, but the question arose was it the one to be repaired, or was it one of those which were in a good state of repair.

The solution of a problem which seems completely beyond our means of scientific investigation has been made in an unexpected manner by Mr. Johnston. It is known that the submarine cables are surrounded by an iron wire rolled in spiral form, which serves to protect the conductor of copper, from which it is separated by one or more envelopes of gutta-percha. A length of about 12 yards of the cable having been hoisted on board, Mr. W. P. Johnston attached one extremity of the wires from a telephone to the armor at each one of the ends of that section, and listened attentively to the sounds produced. Every time that the conducting wire of the submarine cable was used to send a signal, the iron wire was traversed by an induced current, of which a portion, passing by the derived circuit of the telephone, caused a movement of the diaphragm. Thus the signals sent inside were repeated on the outside of the cable. It was then incontestable that the submarine cable wire, whose length was 442 miles, worked very well and needed no repairs. But what was more valuable than this fact was a discovery in physics which was made at the same time and in a manner entirely unexpected.

The force of the derived current was augmented in proportion as the points of contact between the telephone wires and the cable armor were brought nearer together. At a distance of two yards, the sounds were quite distinct.

We will add the numerical data sufficient for judging of the conditions of an experiment, which contain, perhaps, the germ of an indefinite progress.

The circuit of the telephone had a resistance of 2¼ ohms.

The copper conductor of the cable had a resistance of 23 ohms.

The armor of the cable was composed of 12 wires of galvanized iron weighing 924 lbs. per mile. The resistance of each wire being 7 ohms, that of the whole number was 7¼ ohms.

The resistance of the 2 yards of wire sufficient to give a current was then 0.66 milliohms, or 1-3800 of the resistance offered by the circuit.

It therefore follows that, to be heard in the telephone, only 1-3800 of the derived current produced by the primary current passing over the conductor in the cable is required.

The exterior currents, whose existence is thus revealed in an iron wire plunged in the bosom of the ocean, are they not susceptible of other applications more useful? May we not hope that some day cables may be worked without insulation? It is a question that we content ourselves with placing before practical telegraphers, and to which we shall probably not have to wait long for a response. But we doubt that in the number of marvels related of the telephone there will be found any more surprising than the above.

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CORRESPONDENCE.

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VAN CHOATE'S NEW CABLE SCHEME.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of Oct. 23 you devote a leader to the criticism of certain propositions made, as to the working of submarine cables, by Mr. S. F. Van Choate. That article is, permit me to say, not characterised by the usual good judgment attending the statement of facts from the editorial sanctum; for the reason that only half the truth is given.

In the first place, perhaps I owe an apology for bringing myself into the question, but I feel that as one of the reporters on the performances of Mr. Van Choate's instruments, and as a frequent contributor to the columns of your journal, I should not allow erroneous opinions to pass current.

Your editorial speaks of two patents as to the division in length of long submarine cables, one by Macintosh, the other by FitzGerald, as interfering with Van Choate's claims in this subject. Unfortunately for these inventors, Van Choate's patents for the division of a cable (as far as division is alone concerned) antedate theirs; in fact, he, and neither of the others, ranks as the first inventor.

Even were this not the fact, Van Choate's more recent inventions are not affected by either of the patents in court. First, Macintosh distinctly refers to a local battery of sufficient constancy, enclosed in a proper manner, as being sunk into the ocean. A suitable battery, it is scarcely needed to tell your readers, has yet to be invented. Van Choate's relay needs no local battery *in situ*; his relay is altogether of another order to that indicated by Macintosh.

FitzGerald's scheme certainly employs a common feature with that of Van Choate's instrument, namely, an electro-magnet; but unless FitzGerald wants to raise a Page-patent dispute in England such as has disgraced this country, I fear his claim would be untenable. Further, FitzGerald and Van Choate's inventions are entirely dissimilar, because the action of the primary circuit in FitzGerald's scheme does not call upon any fresh source of power in the secondary circuit, as does Van Choate's, for which reason Van Choate's invention must consistently have greater power at disposal. Again, FitzGerald must lose in power on his secondary circuit by the amount or value of the coefficient of induction between his primary and secondary circuits. Now, for the weak currents used in telegraphy, and especially in submarine telegraphy (and with the large soft iron cores necessarily attending FitzGerald's plan, which cores can never even approximate saturation), this coefficient will be only a very small fraction of unity, reducing as multiplier the efficiency of such a system of signalling to very low limits. In Van Choate's system, on the contrary, the received signals may be considerably stronger than those sent.

But Van Choate's invention does not alone depend on submerged relay. It embraces a type-printing system, based, as regards its signals, on a very careful study of the phenomena of induction as indicated by Sir W. Thomson in his well-known investigations. It is sufficient for this letter to say that this system works perfectly on an artificial cable we have here; this cable is of 772 microfarads capacity, and of 4,000 ohms' resistance, with an insulation of about 2 megohms. So, under these conditions, we have every reason to believe that there is a great step made in these matters by an American inventor.

Your criticism as to the small attention given to submarine cable working by the many professors who have seen these instruments I am obliged to notice, because I thought that the claims advanced by so-called "cable-doctors," who, when a poor cable is broken down, tell its symptoms by some unwritten laws of sympathy, were long ago exploded. The phenomena of cable induction are well enough known to those who have a practical laboratory training, or are so easily perceived that it would be farcical on this ground to say that such men as Barker, Dolbear, and especially Trowbridge were incompetent judges because they had not served apprenticeship on board a cable vessel, or in a cable factory.

I do not consider myself at liberty to give unauthorised a more detailed answer to your criticisms, but I shall be pleased at an early date to place before your readers the particulars of this invention. It may be said that Mr. S. F. Van Choate is well known on this side the Atlantic as a telegraph engineer, who has constructed and successfully financed some of the longest lines on this Continent.

My former experience with those in this mundane sphere who make the construction of electric spheres (and cylinders) their business is not so glowing as to warrant that I should blindly tack my faith to any invention or inventor, but in this instance (as you have favoured me by excepting me from the roll of ignoramuses in submarine telegraphy) I have no fear in asserting my full belief in all that the talented and scrupulous investigators have said about Mr. Van Choate's system.—Yours, &c.,

PAGET HIGGS.

Offices of the American Cable Company of New York,
Boston, Nov. 10, 1880.

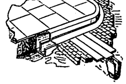
The Electrician, June 11, 1881.

ABSTRACTS OF SPECIFICATIONS.

39. STREET CURBS AND GUTTERS FOR THE RECEPTION OF TELEGRAPH WIRES, *H. J. Haddan.—Dated 4th January, 1881.—(A communication from J. D. Townsend).—(Complete.)* 4d.

This relates to a conduit for telegraph and other conductors, consisting of a flanged case or chamber forming a street curb, a parallel flanged chamber forming the gutter, the chamber being suitably connected together at the side and ends, and covered with a removable cover forming a step and gutter piece for the curb and gutter.

59



CABLE-LAYING IN GUIANA.

BY J. MUNRO, C.E.

On the 27th of May, 1874, the telegraph ship "Hooper" arrived off the Para mouth of the Amazon River with a cargo of submarine cable on board. It was a time of extraordinary activity in cable-laying; and in the two preceding years the "Hooper" had laid cables all along the coast of Brazil from Para to Rio de Janeiro. Her present mission was to link Para, the capital of Brazilian Guiana, to Cayenne and Demerara by cable, and thus to connect the Brazilian cables to those of the West Indies and the United States. It was a trip, as it afterwards turned out, fuller of incident, perhaps, than any other cable expedition except the first Atlantic.

The "Hooper" is a large vessel of over 5,000 tons burthen, built expressly for the work. It had been the practice hitherto to take an ordinary steamer and fit her out with cable-tanks, testing-room, and laying machinery in the best manner possible; but the "Hooper" was the first ship specially built for cable-laying, as the "Faraday," of Messrs. Siemens Brothers was the next. She belonged to Messrs. Hooper and Co., the india rubber cable manufacturers, of Millwall, and the cables she carried were manufactured by them for the Western and Brazilian Telegraph Company, after the designs of Sir William Thomson and Professor Fleeming Jenkin, the company's engineers.

Her crew, like the crew of every telegraph ship, consisted of the captain, officers, and seamen for navigating the ship, the cable engineers and "cable hands" for attending to the mechanical operation of laying, and the electricians engaged in making the electrical tests of the cable. The captain, the cable engineers, and the electricians, inhabited the saloon, while the officers of the ship occupied the mess room, and the cable hands shared the fo'castle with the sailors, not, however, without a good deal of jealousy and grumbling on the part of Jack.

There is generally very little doing on a telegraph ship during the outward voyage. The real work of the expedition only begins with the laying. We whiled away the time in novel-reading, in writing essays for our "Literary and Scientific" Society, or in after-dinner talk on the quarter-deck at sunset. The saloon passengers of a cable ship are generally men of the much-wandering Ulysses type, men who have laid cables or put up land-lines in various quarters of the world, and who have their scraps of romance and adventure to reveal. It was pleasant as the sun went down, and fired the golden west before us, to sit and smoke on deck, and listen to snatches of real experience, instructive, exciting, humorous, pathetic, sometimes even poetical, and always interesting—tales of blockade running, of Australian exploration, of camping out in Persia or the Cape, recollections of Garibaldi's expedition or the Indian Mutiny, reminiscences of Venice, Cairo, Hong Kong, or Stamboul, interspersed with many useful "wrinkles," curious facts, and accounts of marvellous natural phenomena. There was a good deal of banter and repartee, too, and discussion of all manner of themes, as well as anecdotes upon all subjects.

We had amongst us a representative of the first Atlantic cable expedition, who bore a prestige something similar to that of a survivor of the Balaklava charge, and who loved nothing better than to find himself the centre of a circle of admiring hearers. It was his custom then to favour us with some select morsels from the unwritten history of that great undertaking. He was wont to tell us of the wonderful coolness of Sir Samuel Canning, the engineer of the expedition, who at that disastrous moment when the end of the cable parted at the stern of the ship, to vanish into the Atlantic, turned quietly to our storyteller, and simply said, "Have you got the time, Mr. B." We were never tired of hearing, too, of that critical time on board the "Niagara," when the "continuity" signals from the "Agamemnon" failed, and it was feared that the cable was broken between the two ships. There was an anxious gathering of the scientific chiefs in the little testing cabin, where the end of the cable was connected up to the galvanometer for testing. It was like a surgical consultation over some fatal accident. Professor Thomson, seemingly overpowered by the thought of failure, kept his eyes rivetted with a half-despairing look on the mirror of the testing instrument, as one watches for a last breath from the lips of a dying man; Mr. Bright stood by, biting his nails as if he were bewildered; Mr. Canning was grave, but self-possessed; the captain, from behind, dubiously watched the testing, while the sailors crowded round the door and peered over each other's shoulders with confused and wondering faces. After some minutes of painful suspense a feeble quiver of the needle was observed, and this death-bed scene was turned to one of almost frantic joy—the cable was sound!

When we left Gravesend on May-day, the nightingales were singing in the Kentish lanes, and the meadows were speckled with daisies. We halted a few days at the superb island of Madeira, with its vine-clad terraces and violet atmosphere; then, after a run of a fortnight over the deep blue of the Central Atlantic, and through, perhaps, the purest atmosphere on earth, we entered the dull bottle green waters off the Amazon mouth, and could distinguish the dark fringe of the immense primæval forest which shrouds the valley of the great river up to the foot of the Andes. Dull green and savage near at hand it was broken up into clumps of trees by the mirage of the tremulous heated air, and gradually dwindled away into the distance.

Off the Indian fishing village of Collares, whose red-tiled roofs nestle at the roots of the lofty forest, we took on board a pilot from the lightship, and proceeded up the Para, or southern mouth of the river, towards the city of Para, which is situated seventy-five miles from the mouth, and is the only port for the vast and inestimably rich and fertile plains of the Amazon.

It was a burning tropic day, and, as is usual in this equatorial region, there was thunder in the air. All around rolled the brimming yellow flood of the river full up to the dense wall of forest on the left, and the shaggy Eden-like islands on the right. Down its rapid tide many waifs from the interior, cedar logs, dyed reeds, and broken lillies were floated past. The sun streamed down his vertical rays, and sultry clouds hung about the horizon. Close under the main bank of the river where the water appeared cool, smooth and glassy, we could see by our glasses the canoes of native fishermen gliding under the towering forest like tiny paper skiffs, the red brown skins of the half naked Indians contrasting savagely with the dull green of the tropical foliage.

Nature here is on a wild and magnificent scale. At its mouth the Para river, as the southern branch of the Amazon is called, is thirty-six miles wide; at the City of Para it is still twenty miles wide, but the channel becomes so filled up with islands below and above Para that the river there appears only a few miles broad. These islands, which have originally sprung up out of sand banks, are virgin wildernesses treacherously beautiful, and sometimes so overgrown with vegetation as to resemble a tangled hop garden.

In the evening, while the setting sun from behind the western forest filled the broad river scene with his rich golden lustre, we came to anchor in front of Para between the city and the islands, out in mid-stream. Para stands on a small promontory of low land jutting into the river. It is a chimneyless tropic town, with flat, red-tiled roofs, and whitewashed walls, interspersed with the glittering crests of palm trees, and the luxuriant foliage of the bread-fruit, while here and there rise the ornate towers and cupolas of some grey Portuguese convent or cathedral. All behind, the primæval forest hems it in, ever ready to encroach and regain its lost ground. The anchorage in front was full of native craft, manned by Indians and negroes, American schooners with flour from Boston, European ships lading rubber and Brazil nuts, indigo, and cacao, and the white and scarlet river steamers of the Amazon Company, which ply between Para and Manaos at the mouth of the Rio Negro 800 miles up stream, and carry down the produce of the interior, cinchona, indigo, sugar, cashass (rum) in exchange for jerked beef from the island of Marajo, clothing and provisions.

On board the "Hooper" we now began to make arrangements for laying the cable. The salt water which had been allowed to soak the cable during the voyage was now pumped out of the cable tanks, leaving the cable in a damp coil at the bottom of each. Some "faults" or flaws in the insulator, which had developed themselves in the hot atmosphere of the tropics, had to be cut out, and the pieces of cable to be laid had to be made up into one length.

A submarine cable, as is well known, consists of a stranded copper wire or conductor enveloped in a thick skin of gutta percha, india rubber, or some other insulating material. The wire conducts the electric current, and the insulator confines the current to the wire, or, what comes to the same thing, prevents it from escaping to the sea water, or "earth," as it is called. The wire and insulator form the "core" or part of a cable essential to the transmission of the electric current, but in order to guard the core from mishap and to render it strong enough to bear the strain of laying and repairing operations, it has to be strengthened by an outer sheathing of tarred hemp and galvanised iron wires. The shore portion of a cable being that most liable to mishap from anchors, storm-waves, or boulders, it is usual to sheathe the "shore end" very heavily. The "main" cable, or deep sea portion, is generally deposited at great depths out of harm's way, and is, therefore, lightly sheathed; while the "intermediate" type, which comes between these, is of intermediate strength. These three types of cable are stored in the tanks in the order in which they are to be paid out. The "Hooper" had three tanks, and paid out, of course, from her stern; therefore the Para shore end occupied the stern tank, the Para-intermediate, main, Cayenne-intermediate, and Cayenne shore end following in order.

The laying of a submarine cable has been reduced to a science. The arrangements on board a telegraph ship are now in the main everywhere the same. The cable is usually laid under the entire responsibility of the contractors who make it. To them belongs the ship, and all the operations of laying are conducted by them, subject to the approval of a staff of engineers, representing the company's interests, who are temporary guests on board. The head of the expedition is the engineer-in-chief, who directs by aid of his assistants the mechanical operations of laying. Under him are the chief electrician, whose duty it is to see that the cable is laid in good electrical condition, and the captain of the ship, whose office is simply to manœuvre the ship in accordance with the requirements of laying. A fully equipped telegraph ship must be fitted with the necessary machinery for carrying and laying the cable, with proper electrical apparatus for testing it, and also with the most approved means of navigation; for it is of the utmost importance in case of future repairs to be able to lay down on a chart the exact course of the ship, since this is also the exact route and position of the cable. Besides her cable tanks she has force-pumps for filling sea water into them or drawing it off; she has a huge laying machine, consisting of a friction brake, strain dynamometer and drum; she has a powerful steam winch for coiling over cable from one tank to another; and in addition to these she has a store of grapnels for hooking the cable in the sea, and buoys for marking positions or buoying the end up at the surface when it becomes necessary to do so. Projecting from the stern there is fitted up a large deeply-grooved wheel or pulley of iron which revolves on a fixed axle, and is generally surrounded by a narrow platform with a railing round it. This is the "stern sheave" or pulley over which the cable passes on its way to the sea; and this, as well as the red-painted buoys lashed along the taffrail, is one of the distinguishing features of a cable steamer.

While the cable was got ready for laying, we electricians had plenty of leisure to land and ramble about on shore. The "City of Belem," or "Para," was founded as long ago as 1616, by the Portuguese Cadeira. At that time the Amazon, or "mighty Orellana" was a fabulous river, flowing through the magical regions of El Dorado, whose banks were peopled by a warlike tribe of Amazons, and whose sands were sprinkled with diamonds. Time has disenchanted it of its imaginary wealth and glory, but the real natural riches and wonders of its forests which have been revealed have amply atoned for the loss. Last century, when the Portuguese looked to Brazil as their future seat of empire, they built large convents, palaces, and public buildings at Para, for they anticipated that it would become the emporium of the Amazon valley. At the present day these grand edifices are falling to decay. Para has, until lately, been declining rather than advancing. The revolution of 1835 checked its development to an extent from which it has not yet fully recovered. The native Brazilians, leaguing themselves with the Indians, who had been hunted and enslaved by the Portuguese settlers, attacked the latter and overthrew the Government. It was years before the country was tranquillised, and the consequent insecurity to life and property, together with the heavy impost duties imposed by the Brazilian Government, has repelled immigration. Within the last twenty years, however, there has been a marked revival of trade and enterprise. The dilapidated city has been in great part renovated.

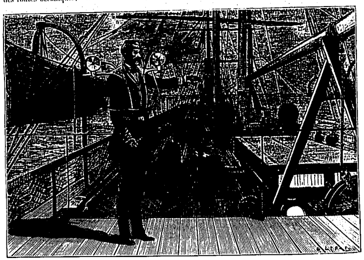
(TO BE CONTINUED.)

126

APPAREIL ACOUSTIQUE

POUR RECONNAITRE EN MER LE LIEU DE PRODUCTION D'UN SON

Depuis longtemps, la fréquence des collisions en mer par temps de brume, et les épouvantables catastrophes qui en résultent, ont attiré l'attention des marins; bien des physiciens ont cherché le moyen d'assurer la sécurité de la navigation au milieu des brouillards, qui rendent si dangereux le parcours des routes océaniques, surtout dans les régions où elles se trouvent le plus abondamment fréquentées. C'est dans le but d'éviter les rencontres, que les bâtiments sont pourvus de cloches, de trompes et de sifflets à vent ou à vapeur. Ces instruments, qui doivent servir à signaler la présence d'un navire dans un rayon plus ou moins étendu, ne remplissent qu'imparfaitement le but : le bruit qu'ils font, est parfois perçu, mais avec une netteté insuffisante pour qu'on puisse juger nettement de la direction d'où proviennent les ondes sonores. Le nouvel instrument que nous représentons, est dû à un Américain, le professeur Mayer. Il est destiné à déterminer la direction et aussi la distance approximative de la trompe ou du sifflet d'alarme. L'action de cet appareil est basée sur ce fait que, si deux ondes sonores de même hauteur parviennent simultanément aux oreilles, le son perçu est doublé; si, au contraire, les deux ondes sont séparées par une demi-longueur d'onde, les deux sons se neutralisent et l'oreille ne perçoit rien. L'appareil se compose de deux boîtes résonantes, montées sur un support qui les réunit; il repose sur les épaules de l'observateur comme les bretelles d'un porteur de lait. Le fond des deux boîtes est réuni aux oreilles par un tuyau flexible de caoutchouc dont on peut réduire la longueur à volonté. L'observateur donne aux tuyaux la même longueur de chaque côté, et il tourne sur lui-même jusqu'à ce que les résonnateurs lui transmettent le son maximum. Il est alors en face de la source sonore. En raccourcissant l'un des tuyaux de manière à séparer deux ondes par une demi-longueur, il doit entendre le son minimum, et cette épreuve doit confirmer la première. En faisant diverses observations dans une même bordée, et à l'aide d'un calcul très simple de trigonométrie, il peut se rendre compte de la distance approximative de la cloche d'alarme ou de tout autre instrument faisant entendre un son.



Emploi du nouveau topophone de M. le professeur Mayer.

Cet appareil, qui a reçu le nom de *topophone*, a récemment été expérimenté par la marine militaire des États-Unis; notre gravure en donne le mode d'emploi tel qu'il doit être usité à bord d'un navire[1].

[1] D'après l'*Engineering*.

127

rate of three miles an hour. His enormous battery consisted of sixty-four cells, containing twenty square feet of platinum.

This was in all respects an apparent failure, and the philosopher was thoroughly disheartened while standing unwittingly on the threshold of a brilliant success. In the first place, he attempted the impossible in trying to get a great power economically from any battery; and, in the second place, no powerful battery had yet been invented. But his engine was an excellent one, and the subsequent inventors failed to equal it until Gramme, of Paris, discovered that one of his own dynamo-electric generators would act in the reverse direction as an admirable motor.

The interval between 1839, when Jacobi's motor was abandoned, and 1870, when Gramme's machines came into notice, was occupied by a large number of inventors, who brought to their work a world of ingenuity and all the learning of all the sciences save one, but that one was the only key to success—*electro-magnetic induction*. In the meanwhile Mr. Joule, himself a former seeker after this nineteenth century philosopher's stone, dashed the hopes of his co-inventors by his demonstration of the Conservation of Energy. This magnificent work, the grandest perhaps in the history of science, was immediately made the basis of a series of experiments, which it would be out of place to detail here. Suffice that Mr. Joule proved to the satisfaction of all scientific minds that the mechanical energy of the electrical current, produced by the consumption of one pound of zinc in a Daniell cell, is equal to 1,106,160 pounds raised to the height of one foot; in a Grove cell, which has $1\frac{2}{3}$ times the electromotive force of Daniell's, to 1,843,600 pounds raised to the height of one foot, or, in the sulpho-chromic acid battery now before you, which has double the electromotive force of a Daniell's, 2,212,320 pounds raised to the height of one foot. Dr. Scoresby and Mr. Joule state their conclusions in the following sentence: "Upon the whole we feel ourselves justified in fixing the maximum available duty of an electro-magnetic engine, worked by a Daniell battery, at 80 pounds, raised one foot high for each grain of zinc consumed." This is about half the theoretical duty. In a Grove battery the same proportion would give 144 pounds, and in the sulpho-chromic battery 160 pounds, raised one foot high for each grain of zinc consumed. This result was immediately compared with the duty of the best type of steam engine per grain of coal, and it was found that one grain of coal lifted 143 pounds one foot high. But zinc, at the most favourable computation, costs ten times as much as coal, and the force it yields is therefore, as 143 is to $\frac{160}{10}$, or about nine times as costly.

The conclusion instantly drawn by the scientific world was that electricity produced by the consumption of zinc can never compete with steam, but it is the purpose of this paper to collect certain facts which will show that this conclusion is erroneous.

History is teeming with instances where noted scientific men declared that there was nothing attainable beyond their immediate vision, and proved with sarcastic argument and brilliant syllogism that further advance in certain directions was impossible. So it was with the steamship. An eminent scholar and mathematician, some fifty years ago, proved beyond the peradventure of a doubt that an ocean steamship was an absurd dream. His calculations showed that one could not be built large enough to carry her own coal across the Atlantic. And so these gentlemen, having proved that electricity produced by zinc is nine times as costly a source of power as steam produced by coal, predict that electric motors can never usefully compete with steam engines. Now, man-power, according to the tables of a well-known English engineer, is one hundred times as costly as steam; nevertheless there are several circumstances in which we prefer men. It is certain that we would never employ men if we could get a steam engine to do the work more cheaply, and it is equally certain that we would not use electricity where steam was applicable. But steam is *not* applicable, for reasons which will be given later in detail, to work in which we require a small amount of power in constant readiness for action. In these cases—such as jewellers' lathes, dental engines, and the various tools of small machine shops, which employ but a small force of men—we have never been able to find a source of power adapted to the work which, if not as cheap in proportion as large steam engines, should yet be more economical than human energy. The fact is that whereas, according to Joule, the best electric motors are nine times as costly as steam power, human energy is eleven times as costly as electricity. And, inasmuch as human energy, which is one hundred times as costly as steam, is frequently preferred to steam engines, *a fortiori* electricity will often be preferred to steam; and it will require no argument to show that the human energy thus saved from exhaustion in the exercise of brute force can be devoted to a higher use.

(TO BE CONTINUED.)

CABLE-LAYING IN GUIANA.

27

BY J. MUNRO, C.E.

(CONTINUED FROM PAGE 82.)

The usual rate of paying out is about five miles an hour. Night and day the cable is running out of the ship at this rate, and extending behind in a slant through the water until it reaches the bottom, at a point varying with the depth, but often ten miles in the rear. A constant watch is kept on the cable in the tank to ensure its leaving the latter freely, for were several flakes to stick together and catch in the crinoline, such is the momentum of the moving ship that the crinoline would be torn up and the cable most likely snapped asunder and lost in the sea. To prevent any accidents on deck through this or some other cause, a man stands near the stern sheaves with an axe in his hands ready to cut the cable asunder at once and relieve the strain. The velocity of the cable and the strain upon it are also constantly noted.

In the electrical testing room a perpetual test is applied to the whole cable to detect any flaw that may break out in the insulator the moment it appears, and signals are exchanged every few minutes with the electricians left on shore to make sure that the copper conductor is intact, and that communication is kept up. The soundness of the insulator is certified by a spot of light from a mirror galvanometer on a darkened scale, and an electrician is told off night and day to watch this spot. So long as it remains steady on the scale all is right, and when relieved from his four hours' duty the watcher may write "O K" (telegraphic parlance for "all correct") in his log book; but should the spot suddenly fly off the scale something is wrong, a fault has broken out, and he at once rings the alarm bell. Then the officer on the bridge signals the engineer, the engines are stopped, the cable is restrained, and the ship brought to rest. There is much excitement on board, from the engineer-in-chief down to the sailors; for the fault may be overboard in deep water, two or three hundred miles behind the ship. In this case it will be necessary to cut the cable and buoy its end, then go back to where the fault is supposed to be, grapnel for the cable on the bottom, haul it up, and cut out the faulty piece. If it be within twenty miles of the ship, she will most likely proceed backwards, hauling in the cable again as she goes, until she arrives at the fault. On the other hand, the fault may be in the length of cable on board the ship not yet paid out, and little time or money need be sacrificed in getting it eliminated. The first thing to be done in any case is to cut the cable near the stern of the ship, and test the length in the sea and the length still on board separately, and in this way localise the fault. Several stories are told of faults having broken out while the weary electrician on watch had dropped off to sleep; and it is said of one green youth who was on duty when a fault occurred that he coolly reported in his log book at 1:15 a.m. "spot vanished"—and went to sleep until he was awakened at four bells by the man who came to relieve him.

While the electricians and engineers are on constant duty, observing all the symptoms of the cable, electrical and mechanical, the navigating officers are no less busy, fixing the position of the ship, by the sun during day, and the moon and stars during night. Soundings, too, are regularly taken every few hours to determine the depth and character of the bottom. The temperature of the water, and the velocity of currents, are also occasionally measured, in order to learn as much as possible of the place in which the cable is deposited.

The morning after leaving Pará we had paid out all the shore end, and were again off the mouth of the Amazon. It was a charming morning. The bottle-green sea was shot with sunbeams which illuminated its depths and showed the glistening silt-like motes. Here and there the olive surface was crested with the foam of breakers, or dappled with the purple shadows of the clouds. White gulls wheeled and gleamed under the cloudy sky like flecks of snow. The violet nautilus scudded along like a bubble before the light sea breeze, and thousands of medusæ, resembling Chinese lanterns, tumbled about at all depths. In the afternoon, shortly after dropping the pilot, we ran into one of the treacherous sand-bars which infest the mouth, and stuck fast, the screw churning up the sand and froth among the delicate pulsating medusæ, which seemed to have crowded round to look at us. The ship, which a moment before had been gliding like a sea-bird over the painted ocean, now lay as helpless as an iron box. All the efforts of the screw were unavailing to get us off the bank, so a kedge anchor was put out, and we waited for the evening flood tide. During the daylight which remained, a boat was lowered to buoy the cable, but the tide rose so rapidly that the boat was caught under the cable, and to prevent her being swamped the men on board were obliged to cut the cable, and in their alarm they cut on the wrong side of the buoy, so that the Para end was lost in the sea. That night a terrible squall of wind and rain came on; the "Hooper" creaked and strained and bumped every now and then against the bank. A very high tide was running up, and this, with the counter flood of the river running down, made the sea very rough. The shouts of the seamen and operations in the darkness, the raging waves, the lightning which flashed out of the gloomy sky in which a new moon was struggling, made a wild enough scene, and the shuddering and groaning of the huge ship as she was knocked against the ground added a spice of danger. About 11 p.m., however, just when the tide was at its full, the engines backed her off, and we were clear. Next day the ss. "Great Northern," the repairing ship of the Western Brazilian Company, sent to us from Para, recovered the lost end of the cable and the buoy for us, not without some difficulty, owing to the high sea which tossed the cutter like a cockleshell, and the sudden squalls which came down every now and again.

After this little episode all went well for a few days, if we except a false alarm of a "fault," which turned out to have been occasioned by some neglect on the part of the electricians stationed at Para, "the men at the other end," who generally come in for as much blame as possible on a cable expedition. If the men at the other end heard all that is sometimes attributed to them on board the ship, they might feel inclined to retort in language not quite Parliamentary; but it is useless to attempt to storm through a submarine cable, all the emphasis is lost

Mile after mile was run out day and night, until the stern tank was emptied, and it became necessary to shift to the tank amidships. The cable being all in one piece, this was effected by slowing the ship until the bight came up out of the empty tank, and straightened itself on the pulleys. It is generally a moment of some anxiety while the bight straightens, for

HISTORICAL MEMORANDA ON SUBMARINE TELEGRAPHY.

BY F. C. WEBB, M.I.C.E., M.S.T.E.

(CONTINUED FROM PAGE 21.) 27

1854 (continued).—In this year Messrs. Glass and Elliot, of East Greenwich, made twelve miles of cable, which was laid between Sweden and Denmark. It had three No. 16 conductors, each covered to No. 2 with G.P., and ten No. 2 galvanised iron wires for sheathing. This was, it is believed, the first cable made by Messrs. Glass and Elliot, which firm, combined with the Gutta Percha Company, forms the present Telegraph Construction and Maintenance Company. In this same year this firm manufactured a cable to be laid between Spezzia, in Sardinia, and the island of Corsica, 110 miles long, and one to be laid between Corsica and the island of Sardinia, across the Straits of Bonifacio. The pattern of these cables was six conductors of No. 16, covered to No. 1, with G.P., and sheathed with twelve No. 1 ungalvanised iron wires. These cables were laid in June of this same year from the s.s. "Persian." Mr. H. Brett was responsible for the laying of these cables, and engaged Mr. Thomson, formerly Mr. R. S. Newall's principal engineering assistant on such expeditions, to assist in the work. The depth of water (350 fathoms) was much greater than had previously been dealt with, and the cable being a heavy one strong break power was required. Two drum breaks were used. Each drum had two break straps, one on each side of the part round which the cable passed. These drums were placed one behind the other. The cable was to make five turns round the foremost drum, and then pass on to the after drum, round which it was to take four turns. The four break handles had tackles on them fast to the deck, so that the handles could be boused down, and thus the break power was considerable. There were wood blocks on the break straps, and the author believes the drums were 8ft. diameter. There was no stern wheel, but only a saddle over the taffrail. Some kind of movable knife was used, which was held by two men, but this was strongly objected to by Mr. Thomson. The following account is from some notes given to the author by Andrew Nelson, a steady-going Swede, who was present on board during the laying, and who for many years was foreman under the author on board the "Monarch," where the poor fellow was eventually killed (after the author left the ship) by being dragged into the picking-up machine on a fine summer's day, when cable was being picked up in the North Sea.

The "Persian" arrived at Spezzia July 21, and landed end at 9 a.m., and payed out till 10 p.m., when they brought the ship up by the cable for the night. July 22, at 4 a.m., something wrong with cable ashore (electrically), and after consultation a steamer was sent back to Spezzia to see what was the matter, and found the clerk asleep and the cable disconnected; commenced paying out again, and went on until 2 p.m., when they had a broken wire, which carried the knife under the drum and flattened the cable. They then cut the cable, and removed the damaged part, spliced up, and proceeded at 4 p.m., until 10 p.m., when they again brought up by the cable for the night. July 23, 4 a.m., commenced paying out, and soon stopped to "ship the other drum" (that is, it may be supposed that up to this only one of the drums was used, and that now the second was placed in circuit by having turns taken round it). In stopping, they damaged the cable, and in repairing it damaged also the taffrail. Laid to for the night. July 24: Commenced paying out, and got to Cape Corsica at 10 p.m., and brought the ship up for the night. July 25: Landed the end at 11 a.m., 91 miles having been paid out in distance of 74 miles.

It appears that the cable often surged alarmingly on the drums. There was no holding back gear, except a nipping arrangement, made by something like a pair of nut-crackers. The fleeting knife, not being fixed to the frame, as had always been the case on all former expeditions, but only held by two men, appears to have been the principal cause of the accidents. The cable, however, was eventually laid in good electrical order. The deepest water previously encountered had been 180 fathoms, viz., on the Portpatrick and Donaghadee line, and here the depth crossed was about 350 fathoms, so that the final success was certainly creditable, and indeed no cable of so heavy a type has, we believe, been ever laid since in such deep water. The electrical tests of this cable were under Mr. H. V. Physick, formerly assistant engineer to the Electric Telegraph Company. The cable lasted good for many years, but when it failed it was never repaired. These cables, made by Glass and Elliot, had a left hand lay, Newall's cables having been right hand.

In the latter part of this year one of the Hague cables failed about thirteen miles from the Dutch coast. The ports on the Dutch coast would soon be frozen, and it was considered unsafe to have a steamer working on that coast under the circum-

128

Iron, Jan 14. 1881

SOCIETY OF TELEGRAPH ENGINEERS.—The Council of this Society have made such arrangements with regard to the Library, at 4, Broad Sanctuary, Westminster, that it has been practically thrown open to the public, and for the convenience of those who are not able to use the Library in business hours it will remain open till 8 p.m. on four evenings a week.

Iron Jan 14 1881

THE ATLANTIC CABLES.—A new double line of cable is about to be constructed and laid down between America and Europe. The capital has been subscribed in New York. The construction of the cables has been entrusted to Messrs. Siemens Bros, Charlton-next-Woolwich, and will afford employment for 2000 hands for the next twelve or eighteen months. The length of the cable to be manufactured is 9000 miles.

THE DUPLEXING OF SUBMARINE CABLES.—In duplexing long submarine cables it was found that one great point to be aimed at is to carefully reproduce in the artificial cable which balances the working cable an exact imitation of the first 300 miles or so at each end of the working cable, both as regards the resistance and electrostatic capacity of each consecutive mile of cable in its proper relative position. For this purpose, says the *Electrician*, the "section books" containing the tests of each mile of cable before it is added to the cable, are consulted, and the artificial resistances and inductive resistances forming the artificial one made to correspond—the remaining portion of the working cable being represented in the artificial cable more in the gross than in exact detail. This shows that the labour expended on the careful compilation of exact tests during manufacture is not thrown away, but is becoming of increased importance. So sensitive is the balance to this exact representation of the first few hundred miles of cable, that even a slight decrease in insulation at one spot within that distance can only be rebalanced by a similar decrease of insulation at exactly a corresponding spot along the artificial cable; and this seems to open out a new and accurate method of determining the distance and magnitude of a small fault of insulation. In fact, for finding the distance of a fault in a cable, we should have for one side of the bridge an artificial cable having electrostatic capacity and resistances exactly similar to the cable under test when perfect.

the repair until next spring.

Journ. Tel. John 16 1881

The Mexican Telegraph Cable.

IT is expected that the lines of the Mexican Telegraph Company, connecting with the Western Union Company at Brownsville, Texas, thence to Tampico and Vera Cruz, by cable connecting with government lines in Mexico, will be in operation about February 1st. Due notice will be given of tariff rates, etc., when the cable is laid.

Jan. 12 '81

THE NEW ATLANTIC CABLES.—The following paragraph in some shape or other has been going the round of the papers during the past fortnight. A Woolwich paper gives it thus:—"The chief topic of conversation in Woolwich this week has been the news that Messrs. Siemens Brothers have secured an order for the construction of a double line of cable between America and Europe. The length of cable to be manufactured is 9,000 miles, the largest order probably ever given in the history of ocean telegraphy. It is stated that the firm will find employment for 2,000 hands for 18 months." We have reason to believe that Mr. Jay Gould is now in London, and that the order for the two new cables has actually been given

Electrician Jan 15 1881

the arrangement with the new French Cable Co.

Journ Tel John 16 1881

Atlantic Cables.

Jan 14 1881

THE lengths of the several cables between the United States and Europe and their locations are given as follows: The three Anglo-American cables now in use run from Ireland to Newfoundland, 1,850 miles, and from Newfoundland to Sydney, over 300 miles—a total distance of 2,150 miles each; the Anglo-French cable from Brest to Duxbury, by way of St. Pierre, is about 3,329 miles long; the Direct United States cable from Ireland to Torbay, and from Torbay to Rye Beach, 2,360 miles; and the new French cable from Brest to Louisburg, 2,430 miles, from St. Pierre to Cape Cod, 880 miles, and from Brest to Penzance, 151 miles—a total length of about 3,461 miles.

Of the cables laid by the Anglo-American Company, the one put down in 1865 was broken March 11, 1873; and finally abandoned February 1, 1878; that laid in 1866 was broken January 13, 1877, and abandoned July 27, 1878. The latter cable, except the shore ends, was renewed last summer at a cost of £222,300; it is now called the cable of 1880. The cable laid in 1873 was broken April 2d, 1879, and was repaired in the same month; it is now in operation. No break has yet occurred in the cable laid in 1874. Of the three cables now working, which were laid by the company, one has been down over six years and another over seven years. The Erlanger cable, under the management of the Anglo-American Company, was laid in 1869; it was broken in the following May, and several times since the same accident has occurred. It was last repaired in August, 1879, having been broken February 22 in that year, but it was again broken last month.

The cable of the Direct United States Company was laid in 1874, and has been broken twice: the first time, January 4, 1879, on the ocean side near Torbay, and in February, 1879, in the Rye Beach and Torbay section. Both breaks were repaired, and the cable is said to be now in good condition. The cable of the new French company has been down about a year. It was broken May 2, 1880, near the Island of St. Pierre, and repaired the same month; the section between Cape Cod and St. Pierre was broken November 21, 1880, and is now repairing.

Iron Mch 18 1881

27

SUBTERRANEAN CABLES IN FRANCE.—The work of laying subterranean cables is proceeding favourably from Nancy to Paris. This telegraph line is composed of twelve insulated wires placed in a large tube of cast iron. For each length of 500 metres doors have been arranged so that any section can be removed and replaced without having to open the ground, which is necessary in the German system of laying the cables in a solid bed of asphalte.

Herald. Aug. 3. 1881.

UNDERGROUND WIRES.

The underground telegraph communication between the Central Office and Fireman's Hall was yesterday established. In the past, when the wires were at the mercy of the weather, it frequently happened that messages could not be conveyed, and the co-operation of the police with the firemen in cases of conflagration was impeded. Now it is intended that, in spite of all obstacles, news will be transmitted readily from one headquarters to another. In the new system the wires are enclosed in a layer of chemical compounds which are not subject to changes of temperature. There is no possibility of their crossing, as was the case with those upon the poles, and there is no possibility of either the wire or the material around it rotting. For some time the concern who have the patent for the new system have been at work laying their wires underground from Firemen's Hall to the Central Office, and yesterday they completed the work and brought the wire to the stoop of Police Headquarters. To-day it will be connected with the telegraph system under Superintendent Crowley's charge, and it is possible that it will transcend the old telegraphic method and be used entirely by the police force. The system has already been used by private parties in Brooklyn, and is said to have accorded general satisfaction.

1881

129

THE NEWS FROM EUROPE.

Auspicious Arrangements for Opening the New American Cable by September 1.

HIGHLY SATISFACTORY TESTS.

The Steamer Faraday Shipping the Deep-Sea Section of the Second Cable.

CORNELL BEATEN AT VIENNA.

One of the Crew Takes Cramps When Half the Course Has Been Traversed.

[SPECIAL CABLE DESPATCH TO THE WORLD.]

THE NEW AMERICAN CABLE.

LONDON, August 11.—I have the pleasure to-day of sending you over the new American cable some particulars of interest as to the arrangements for throwing the cable open for business to the public. The American Cable office in London, which will be ready for occupation very shortly, is in the most admirable position at No. 31 in the Royal Exchange, on the corner of Threadneedle street and opposite the little square in which Mr. Story's statue of George Peabody, the American banker and philanthropist, smiles benignantly on the passing crowds in front of the windows of the Scottish-American Insurance Company. As I came out of the office this morning I stood for a moment looking at the statue and could not help recalling the resolute, unobtrusive way in which George Peabody some twenty years ago, with his partner, now Sir Curtis Lampson, took up and carried through the first great ocean cable enterprise when all others had abandoned it. They generously left the credit and a good deal of the profit of the undertaking to your ubiquitous fellow-citizen, Mr. Cyrus W. Field. But though most of the capital with which the work was done was English capital, that capital was raised and new life was put into the enterprise by these two transplanted Yankees, George Peabody and Curtis Lampson. The first, after resting from his labors in Westminster Abbey, was sent to his long home in his native Massachusetts, under the English flag, in an English man-of-war. The second, having established himself with all his property and interests in this country, has accepted a British baronetcy, offered in recognition of the success of the ocean cable. But both were true Americans at heart, and there is something, therefore, both pleasant and appropriate in the establishment of the office of the first really American cable under the very eyes, as it were, of George Peabody's statue. Of course, business and not sentimental considerations determined the choice of the site, but a company with such prospects ~~before it can afford itself the luxury of a~~ little sentiment. The first of the two transatlantic cables of the company was formally handed over by the contractors, Messrs. Siemens Brothers & Co., on Friday last, on which day the guarantee term of thirty days of perfect testing subsequently to the laying of the cable expired. Since the connection between Whitesand Bay and Canso was completed hourly

electrical tests have been made by the electricians in charge. They report the cable to be the very best ever laid under the Atlantic Ocean. A speed of transmission has been attained on it 30 per cent. in excess of the guarantee and 20 per cent. in excess of the speed ever attained on any other ocean cable. All that now remains to be done before opening the offices of the company for business is to complete the quarters for the company's staff at both ends and the land line connections in England. The company's staff will be made up of men picked from the whole cable service of the world. The quarters for the American staff will be at Canso, in Nova Scotia, and as the season fortunately favors them, and the work, thanks to the energy with which it has been pushed, is now substantially six weeks ahead of the time contemplated in the contracts for making the cable, it is expected, I learn at the London office, that the American staff will be comfortably under cover and ready for business before the 1st of September. The English staff are established already at Whitesand Bay, a remote but very beautiful spot near the Land's End, on the wild and picturesque west coast of Cornwall. There the English shore end of the second cable of the American Company has already been laid. The cable steamship Faraday is now taking on board the deep-sea portion of this second cable at the works of the Messrs. Siemens Brothers & Co. at Woolwich, and will soon proceed to sea to lay it. It is possible indeed, that both the cables of the new company will be laid and in operation before the time at which, judging from the experience of the European companies, we should have been justified in expecting to see the first one actually in use. To complete the English connections by land of the American cable, the Postal-Telegraph Department is now constructing a system of special land wires which will furnish direct working circuits from Whitesand Bay in Cornwall (there is another Whitesand Bay, let me remind your readers, on the south coast of Devonshire not to be confounded with this) to London, 291 miles; to Liverpool (where the Company has its offices at No. 5 Exchange Buildings), 320 miles, and between London and Liverpool, 206 miles. This will secure duplicate circuits for the business of the company between the cable landing in Cornwall and London, one being available in case of an interruption of the other. From what I have seen and learned myself to-day it appears to me quite clear that Pender & Co. and the British Globe cable monopoly may as well make up their minds to see the new American company under way and in successful operation by the 1st of September at the latest. All the people in charge of the new enterprise have a quick, alert, quiet and expeditious way with them which seems to me of evil augury for the old concerns. Americans here take a great deal of patriotic interest in the work, for which I do not blame them. They have a right to be gratified, I think, at the prospect of seeing a large part of the profits of the ocean cable business at last diverted into the pockets of the American public, which has done so much to build the cable business up and to make it profitable. How profitable it has been made you may infer from the recent half-yearly reports of the Anglo-American and the Direct companies. These reports show for the six months ending June 30, 1881, a gross revenue of $2,000,000. The total working expenses at a liberal estimate have not exceeded 20 per cent. of this amount, and the two companies have been enabled besides paying their dividends to add the snug little sum in round numbers of $550,000 to their reserve funds. Furthermore, while the English companies have been doing this business, the French company formerly managed by Count Dillon, which forms the third member now of the great European Pender cable pool, has taken in during the same period not far from $500,000 of gross revenue. With a much smaller capital invested, greatly improved cables and a thorough-going active American administration in charge, the new American Cable Company may be expected to swing even more than its natural proportion of the profits of this rapidly increasing business back to your side of the water, from which they are so largely drawn.

LORD SALISBURY AND THE GOVERNMENT.

Panama Star & Herald
Apr. 14. 1881.

THE CABLE.

The recent operations of the *Grappler* in repairing the cable near Colon, are reported as having been entirely successful. The cable was picked up at the precise spot where tests, previously made, showed it to be injured. It was not broken, but was frayed and untwisted, and generally used up. The injured portion was cut out and new cable added, to supply its place. Subsequent tests showed another difficulty 310 miles from Colon, although it is not known whether the line is broken or not, as the Holland Bay station is probably not advised of operations in progress here the *Grappler* having come from Barbadoes direct. Certain indications would seem to show that tests are in progress at the other end of the line, as faint signals are observable in Aspinwall, but not sufficiently clear to amount to a demonstration. One of the electricians of the party went to Kingston by the *Don*, yesterday morning. When he arrives he will get hold of the machine there and endeavor to work through. Should he fail in doing so the *Grappler* will underrun the whole line to Jamaica, and complete its effectual repair.

World Aug. 21.
1881.

THE AMERICAN CABLE.

Where It Lands in England and How the Steamer Faraday Does Her Work.

[SPECIAL CABLE DESPATCH TO THE WORLD.]

WHITESAND BAY, Cornwall, August 20.—We are expecting to welcome to-night or to-morrow morning the cable steamship Faraday which sailed from Woolwich yesterday at 8 A. M. with 1,500 miles, being considerably more than half, of the second Atlantic cable on board. The shore end was buoyed off this cove some time ago and awaits her arrival. She will take it up at once and start westward to lay it. With ordinary weather she ought to get the whole length she now carries laid and buoyed in about eight days. As you know, the Faraday, after the Great Eastern, is the largest vessel afloat, being 305 feet long, 52 feet beam and 30 feet deep. She is so deep, in fact, that whenever she lies in the Thames they have to dig a cradle for her at Woolwich in the river-bottom to float her. The wonderful speed with which she does her work is due to the perfection of her equipments. She is fitted up with electric lights of two patterns. Her deck is lighted with the new Siemens light, of the effects of which on the ocean, even before it had attained its present perfection, Mr. Laurence Oliphant gave you such a striking description after his voyage home in the Faraday three years ago. Her main saloon is lighted with the Swann electric light. Thanks to this perfect illumination, the men on board can work night and day with equal ease, and such is the excellent adjustment of her machinery that it makes little difference to her what the weather may be or the rolling of the sea. She has three cable tanks—fore, aft and amidships—filling the whole width of the ship. These are of iron and are water-tight, and they are so arranged that as fast as the cable is paid out water can be taken in as ballast to steady the ship. The cable is coiled into the bottom of the tanks from the inside to the outside. It is paid out in reverse order from the outside to the inside. The bight of the cable is brought up through a kind of cage called a crinoline passed over a revolving wheel, carried along down a shoot astern about thirty feet in length, and then passed between three sets of super-posed wheels, which act either as drags to retard or spurs to accelerate the paying out of the cable according to circumstances. Emerging from these, the cable is passed three times around an eight-foot drum, from whence it goes to a dynamometer fixed about thirty feet further astern. From this it is carried over the stern of the vessel by a wheel so rigged as to pay the cable out at any angle. When the weather is very rough they take an extra bight in the cable from the drum and carry it forward about one hundred feet through another triple set of wheels and another dynamometer. This prevents any sudden strain from snapping the cable. The drum acts as a brake and an automatic recorder which gives the amount of strain on the cable as it passes over, and the strain can be so regulated as to secure an uniform strain, not varying far from 5 per cent. The Faraday carries a crew of 200 picked men and about twenty-five officers and electricians. She is commanded by Captain Maypeo Mr. John R. Brittle is chief engineer of the expedition. Mr. Humstone, who came out in the Faraday from America with the first cable to represent the company, was so well satisfied with the arrangements of the ship and the organization of the enterprise that he has returned to the United States. An officer who came out in the Faraday tells me that she always makes her own soundings on every voyage. She has Sir William Thompson's patent sounding machinery on board, and she has crossed the Atlantic so often that she now sails chiefly by her own chart, which is more exact than any Government chart in existence. She is a kind of floating farm, too, carrying her live stock, bullocks, sheep, geese and fowls of all kinds, so that her people live like fighting-cocks. The weather-wise here to-day tell me to expect her to-night. She landed the first cable by moonlight at 10 P. M. on the 9th of June last. She arrived off Whitesand Bay on Sunday June 5. But this is a wild coast when the sea runs high, and she had to lie in Mouse Bay until the 9th before the weather would allow her to land the cable. I should be glad to see her come, but a man might easily be in a worse place to wait for her. No words can describe the sublime grandeur of this granite coast, from the Land's End to Cape Cornwall, and Whitesand Bay is perhaps the most picturesque indentation. It is a historical bay, too, for King John landed here when he came back from Ireland, six or seven hundred years ago, and the unhappy Perkin Warbeck came here on his last expedition to maintain his claim to the English crown. The quarters of the Cable Company here are established in the bight of the bay, about three and a half miles from the Land's End, upon land leased from a parson who is a local "swell" of importance. They stand a little up the direct road from Penzance to the Land's End, and are reached by a cross-road which diverges from the main road opposite a remarkable-looking educational institute and just above the two queer little local hotels. Of these hotels one is occupied all the year through, the other, which is almost on the verge of the shore, serves as a kind of summer resort. The local wits speak of them as the "First Inn and last Out." The road to the cable quarters passes some straggling huts and a few little cottages and runs very steeply down-hill to what is called Senen Cove, where a patch of slate comes into the granite. This is a charming place which Starfield would have been delighted to paint, picturesque with fishermen's black boats, old nets, and at certain times of the day with fishermen and fisherwomen as picturesque as the boats and the nets. They are a strange stalwart, primeval sort of race, these Cornish folk, and the women rule them by sheer strength as much as by the usual graces of their sex. When the Faraday came here in June she sent a boat ashore to pick up a pilot on a Sunday morning. The boat's crew came on an old Cornishman, who offered to find a pilot for them. He led them to one of the huts I have spoken of, but could not get in. After much knocking at the door they got speech through a window with an old fellow within, who explained that his wife had locked him up and gone off to church, and that the visitors must see her if they wanted to get him out. They posted off to the church and with some difficulty induced the old lady to come out and consent to release her husband.

She seemed to be an amiable giantess, so the officer ventured to ask her whether she had incarcerated her husband in order to keep him sober. "Oh, no," she said—with much simplicity, "it's only to keep the women away from him."

From this point to Penzance, about nine miles, the telegraph part of the cable is carried on iron posts. From Penzance two lines pass through Plymouth up to Exeter. At Exeter one line diverges eastward through Honiton and Axminster to reach London by the Great Western line. Another runs northward by Taunton and Bridgewater to Bristol, whence it proceeds to Liverpool and from Liverpool again goes eastward by the Midland Railway to London, making thus, you will see, a double circuit for the cable connections in England. I was in Liverpool last week and saw the cable offices there. They are at A 5 in the Exchange Buildings, directly under the great news-room and next door to the Anglo-American office. The rapid progress of the new American Company has waked up cable people in England and in Europe generally to the growing importance of the American business. The Dacia, Sir Charles Bright's old West India ship, has just sailed with a cable some four or five hundred miles long, constructed at the Silvertown Works for a Spanish company, which is to be laid from Cape San Antonio in Cuba to the Belise in British Honduras.

End of "News from Europe."

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World. Aug. 12. 1881.

THE NEWS FROM EUROPE.

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They generously left the credit and a good deal of the profit of the undertaking to your ubiquitous fellow-citizen, Mr. Cyrus W. Field. But though most of the capital with which the work was done was English capital, that capital was raised and new life was put into the enterprise by these two transplanted Yankees, George Peabody and Curtis Lampson. The first, after resting from his labors in Westminster Abbey, was sent to his long home in his native Massachusetts, under the English flag, in an English man-of-war. The second, having established himself with all his property and interests in this country, has accepted a British baronetcy, offered in recognition of the success of the ocean cable. But both were true Americans at heart, and there is something, therefore, both pleasant and appropriate in the establishment of the office of the first really American cable under the very eyes, as it were, of George Peabody's statue. Of course, business and not sentimental considerations determined the choice of the site, but a company with such prospects before it can afford itself the luxury of a little sentiment. The first of the two transatlantic cables of the company was formally handed over by the contractors, Messrs. Siemens Brothers & Co., on Friday last, on which day the guarantee term of thirty days of perfect testing subsequently to the laying of the cable expired. Since the connection between Whitesand Bay and Canso was completed hourly electrical tests have been made by the electricians in charge. They report the cable to be the very best ever laid under the Atlantic Ocean. A speed of transmission has been attained on it 30 per cent. in excess of the guarantee and 20 per cent. in excess of the speed ever attained on any other ocean cable. All that now remains to be done before opening the offices of the company for business is to complete the quarters for the company's staff at both ends and the land line connections in England. The company's staff will be made up of men picked from the whole cable service of the world. The quarters for the American staff will be at Canso, in Nova Scotia, and as the season fortunately favors them, and the work, thanks to the energy with which it has been pushed, is now substantially six weeks ahead of the time contemplated in the contracts for making the cable, it is expected, I learn at the London office, that the American staff will be comfortably under cover and ready for business before the 1st of September. The English staff are established already at Whitesand Bay, a remote but very beautiful spot near the Land's End, on the wild and picturesque west coast of Cornwall. There the English shore end of the second cable of the American Company has already been laid. The cable steamship Faraday is now taking on board the deep-sea portion of this second cable at the works of the Messrs. Siemens Brothers & Co. at Woolwich, and will soon proceed to sea to lay it. It is possible indeed, that both the cables of the new company will be laid and in operation before the time at which, judging from the experience of the European companies, we should have been justified in expecting to see the first one actually in use. To complete the English connections by land of the American cable, the Postal-Telegraph Department is now constructing a system of special land wires which will furnish direct working circuits from Whitesand Bay in Cornwall (there is another Whitesand Bay, let me remind your readers, on the south coast of Devonshire not to be confounded with this) to London, 291 miles; to Liverpool (where the Company has its offices at No. 5 Exchange Buildings), 320 miles, and between London and Liverpool, 206 miles. This will secure duplicate circuits for the business of the company between the cable landing in Cornwall and London, one being available in case of an interruption of the other. From what I have seen and learned myself to-day it appears to me quite clear that Pender & Co. and the British Globe cable monopoly may as well make up their minds to see the new American company under way and in successful operation by the 1st of September at the latest. All the people in charge of the new enterprise have a quick, alert, quiet and expeditious way with them which seems to me of evil augury for the old concerns. Americans here take a great deal of patriotic interest in the work, for which I do not blame them. They have a right to be gratified, I think, at the prospect of seeing a large part of the profits of the ocean cable business at last diverted into the pockets of the American public, which has done so much to build the cable business up and to make it profitable. How profitable it has been made you may infer from the recent half-yearly reports of the Anglo-American and the Direct companies. These reports show for the six months ending June 30, 1881, a gross revenue of $2,000,000. The total working expenses at a liberal estimate have not exceeded 20 per cent. of this amount, and the two companies have been enabled besides paying their dividends to add the snug little sum in round numbers of $550,000 to their reserve funds. Furthermore, while the English companies have been doing this business, the French company formerly managed by Count Dillon, which forms the third member now of the great European Pender cable pool, has taken in during the same period not far from $500,000 of gross revenue. With a much smaller capital invested, greatly improved cables and a thorough-going active American administration in charge, the

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The Ironmonger, April 2, 1881.

UNDERGROUND TELEGRAPH WIRES.

There appears to be an increasing tendency to lay wires for telegraphic and telephonic purposes underground; in place of suspending them overhead. So far as the general public is concerned this tendency is viewed with decided approval, there being a widespread and well-founded idea that the existing network of suspended wires not only disfigures the thoroughfares of our towns and cities, but is a serious danger. In London this is especially the case, some of the streets of the City being covered with perfect cobwebs, so to speak, of these wires, some of which have on more than one occasion broken with fatal results to pedestrians and passengers on the outside of omnibuses. On every public ground, then, the alteration is to be warmly welcomed, and there are few, if any, sound practical reasons why every aerial wire should not be brought down and buried. The only drawback is the allegation that some loss of electrical conductivity arises in subterranean lines; but this is surely a relatively slight matter on short circuits, such as are chiefly affected in this manner. In Germany thousands of miles of military and other telegraph wires are now underground, without any complaints as to the effects of "earth," and in the United States the lines are being boxed up in a non-conducting mixture, composed of pitch, pulverised glass, and other materials, with the greatest success. What can be done elsewhere can be effected here. Once the authorities feel the pressure of public opinion the change will speedily follow. When that happens there ought to be a good demand for cast or wrought iron pipes in which to convey the guttapercha-covered wires.

The Electrician, July 16, 1881.

RECENT INVENTIONS.

ABSTRACTS OF SPECIFICATIONS.

4482. Cables for Telephonic Purposes, *E. George and J. B. Morgan.*—3rd November, 1880. 6d.

This invention has for its object the obviation of the effects of induction, to effect which the inventors cover the telephone wires with an ordinary insulating substance, and imbed or combine with this insulator wires or metals. These wires or metals, or the outside surface of the insulating substance, are connected to earth by conductors

4482

at intervals. The non-induction insulated or open wires or metal may be laid around, parallel to or otherwise in connection with each insulated conductor, so that when placed together such conductors form a cable; this is strengthened by a metallic core in the centre, and is surrounded by a network or riband of metal. It is carried on supports or standards. The drawing shows the system of suspending the cable.

N. Y. Herald, Oct. 1st 1881.

Put the Wires Under Ground.

The practicability of putting the telegraph wires under ground is being amply demonstrated by the German government. More than two hundred cities and towns of the Empire are now connected in this way, and the operation of the wires is, we are told, a complete success. The experiment is of very great practical interest and value to our own country, where the question, particularly in the large cities, has been agitated for many years. Thus far the wires are under ground in, we believe, only one of our cities—Washington—and there they are carried along in the sewers by a company which could not obtain the privilege of disfiguring the streets. No difficulty that we have heard of is experienced in the working of these lines. The only obstacle in the way of securing the same results all over the Union is the disinclination of the companies to incur the extra expense. According to the statement of the present head of the Department of Public Works the sewers of this city are large enough above Fourteenth street to admit of the wires being carried through them, but in the absence of compulsory legislation on the subject the old plan is continued, and some of the most beautiful portions of the city are made hideous by the erection of clumsy contrivances which are a disgrace to our civilization. The planting of another telegraph pole in any portion of the metropolitan district should be absolutely prohibited.

Menlo Park Scrapbook, Cat. 1042

No. 28. "Telegraphy - Automatic"

This scrapbook covers the years 1873-1881 and contains clippings about automatic telegraphy. There are 138 numbered pages.

Blank pages not filmed: 2-7, 28-138.

Telegraphy 1042

Automatic

28

8

THE SECRECY OF "GOVERNMENT TELEGRAMS" SECURED BY THE USE OF THE AUTOMATIC TELEGRAPH.

To the Editor of the Telegraphic Journal.

SIR,—In reference to the intercepting or taking off messages from telegraph wires, as referred to in the resolution introduced on the 23rd of March last in the House of Representatives at Washington, involving the want of secrecy in the handling of Government telegrams, Mr. Edward Clarke, in his reply to the Hon. James E. Blaine, Speaker of the House of Representatives, very truly says that in some cases the wires connect with instruments in hotels, and that all the wires connect with various cities and stations between Washington and the northern cities.

Permit me to say that the trouble does not end here, and that Mr. J. G. Smith's suggestions, as regards the use of silent Morse instruments in any form, offers no security whatever against the abstraction by unauthorised persons of telegrams from the through wires at way stations, or at any point on a line of telegraph by any ordinary Morse operator as well as by experts, and, therefore, does not, in my opinion, meet the requirements, so far as it relates to the abstraction of Government *or other* despatches.

The only security lies in the use of the "automatic telegraph," for the following reasons:—First, by causing the pulsations of electricity to travel at any rate of speed above that at which a Morse expert is only able to interpret the same either by feel, taste, or by sound. I here refer to the American automatic telegraph, which has been in practical public operation for over two years between Washington and New York. It is an impossibility for the greatest Morse expert to abstract by feel, taste, or by sound, at any point on this line, during automatic transmission of a telegram, as in such attempts it becomes to the party "*ignotum per ignotius.*" And in regard to the office, the *modus operandi* is that of silence; and it matters not how many persons may be in each office during the transmission or reception of a message, by *my* automatic system no one but the copyist need know its purport; and, to meet the copyist's case, Mr. Edward Clark suggested the propriety of passing a law fixing a penalty or punishment on any person who may divulge any message sent by telegraph.—I am, &c.,

GEO. LITTLE.

Passaic City, New Jersey, U.S., June 9, 1874.

Tel Jour Dec 1 73

735. T. A. Edison, of Newark, New Jersey, U. S. A. *Improvements in Circuits and Instruments for Chemical Telegraphs.* Dated February 27, 1873.—This invention is to increase speed on long chemical telegraph lines and render the marks clear and distinct. The counter current set up in an electro-magnet as it discharges itself upon breaking the circuit is employed in a shunt or branch to neutralise tailings. Two or more stylus or pens in main line with shunt circuit and magnet in each are also used. Drop copies are taken by a division or branch and the magnet and receiving instrument or a vessel of water into which the circuit wires are introduced. With a very rapid circuit breaker and resistance in the main line, the transmitting instrument is placed in a circuit connecting at both sides of the resistance. An induction coil is employed as a relay for the automatic transmitting system, the same sending a secondary current to the receiving instrument or to another induction relay. Reaction batteries are introduced upon the line or in branch or shunt circuits, to clear the line of surplus electricity, the power of the same being much less than that of the main battery, and the poles opposed.

Tel Jour July 15 73

9

June 21st, 1873.

Condenser for the Little Automatic Telegraph.—In order to use a chemical telegraph in connection with electro-magnets in the circuit, it is requisite that a condenser should be used in connection therewith. After much experiment to obtain the best form of condenser, Mr. George Little, consulting electrician to the Automatic Telegraph Company, informs us that the condenser he prefers to use with the electro-magnets, in order to avoid or lessen the disturbing influences of extra currents, &c., is a modification of M. Planté's liquid condenser, and consists of two thin leaden plates, of about ten inches square surface, between which is a thick piece of flannel, saturated with glycerine, so adjusted as to offer about seven times more resistance than that represented by the helices of each electro-magnet, the whole being enclosed in a strong flat mahogany box, and hermetically sealed with paraffin.

Tel Jour Aug 1. 76

Correspondence.

Aug 1 76

To the Editor of the TELEGRAPHIC JOURNAL.

SIR,—I notice in your issue of the 15th inst. a review on some portion of the contents of No. 11, Vol. IV., of *The Journal of the Society of Telegraph Engineers*, and noticing some remarks on a communication by a Mr. Edison, on the imperfect contacts which occur in signalling with *rigid points* by a Bain's printer—please do me the justice by permitting me, through the columns of your journal, to say that a *non-rigid* stylus, made from No. 30 wire, and about one inch in length, was used by me, assisted by Professor Farmer, on the 19th August, 1870, on a line built for my system between the cities of Washington and New York, since which time *non-rigid* styluses have always been used in connection with my apparatus for cheap telegraphy, and clearly shown in my English patent, of date April 22nd, 1872, at letter *i*, fig. 19, sheet 8; as also in my American patent of September 2nd, 1873, at fig. 23, sheet 3.

Yours truly,

GEO. LITTLE,

June 30, 1876. Richmond, Va., U.S.

Tel Jour Aug 1. 76

2,803. R. MORLEY, London.—"Improvements in electric telegraphs." Dated August 9th, 1875. (A communication.)—This invention has for its object to avoid the unevenness and spreading of colour in the signs made on chemically-prepared paper in some automatic telegraphs. It does so by discharging a battery upon the receiving apparatus at the same time that the line is traversed by currents from two batteries alternately positive and negative. An arrangement is also described for transmitting signals at a high rate of speed at the same time in opposite directions over one wire.

LITTLE'S RAPID AUTOMATIC TELEGRAPH SYSTEM.

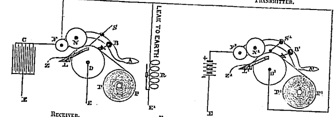
The devices employed in this system are, as will be seen by reference to the diagrams, classed under two heads—a chemical writer, which is involved in a system of the first order, and an ink writer, in a system of the second order.

It should be stated that any number of the Little automatic apparatus may be run, all at varying speeds, on the same circuit, without in the least interfering with the legibility of the writing, as the characters on each receiving instrument assume their own relative proportions with mathematical accuracy.

The Automatic Telegraph Company, of which the Hon. George Harrington is President, have now this system in operation, by virtue of an agreement with Mr. Little, between the United States Capitol at Washington, D.C., and some of the most important commercial cities in the country.

In the chemical writer (Fig. 1) D D' are flanged drums, which may be set in motion by any of the well-known devices, but preferably by a small belt leading to a crank-handle, to be worked by hand power, the labour required being very slight. P P is a roll of chemically-prepared paper; P' P' a roll of paper having telegraphic symbols, perforated or embossed on the same. The end of each roll of paper, Z Z', is passed over the drums, and held in firm contact with their surfaces by the nipping

Receiver. Fig. 1. Transmitter.



Receiver. Fig. 2. Transmitter.

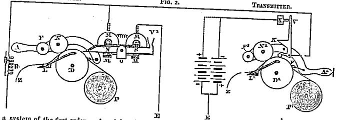
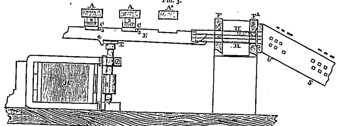


Fig. 3.



10 12

Electrical news
Oct 14 1875.

166,859. *Chemical Telegraphy.* Thomas A Edison, Newark, N. J., assignor to himself and George Harrington, Washington, D.C. Filed July 25, 1874.—Current passing through moistened paper causes evolution of hydrogen, which, uniting with tellurium of stylus, forms hydrotelluric acid, leaving red mark on paper. 1. The method of recording telegraph or other signals by the electro decomposition upon moistened paper or other material of a stylus tellurium. 2. A paper moistened with hydrates of lime, potash, or the cyanides of potassium, for use with a tellurium stylus, for the purpose set forth.

166,861. *Chemical Telegraphy.* Thomas A. Edison, Newark, N.J., assignor to himself and George Harrington, Washington, D.C. Filed July 25, 1874.—Oxygen evolved at stylus raises protoxide to a sesqui or peroxide, which combines with the sulpho-cyanide of potassium, to form red sulpho-cyanide of iron. The combination of a proto-salt of iron, sulpho-cyanide of potassium, and a non-oxidisable stylus, for the purposes set forth.

13

Proceedings of Societies.

OCIETY OF TELEGRAPH ENGINEERS.

dinary meeting of this Society (the last meeting ously to the summer recess) took place on nesday evening, the 13th of May. Mr. Latimer occupied the chair.

o discussion on Mr. LANGDON's paper "*On the y and Preservation of Telegraph Poles,*" which been adjourned from the 25th of March, was ned.

. LANGDON said that by the kindness of Mr. Culley as able to furnish specimens of that partial m of creosoting timber which was referred to in paper. Mr. Golsten had also sent one of the poles h was planted on the Portsmouth branch in 9. This was removed during the last month rpose to be brought to this meeting as an example e durability of creosoted timber. Lieut. Ramsay supplied a specimen of a Boucherised pole planted t three years ago. It was broken off short by the nd line. This supported a statement made in the r to the effect that all the preparations which used to arrest decay tended to destroy the flexibility e timber. During the last discussion Mr. Clark d whether any one had ever heard of a case of yed creosoted timber. That induced him (Mr. gdon) to write to several gentlemen and ask ther such a case had ever come to their knowledge. had received answers from Mr. Newman, of the don and North Western Railway; from Mr. wick, of the Midland Railway, who had had een years' experience of creosoted timber; from Cripps, of the London, Brighton, and South Coast way, who had had six or seven years' experience; n Mr. Haynes, of the Bristol and Exeter Railway, who had eleven years' experience; and from Mr. Sach, he Great Eastern, who had had twelve years' experience; and they all agreed that creosote was the preservative which they had had under their rvation, and the only one which had given perfect sfaction. Not one of them had any knowledge tever of a decayed creosoted pole. Mr. Webber had, ever, forwarded to him a specimen of what he ned creosoted timber. It was in a state of great y. This piece of wood was accompanied by a er, in which Mr. Webber stated that the specimen selected from numerous other pieces which were ayed to an equal extent. They had been in use en or eight years in a bridge near Totnes on the th Devon Railway. The timber was in gravelly , and in such a position that water could drain ough it under the railway. The writer added, "On other hand, last summer I saw some creosoted es cut which had been in the bed of a tidal river twenty-eight years. They were as sound as when t put in."

Mr. W. H. BATEMAN had called his (Mr. Langdon's) ention to an error which had crept into the paper. was stated that sulphate of zinc was used in one the processes. It should have been chloride of c. He had received a letter from Mr. Saunders ting doubt upon the statement made by Mr. Haynes o the present existence of iron socketed poles upon Bristol and Exeter Railway. He (Mr. Langdon) l entered into correspondence with Mr. Haynes on subject, and not only did Mr. Haynes adhere to statement that there were standing, at the present ment, several of the poles originally planted, but he l sent him one as a specimen. The pole which had n sent had the slots of the old arms which had n originally fixed for the No. 3 insulators, and this t identified it as one of the original poles. Mr. ods, who was connected with the same section the line on which the poles were planted, confirmed the statement made by Mr. Haynes. Hence it was only fair to conclude that Mr. Saunders must have made a mistake.

Mr. SPAGNOLETTI said that the subject of the paper was one of considerable interest to those who had charge of pole telegraphs, because timber formed the greatest item of their expenditure. Therefore anything which would prolong the life of a pole was of great importance. His experience of several years showed him that as much depended upon the selection of the timber as upon the mode of preparing it. Good hard mountain grown larch, which had been felled in the proper season, and well seasoned before being fixed, would last from seven to ten years without any preparation. If it was very good, or extra quality, it would last rather longer. Tarring and charring, he believed, was good, as the process prevented the chance of vegetation attaching itself to the pole. There were very many persons who were opposed to that method. The system of Boucherising did not seem to add much to the life of the pole. He had placed on the table a piece of a pole which was Boucherised and planted in 1866, and was entirely decayed when it was removed in 1872. This was one of a large quantity of poles bought of Sir Robert Harvey. The trees from which they were made were thickly planted and quickly grown, and did not contain more than forty or fifty rings. He believed that one cause of their decay was that the tissues and pores of the pole were so coarse that the moisture which was attracted into the wood would cause the copper preservative compound to dissolve so that it could leak out. In some of the poles there was not the slightest trace of the preservative material, except just in the very heart of the wood. The sulphate of copper had been found very destructive to the iron-work about the poles, especially as the iron-work was of a very light character. The earth wires on the poles were generally only No. 16 gauge, and they were soon destroyed by the sulphate of copper. The same effect was produced on the stay wires and the arm bolts. Some poles might have decayed from the fact of the timber being bad or dead before the process was applied. The next process was Kyanising, which he applied to about fifty-six miles of poles, which were planted in 1855. These poles, with the exception of a few planted in the chalk, were all good to this day. An interesting specimen of Kyanising was a piece of wood which was put down as a longitudinal sleeper on the Great Western Railway in 1840, of which the sap wood was still perfectly good. He was afraid, however, that the effect of Kyanising on the light iron-work would be the same as that of Boucherising. 2 lbs. of corrosive sublimate at 3s. a lb. was sufficient to preserve 50 feet of timber, and the time required for preparing the wood was one day for the inch and one day over. According to Faraday, the corrosive sublimate combined with the sap of freshly cut wood and formed an insoluble compound; but creosoting appeared to be the best system if it was properly performed and if the timber was well seasoned. It had, however, the disadvantage of making the timber exceedingly brittle. Creosote was, however, a very awkward preservative for poles which were placed on public roads or on railway platforms, because the heat of the sun drew the creosote out. He put up some creosoted poles three years ago and found that the banks of the railway were all saturated with creosote for about a yard round the pole. The heat of the sun allowed the creosote to gravitate downwards, and it went to the point which it was wished to preserve. In the case of which he had spoken the vegetation round the pole died. Then creosote was not at all destructive to the iron-work, but he found that in some cases the creosote insulated the earth wire of the arm. With regard to iron sockets there were a good many of them in use. They were tried on the Wootten Basset in-

The Invention and Inventors of Automatic Telegraphy.

NEW YORK, *Aug.* 18.

TO THE EDITOR OF THE TELEGRAPHER.

I NOTICE in your issue of the 15th instant this question by "Peter Simple," "Can you tell me who the inventor of practical automatic telegraphy in this country really is?" I am led to ask if you or "Peter" think that any *one* person can honestly claim to be the inventor of automatic telegraphy, even as it exists today? I am also led further to ask if there *has* yet *been* invented and developed a *practical* automatic chemical telegraph system?

I am well aware that G. L., who does not know "how some things are done," etc., as well as he ought to at least, claims to have forty-three patents, and that it is "notoriously patent" to the whole scientific world (unfortunately that does not include your humble servant) that everything belongs to him; and also claims that, "under the guidance of a mysteriously beneficent Providence, he has been made a chosen instrument" in the discovery and development of telegraphy, "thereby rendering the same *practically universal*"—a statement that no one but G. L. believes, and which he has failed to demonstrate.

I am also aware that the great inventive humbug from Jersey—familiarly known at the Patent Office as a "model maker"—claims to have *wasted* a great many "consecutive nights" in perfecting automatic telegraphy, which resulted in accomplishing just what Mr. G. Grace had been doing for a year or two.

I am also aware that he has been reissuing other people's patents, but always to himself, and, as "Peter" says, "they are numerous, but their value is not so apparent."

I am also aware of the fact that the Automatic Telegraph Company, under the Lefferts, Little, Grace, Edison patents, manage to do very good and fast telegraphing on a circuit of about 300 miles, specially constructed for the purpose, and claimed to be the most perfect line in the country; but I am not aware of any system of *practical* automatic telegraphy by which could be done, for instance, the every day business of the W. U. Tel. Co., over its long lines and cables, branching to all parts of this country, at the same rate of speed that they do it, or even do it at all—and until this, at least, can be accomplished, automatic telegraphy is not *practical* to my mind.

If this *has been* or *can be* accomplished under any present automatic system, I should like very much to know it; and if you, Mr. Editor, or "Peter," or any of your many readers will enlighten me through your columns in regard to this, "I shall not feel hurt;" in fact, "there is nobody hurt," I hope, by such a proceeding.

INQUIRER.

10 1896

One of my Electro-Chemical Problems.

To the Editor of The Telegrapher.

In reference to my duplex review of the 10th inst., permit me to call attention to the following dates relating to a portion of my many specifications (some seventy) bearing fully upon the above subject, being one of several electro-chemical problems solved by myself—namely, the problem of how to neutralize a decomposing current in the chemically prepared paper of a chemical telegraph by the aid of the single row of perforations composing the telegram itself at the transmitting end of the line, or by one or more rows of perforations, and recorded in the archives of the various governments of Europe, Asia and America, and signed by me in the following order: August, 1870; August, 1871; November, 1871; May, 1872; June, 1872; September, 1872, and February, 1873.

The above specifications, involving the use, among many other salient features fully described and shown by models, as also by elaborate drawings, of a paper fillet having one or more rows of perforations and operating one or more insulated styluses, for the purpose of completing, breaking or neutralizing circuits in a chemical telegraph using a chemically prepared strip or fillet, or a sheet of chemically prepared paper.

This one of the somewhat "paradoxical problems" presented to my mind in the early part of 1869 consisted in how to open or close an extra circuit, or to transfer or throw upon a chemical telegraph line a neutralizing or opposing current by the use only of the same single row of perforations which go to make up the telegram itself. The (in this case) single transmitting stylus itself being made to perform that extra function controlled by the perforated row of symbols in the paper fillet by opening or closing an extra circuit or by bringing into action an extra battery, so as to act in opposition to the battery used to make the mark in the chemically prepared fillet or sheet at the receiving end of the line wire.

The above problem was practically solved by me in the early part of 1870 between the cities of New York and Washington.

In my specifications of 1872 I also describe and show that if separate reverse currents are employed the paper is made with two rows of perforations. A portion of the instrument is shown adapted to receive a message. The pen may be used upon paper in place of the ordinary stylus to mark the pulsations by decomposition in the chemical paper. Two batteries are connected, so as to make the respective currents of equal force, or the force may be varied. Positive pulsations will be sent by one line of perforations and negative pulsations by the other line of perforations, and these will be alternated according to the position of the perforations in the paper, and these pulsations are to be of a character adapted to operate the receiving instrument at the distant station. The receiving pen or stylus may also be vibrated when chemical paper is used.

Geo. Little, C. E.

The Automatic Telegraph Company.

The Automatic Telegraph Company have recently established a number of additional auxiliary offices in this city, so that persons who desire to avail themselves of the cheap rates for telegraphing established by this Company, and their facilities for prompt and rapid transmission of business, can find accommodations for so doing without the necessity of visiting the main office. The advertisement of the Company, which will be found in this paper, will show the comparative cheapness of their charges for telegraphic service, and the location of the offices.

We understand that the Automatic Company is being very liberally patronized, and gives much satisfaction to its customers by the promptness and reliability of the service rendered.

[illegible] establishments will furnish the remainder.

Automatic Telegraphy.—An automatic telegraph has been tried between Adelaide and Melbourne, and it is stated with considerable success.

Engng Dec '73

[illegible] portion of the work.

The Latest Application of Electricity.—The Automatic (Fire) Signal Telegraph.

Since the time when Sir Walter Scott pronounced his eloquent eulogium upon James Watt, that "potent abridger of time and space," so marvellous has been the progress of invention in the improvement of the locomotive and the steamship, and particularly in the application of electricity through various stages of increasing serviceability, that its subject himself, hardly less than the "bard" who pronounced it, would be startled almost into incredulity by the audacious ingenuity which, in the most advanced nations, has completely transformed the aspect of their civilization. It is not our present purpose to yield to that fascinating temptation which would set us about stating in a detailed and sequential form what these developments and inventions are, but to call the attention of our readers to the latest, and, so far as we know, the most interesting and surprising adaptation of human control over the electric fluid.

17

We are indebted to Mr. W. B. Watkins for this wonderful invention. This gentleman, originally a dry goods merchant in New York city, having for several years employed himself in the endeavor to discover some means of obviating the great damage done by water at fires, on account, chiefly, of the headway made before the possible arrival of appliances for extinguishing them, in the year 1870 procured his first patent for an invention by which a fire was itself made to give an alarm in its incipient stage, thus inducing the earliest possible use of the facilities already in employment for the purpose of putting out conflagrations. Between that date and April, 1873, he took out other patents for the protection of the several improvements he successively introduced, and during the following summer the Automatic (Fire) Signal Telegraph Company was formed, with the following officers and directors, who, by the way, all of them still hold their respective positions: President, John C. Beale; General Superintendent, J. E. Fenn; Directors—E. W. Crowell, David Solomon, J. Boorman Johnston, John C. Beale and Wm. B. Watkins.

These gentlemen immediately entered into negotiations with the Committee on Fire Patrol of the New York Board of Fire Underwriters to secure a connection with that body, and arrangements were made whereby the Fire Insurance Patrol stations were constituted the terminal offices for the company's fire circuits, and since that time Mr. Watkins' invention has been employed as the most effective of recent accessions to the utility of this organization. The next few months were occupied in perfecting the system and apparatus of the company, and late in the fall of 1873 it commenced active operations.

Shortly after, the attention of the Board of Fire Underwriters being directed to this system, they, after careful investigation, became fully satisfied in regard to the benefits to be derived by the insurance interests from its general introduction, and accordingly adopted resolutions granting a reduction of insurance rates to all property protected by this company's apparatus.

Our readers are already aware that the Patrol is a body of firemen employed since 1839 by the Board of Fire Underwriters, and is an organization entirely independent of the city Fire Department. In case of fire they do their utmost to extinguish it, since the invention of Mr. Babcock's Extinguisher, by means of this contrivance; or, failing in this possibility, they protect, so far as they can, the endangered property by covering it with waterproof tarpaulings inside the building, or removing it into the street and protecting it there by the same means. It is plain that such an invention as Mr. Watkins' must be of incalculable value to this organization, and since its association with the Automatic (Fire) Signal Telegraph Company its usefulness has been greatly promoted.

An inspector in the service of the telegraph company is now to be found both night and day at every Fire Insurance Patrol, and his duties are to see to the instruments, and when a signal is given to communicate with the Patrol. He is anticipated in this latter duty, however, so far as indicating the necessity of the services of the Patrol goes, for the moment his bell commences to strike, the intelligent horses, who have stood ready harnessed, rush from their stalls, and the firemen have made ready to go out almost with the completion of the signal, which, as we shall presently see more particularly, gives not alone the street where the fire is located, but the number and which floor of the building is attacked. This is a great advance upon the capability of the Fire Department, which is yet dependent for signals altogether upon the old fashioned pole boxes, which merely indicate the district in which a fire has broken out.

But to explain more minutely by what means the wonderful results we have already indicated are brought about by the new Automatic Alarm: Let us suppose the case of a building in Broadway in connection with the Patrol in Murray street. It consists of five stories. Placed along the ceiling, at intervals of twenty-five feet in each of these stories, is a number of what are called thermostats. These are small instruments consisting of a brass tube, in which is placed a compound metallic coil, composed of two metals of unequal expansive and contractive power. By the action of heat upon this coil it expands until it touches an adjustable screw, which projects through the side of the tube. By this means a connection is formed with a galvanic battery through the wires by which the thermostat is connected with a larger instrument, called the transmitter, one of which is to be seen on every floor of the building. The electric current operating through a magnet in connection with the kind of clock work of which the transmitter partly consists, conveys a signal to the Patrol station. Three slow beats of the bell indicate the street and number of the house from which the signal has come, and rapid strokes, immediately succeeding them, the floor. In short, all necessary particulars for the use of the Patrol are available in almost a flash from the time when the atmosphere of

18

THE TELEGRAPHER
A JOURNAL OF
ELECTRICAL PROGRESS.

J. N. ASHLEY, - - - - - - - - - - PUBLISHER.

SATURDAY, OCTOBER 3, 1874.

VOL. X. WHOLE No. 420.

My Last '73.

WELL, boys, I'm done with the business—
My fingers are stiff at last,
And I'll never jerk the lightnin'
Like I did in the days that's past.

My "battery" is busted,
The "vitriol" all played out;
There's no more "local current"
Than you'll find in an old eave's spout.

My "magnets" have lost their power,
My "key" all covered with rust;
I hate to "cut out" forever,
But I must, for I can't adjust.

I've "pounded brass" for a livin'
Nigh onto forty years,
But the click of the "giant sounder"
Don't come to my weary ears.

I can't go back on "paper,"
For my sight begins to fail;
And I couldn't tell, to save me,
A "pole" from an old fence rail.

I feel the "relay" workin',
But cannot hear the sound.
I can't tell by these "patent fixins,"
The "cut out" from the "ground."

To-day the "circuit" busted,
And I done my level best
At testin'; but, to save me,
Couldn't tell "east" from "west."

I tried to "screw up" for "X" to-day—
For I thought he was callin' me—
But with the magnets rakin' the armature,
I couldn't a worked with "B."

So, I says, old man it's comin',
You've surely had your day.
When you try to "adjust" by turnin'
The "screw" the other way.

So I wrote the train despatcher
That my day had come and gone;
If he had another man, I wished
He'd send him right along.

"On No. 3," he told me,
I can see the head lights shine.
So now I say good-bye to all
The "old boys" on the line.

Farewell! may Heaven bless you.
I can hardly hold the key;
Tears come when I try to say it,
My last long "73."

I. C. EDWARDS.

The Boston Industrial Exhibition.

THE fair of the Massachusetts Charitable Mechanics' Association has been open at Boston for two or three weeks past, and is very complete and successful, as the exhibitions of this association always are. They are held but once in five years, and are a notable event in New England.

A correspondent sends THE TELEGRAPHER a brief account of the electrical and telegraphic instruments and apparatus on exhibition, which will be of interest. He writes that there is nothing especially new or interesting in the applications of electricity, unless we except the remarkable magneto-machine of Mr. Moses G. Farmer.

Mr. Charles T. Williams, the well known and long [illegible] manufacturer and dealer in electrical and [illegible] Street, Boston, has a [illegible] exhibition, which [illegible] and highly [illegible] de- graph apparatus, electric bells etc., which are well made.

Messrs. Welch & Anders exhibit Anders' magneto-printer and magneto-dial instruments. The magneto-printer operates very efficiently and with considerable rapidity—as high as thirty words per minute being obtained on it.

The Gold and Stock Telegraph Company exhibit the celebrated Gray & Barton printer, and also a pair of the repeating instruments used in the business of the Company.

Mr. Edwin Holmes exhibits his well known and highly successful burglar alarm, which has been so generally introduced.

Another firm show many forms of the French annunciators and house telegraphs.

Press Telegraphing in Great Britain.—Inefficiency of the Postal Telegraph.

IN the *New York Tribune*, G. W. S., its London correspondent, writes, under date of September 3d, in regard to telegraph matters in connection with the press as follows:

Of the curious views which some people who might know better entertain about journalism, a specimen has just turned up. I find in an important periodical two references to the report of Prof. Tyndall's address. It is described as occupying eight and a half columns of *The Times*, and every word of it, we are told, "was transmitted by telegraph at an immense cost to the leading journal." The telegraphic despatch is again mentioned in the same periodical as "one of the latest wonders of journalism, the cost of which, it is manifest, must have been enormous." I quote from *The Publishers' Circular*, which, concerning itself with practical matters touching literature of all sorts, ought to be better informed about the literature of journalism, and the expense of putting it in shape to be read. There is something ludicrous in the notion of enterprise and expenditure in getting Professor Tyndall's address. Whether the address was telegraphed at all may be doubted. It was in type in London some days before the meeting of the Association in Belfast. That copies were deposited with the principal journals of London may be inferred from the fact that one evening paper published extracts from the address some hours before it was delivered. It would be odd if no copy were sent to *The Times* office, or if their Belfast correspondent did not know that one had been sent, and so treated them to a telegraphic copy. Even in the latter case the expense would not cripple the paper. The actual cost which *The Publishers' Circular* speaks of as "immense" and "enormous" would be about nine pounds sterling, or $50 in currency. I believe I have explained before that the English press gets its telegraphing done at very cheap rates. The ordinary rate for a telegram between any two places in the kingdom is one shilling for twenty words, addresses free. When the Government took over the telegraphs, a clause was put into the act securing to the newspapers the privilege of receiving one hundred words for one shilling. That is the price they now pay. In a *Times* column of solid minion there are about 2,100 words. If telegra- phed, the column comes as near as possible to $5. This is rather less than the $2,100 gold we should have the pleasure of paying the Anglo-American Company for the same quantity of matter.

It is remarkable that the London papers, notwith- standing the cheapness of the inland telegraph, do not use it freely. One reason may be the inaccuracy of it, though special efforts are made to do good work for the papers. The meeting of the British Association is more fully reported by telegraph than most others, and a statement about it, either official or from official sources, has been published. The whole number of words transmitted during its six days' session to the English, Irish and Scotch press was 405,000. The cost is not mentioned—that would reduce the importance of the event too much—but the sum which the newspapers of the whole United Kingdom paid was a little over £200. I should say that *The Northern Whig* of Belfast spent just about the same amount for its extra reporting. The Post-office desires to have it understood that some of the wires between England and Ireland are out of order. There are 22 in all, contained in four cables, and seven out of the twenty-two were under repair. The remaining fifteen were asked to transmit on the busiest night of the meeting 80,000 words—and failed. The official account remarks that some portion—it does not say how much—of the matter telegraphed was "necessarily" too late for publication next morning. The sections adjourned at three in the afternoon, the papers go to press at four or later next morning, and, if the matter was reasonably handed in, one does not quite see the force of the "necessarily." Deducting two wires for the Anglo-American Company—of which they have the exclusive use between London and Valentia—there remain thirteen wires, which were asked on this one occasion to transmit less than 600 words each per hour, plus the ordinary business, and "necessarily" failed. But the official apologist for the Department thinks that, having regard to its "vastly diminished resources," the work was "singularly well done."

Cuba Submarine Telegraph.

THE directors in their report state that the gross receipts for the half year ending 30th June amount to £7,825, ordinary expenses to £1,930, leaving a balance of £5,895. The extraordinary expenditure for the repair of the cable has, however, amounted to £21,747, absorbing the whole of the balance of the reserve fund £12,283, the above balance of the half year's revenue £5,895, and leaving the sum of £3,567 to be carried forward to the debit of the current half year's account. They regret that the result is not more satisfactory. This is to be explained by the fact that the steamship Investigator, despatched by the Telegraph Construction and Maintenance Company in the beginning of December last year, took double the time to effect the repair to the cable that was anticipated, in this way doubling the cost of repair, and at the same time shortening the period during which the cable has been at work to about three months of the current half year. The receipts since the restoration of the cable have been satisfactory, and show a material increase on those of the corresponding period last year. The whole of the new capital authorized by special resolutions passed at the extraordinary general meeting of 12th of June last, was subscribed by the shareholders, and the contract for the new cable has been duly entered into with Messrs. Hooper's Company. The manufacture of that cable is now nearly completed, and the steamship Hooper is expected to sail in the beginning of next month to lay it. Instead, however, of landing the cable at Santiago de Cuba, it has been agreed, on the suggestion of the West India and Panama Company to carry it to Holland Bay, Jamaica, that company paying for the additional length required, but without thereby acquiring any property in the cable, which will remain the sole property of this company. By this arrangement, not only will a duplicate means of communication be provided over the whole of this company's system, but the extremely important section of the West India and Panama Company, between Cuba and Jamaica, will also be duplicated—an object of only greater importance to that company than it is to this. Arrangements are also in progress whereby it is believed the differences between this company and the West India Company will be brought to an amicable settlement, and a suitable vessel provided and stationed in the West Indies for the repair of both companies' cables. The cable of the Central American Company, referred to in the fifth paragraph of the special report submitted to the general meeting of 12th June last, has only been laid thus far from Para to Cayenne. The remaining section to Demerara is expected to be laid in November, and will then complete telegraphic communication between North and South America *via* the West Indies—a connection which, as previously stated, is expected to result in a very large increase of traffic to this company. Notwithstanding the diminished income for the working of the past year, owing to the length of time occupied in repairing the company's cable, the prospects of the company are better than at any former period. With duplicate lines of cable from England to the United States, thence as far as Trinidad (as will shortly be the case when the cable now in course of manufacture for the West India and Panama Company has been laid), and with the communication between South America and the West Indies established, there is every reason to believe that the company will be in a position to pay regular dividends to its shareholders, and, at the same time, lay aside a substantial sum to provide for any extraordinary repair or other contingency, which can never, under these circumstances, affect the prosperity of the company so seriously as it has done in the past.

A Telegraphic Blunder and What Came of It.

MR. GIBSON, solicitor, writes to the *Times* that at the recent Assizes for Kent it became his duty to telegraph to a plaintiff and witnesses to attend the court on a particular day, and instructing them to travel by the "seven-thirty" train. The action was for breach of promise of marriage, and when the case was called on the plaintiff and her principal witness were absent. The case was so fortified by other evidence that counsel advised it should proceed, and the plaintiff obtained some damages, but not without strong and damaging observations by defendant's counsel upon the absence of the plaintiff and her family witnesses. A few minutes before the jury gave their verdict (about one o'clock) the plaintiff and her father came into court, and then produced a telegram directing them to travel by the "eleven-thirty" train—just four hours after the time appointed by my telegram. On inquiry it turns out that some one in the Post-office employ (elsewhere than at that town, though the

10

Edison's Motograph.

W. T. Sprague, replying to an inquiry regarding this instrument, a description of which is given in his book, "Electricity: Its Theory, Sources, and Applications," lately published, says:

"I wished to include in my work the latest discoveries in electricity; hence I gave a description of the motograph. But when I wrote there was no other account extant, except that which I used; nor was an instrument in existence in England. One was subsequently brought over and exhibited at the Soirée of the Telegraph Engineers, where I saw it, and therefore added a few lines in the revision of my book before publication. I clearly understood the principle of the instrument; but it appeared to me best to use Mr. Edison's own description, notwithstanding the somewhat peculiar and confused style in which it was written.

I will now endeavor to make the matter more intelligible—as to its principles, that is to say.

All recording instruments (not counting those which print in letters, though they really come under the same generic principles) consist of a roller, which supports a band of paper drawn through the instrument, and of a style or pen pressing on the paper. In the mechanical recorders, such as the Morse, this style is attached to the armature of an electro-magnet, and when a current passes it is pressed on the paper, so producing marks; when no current passes, it leaves the paper, which moves along unmarked. In some cases the reverse principle has been used, and the signals are shown by the absence of marks—that is, by spaces, instead of lines and dots. In chemical recorders—of which Bain's is the original and type—there is no magnet: the style presses continuously on the paper, which is moistened with some liquid capable of electrolysis and of union with the metal of the style when the current passes. A common form consists of an iron style and paper moistened with ferrocyanide of potassium. When no current is passing, no action occurs; but so long as a current passes, the solution is electrolysed, acts on the style, and forming Prussian blue, makes a blue dot or line on the paper.

Now Edison's discovery is based on a very simple observation, but one which he alone has noticed. It reveals a new action of the electric current, which appears to open as new a line of scientific research and of practical application as did Jacobi and Spencer's observation of the effects of the deposit of copper in the Daniell cell, which is the basis of our modern art of electro-metallurgy. He simply noticed that while the current passed *the paper became slippery*, and ran more quickly through the machine. He now tried the effect of attaching a spring to the style, and behold! mechanical motion is produced capable of varied modification. The style will ring a bell while the current is passing, or will act as a relay and send a current mechanically, repeating the signal in one or a thousand new circuits. I caught sight of the instrument standing on a table unnoticed at the conversazione,

20

THE OPERATOR.

1875

and before seeing its label, at once recognized it, and took the opportunity of a careful examination before others had discovered it. My friends laugh at me because I button holed them one after another and led them off to see something worth looking at; but after a time it was a hard matter to get a good look at it, as, once discovered, it became the attraction of the evening. The *fact* is that the instrument itself is nothing: it is a scarcely noticeable alteration of the common Bain's recorder. It is the *principle* which is important. Instead of a simple style or pointed rod, there is a rod fixed upon a rocking-cradle held by a spring. A thousand people might see it and think it was nothing; but it is a cradle with an infant lying in it, whose future only the few prophetic minds can catch a glimpse of; and it must be remembered that only the prepared mind can ever understand the prophetic utterances. In the vision of the Apocalypse, how often is it said, "He that hath an ear, let *him* hear." It is so in science. Edison's description of his discovery is confused in language (in fact, I suspect it has passed through the hands of two or three compositors before it reached me), and it is only he "that hath an ear" who can grasp its meaning. I think "H.B." can catch it, if he listens to the echoes of it which I have repeated; but if not I will enter into further explanation.

21

The "Ticker" in Wall Street.

Joaquin Miller relates the following scene familiar to most New Yorkers, but not to those who are less acquainted in the ways of this metropolis or the mysteries of Wall street:

"I went to a broker whom I had met at the Union Club," says Mr. Miller, "and told him what I wanted to learn. He kindly took hold of the tape which continually streams out from the 'ticker,' as the little wheel of fortune is called, which constantly records the rise and decline of stocks, and tried to explain all about it.

"I found it impossible to get interested. There were about 200 different names of stocks on the list. These were represented by one, two, or three letters, or figures, or some sort of abbreviated word that I could not understand or distinguish, and was constantly getting confused.

"Around this 'ticker' gathered and grouped a knot of eager, nervous, and anxious men. Ten, fifteen, or twenty at a time would clutch at the tape, as it streamed out with its endless lines of quotations, and mutter to themselves, jabber at each other, swear like pirates, drop the tape, and dash away. Others would dart in, clutch the tape, swear or chuckle as their fortunes went, wheel about, give orders to their brokers to buy or sell, as they prophesied the future of the market; and so it went on all day from 10 till 3, when the battle was ended by the fall of the hammer in the Stock Exchange.

Scientific American Oct 1880

respond with the varying lengths of the telegraphic characters, and thus a uniform space is ensured between the successive characters, however greatly their respective lengths may vary. Many experiments were made, in connection with this perforator, with the Bain system of transmission, which had been somewhat modified and improved by Humaston, on the lines of the American Telegraph Company from 1861 to 1866, in which a speed of 100 to 120 words per minute was attained upon ordinary circuits, but the system was never brought into actual service.

1022

AUTOGRAPHIC TELEGRAPHY.—Autographic telegraphy or the process of transmitting messages in the actual handwriting of the sender, has occasionally during the past 30 years constituted the special study of scientific minds. So long since as 1850 Mr. F. C. Bakewell invented a copying telegraph by means of which autographic telegraphy was effected, and this was probably the first time it was effectually accomplished. In this instance the message was written by the sender with a gummy ink or varnish on metallic paper or tin foil, and this writing was by the aid of mechanism used to actuate electric currents in such a way as to produce a record at the distant station by the chemical decomposition of a solution with which the receiving paper was damped. Both the written message and the paper were fixed around cylinders of similar form and dimensions, one being placed in the transmitting and the other in the recording instrument, and the cylinders were caused to revolve with corresponding velocities. Each time the gummy, and consequently raised, lines of the writing were crossed by a pointer under which the metallic paper was traversed in the transmitter, a mark corresponding in position was made on the prepared paper at the receiving end. It therefore followed that the sum of all the marks reproduced the writing itself. Mr. Bakewell successfully reproduced the writing in white on a blue ground, but the process failed to become one of public utility owing to the extreme slowness with which the apparatus worked and the difficulty that was experienced in maintaining uniform and synchronous motion in the instruments. In 1856, the Abbé Caselli, in Italy, endeavoured to solve the problem of autographic telegraphy in a similar manner. His apparatus was exhibited in England, and it was used practically between Paris and Marseilles and Paris and Lyons. Plans, drawings and autographic sketches were faithfully reproduced at distant places, but it was found that the apparatus had not only the defects of Bakewell's but it was very costly and complicated. Two other subsequent workers in this direction were M. Meyer and M. Lenoir, who tried to accomplish the same results with ordinary ink. They, however, pursued their investigations quite independently of and unknown to each other. We have recently been afforded the opportunity of examining the latest example of this class of apparatus at the General Post Office, where it has been submitted to the authorities for trial. This is the invention of M. d'Arlincourt, of Paris, and its general principles are similar to those which govern Bakewell's system. The distinguishing feature in D'Arlincourt's apparatus, however, is the introduction of an extremely ingenious synchronous movement, by means of which the speed of travel of the cylinders is rendered uniform, both in the transmitting and the recording machine. The message to be sent, which may be either in the ordinary hand or shorthand, is written with a thick gummy ink upon a strip of metallic-faced paper about 12 inches long and 2¼ inches deep, which is wrapped around the cylinder of the transmitting instrument. A strip of white paper chemically prepared and of similar dimensions is placed on the cylinder of the recording apparatus, and the instruments are placed in electrical connection and started. The raised writing, actuating the electric current, causes a reproduction of the original message in *fac-simile* on the paper in the recording instrument, which may be hundreds of miles away from the other. Upon the occasion of our visit the two instruments, although in the same room, were practically placed 200 miles apart. The writing can be reproduced in either blue, brown, red, or black, according to the chemical preparation of the paper, but always on a white ground, and a number of copies can be taken from one original. In the same way, sketches, plans, or drawings may be faithfully transmitted; some sketches were, in fact, accurately reproduced on the occasion of our visit. Although the apparatus is perfect in its action, it still has one drawback, which was common to its predecessors—that of slowness of reproduction. The time occupied in revolving the cylinder a sufficient number of times to allow the pointer to traverse the whole surface of the paper is seven minutes, and this rate of speed is far below that required and attained in practice for commercial purposes. The Post Office authorities, to whom we are indebted for our inspection, do not, therefore, see their way to utilise M. d'Arlincourt's ingenious invention at present. It is, however, being worked in France in fortresses and for similar military purposes for use in which and in some special cases it is exceedingly well adapted.—*The Times.*

The Magnet - Sept - 15 - 1880

NOVEL SYSTEM OF TELEGRAPHY.

An afternoon paper a few days ago printed the following article, which will be read with interest:

Royal E. House, the last of the original telegraphers of the Morse time, thirty years ago, proposes to revolutionize telegraphy, and may do it before he dies. He is an old man, although the youngest of the leaders in the days when "far writing," which has become a fact, was regarded as a myth. He has perfected a system by which from 250 to 300 words a minute can be transmitted, received, and permanently recorded, and which is automatic. The new designs are the perfection of the old House ivory-keyed, automatic instrument of thirty years ago, and are the result of twelve years of unremitting labor. In a sentence, it is intended to make cams, cogs, levers, and electricity do the work of brains, hands, and experience; to send messages with the enormous rapidity of mechanism; to have them received and recorded automatically and without the necessary presence of an operator; to make money for the capitalized companies and to save it to individuals. If successful, it is the cheap postal telegraph system in a nutshell. The inventor calculates—and figures seldom lie—that messages can be sent by the new system at something less than one-tenth of their cost by the present improved Morse system, allowing for power, machinery, batteries, paper, and the salaries of operators and other employes.

There are four machines, or instruments, which constitute the system. Each one of them would be useless without the others. The first is built on the general principle of the type-writing machine, but instead of printing characters cuts slits of greater or less length in an interminable strip of hard and stiff Manilla paper, with pointed knives which are raised alternately through the lower and upper edges of the paper by a system of levers worked by a series of brass keys, the strip of paper passing from a wheel through a narrow brass galley and under constant pressure over the little slots through which the knives work. Foot, hand, water, or steam power may be used in running the machine, and an expert operator can strike from 150 to 200 letters per minute. The length of the slit indicates the letter to a small fraction of an inch.

This strip of paper, whose marks are not those of a punch, but cut slits in a rapidly moving strip, is then placed in a machine connected with a battery, and moves quickly through it. Two constantly revolving wheels, with sharp but not keen edges, fall readily into the slits—upper and lower alternately—of the paper, and thereby make an electrical connection with a receiving instrument at another office, with a set of knives similar to those in which the original slip is placed. The knives in the second machine cut slits of a length corresponding to those in the original, and can be read by an expert, although they can be printed in the fourth machine with such rapidity as to make handwriting comparatively tedious and useless. This last instrument prints on somewhat the same principle as the gold and stock automatic telegraph, but the letters are printed from the cut slip without any other interference than that of the power by which the machine is run.

These messages record themselves, and the presence or absence of an operator at the receiving end is of no consequence. They can be sent with all the rapidity of which perfect mechanism is capable, and will, it is claimed, average 200 to 250 words per minute, or approximate 15,000 words per hour of constant work. All delay will be in the preparing instruments, and the work then can be accomplished by operators at such times as the wires are occupied from other stations.

Perhaps the most remarkable feature of the system, and the one which will strike operators and electricians as the most improbable, is the simplest. It is that all messages can be sent to any particular station and to no other, and without being heard or repeated at any other. The "call" is so arranged in its automatic way that while the machinery is in movement in every office, the knife-like wheel only fills the call slits on the tape in the office for which it is intended, giving an automatic reply, and the similarly moving wheels in every other office, failing to fit the slits, have no impression.

which the paper is rapidly whisked by turning a revolving handle. The turning of this handle is therefore all that the operator requires to do in the act of sending a message.

The distinguishing feature of the rapid telegraph, and the source of its high speed, is the absence of spaces between each signal current composing a letter. In the old system, as is well known, each signal current of a letter or "dot" and "dash," is separated from its next neighbour by a space; and, of course, much time is lost in transmitting these gaps. In the new system the spaces are avoided by causing the receiver to mark the successive signals of the letter at opposite sides of the axis of the moving paper. Thus by the simple device of placing the signals in double file, the time lost in separating them by longitudinal spaces when placed in single file is saved, for the end of one signal may coincide in point of time with the beginning of the next, although the signals are rendered quite distinct by their side-by-side position. This arrangement will be best understood by a reference to the following diagram, which represents a portion of a message as received with the corresponding punched slip beneath.

FIG. I.

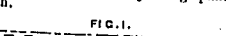
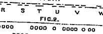


FIG. 2.



The signals themselves are dots and dashes, the latter being shorter than is usually the custom, and the space between each two *letters* is marked by a longer dash.

The transmission of the signal currents is effected by employing two batteries, one having its copper pole to line, and the other its zinc pole. The double row of holes in the punched paper transmit alternate currents from these two batteries into the line by means of the two spring points, which make contact with the metal pulley over which the paper passes whenever a perforation in the paper allows them to do so. For this purpose the pulley is made double, so that there is one point to each distinct half of the wheel. When it is known that each half of the wheel is connected to its own battery, and that both the points are connected to the line, the course of the current will be readily understood.

The marking of the message is effected in the receiver by a modification of Bain's electro-chemical process. The currents pass from the line to a pair of pointed steel styluses, which rest side by side upon a travelling slip of paper, which has been impregnated with a solution of equal parts of nitrate of ammonia and ferrocyanide of potassium. From these styluses they pass through the paper to a metal pulley beneath, and thence to earth. In passing through the prepared paper, the currents decompose the chemical solution with which it is moistened, and stain the track of the styluses with a succession of dots and dashes, the shorter currents marking dots, and the longer ones dashes. The blue stains are due to the formation of Prussian blue.

The American rapid telegraph is the invention of Messrs. Theodore M. Foote, C. A. Randall, and Frank Anderson, and was first put into practical operation on the 19th July last between Boston and New York. The ordinary rate of working over this line, a distance of 250 miles, is 1000 words per minute, but the apparatus can readily work up to 1800 words per minute. The American Rapid Telegraph Company is succeeding so well with it that, though they began business so recently, they will soon possess their own lines from New York to Washington, Cincinnati, and Chicago.

A practical trial of the apparatus has been made on some of the longer English lines by Mr. W. H. Preece; but the induction which is so strong on our lines has reduced the speed of working considerably, and lengthened out the signals by its retarding effect. In fact it has not proved so rapid as the Wheatstone system now employed by the Government electricians, and in the mean time the use of the apparatus is in abeyance. On the American line there is little or no induction, owing to the fact that it has been as yet operated along a line carrying only one wire; but the inventors hope yet to improve its speed on English lines. The apparatus shown at the Society of Telegraph Engineers has, we believe, been taken over to Paris, in order to try it on the Submarine Company's line from Paris to London.

Engineer Oct. 15. 1880

23

Engineer Oct 15 1880

A NEW TELEGRAPH MACHINE.—Mr. Royal E. House, the last of the original telegraphers of the Morse time thirty years ago, has, it is said, perfected a system by which from 250 to 300 words a minute can be transmitted, received and permanently recorded, and which is automatic. The first is built on the general principle of the type-writing machine, but instead of printing characters cuts long slits of greater or less length in some strip of hard and stiff Manilla paper, with pointed knives, which are raised alternately through the lower and upper edges of the paper by a system of levers worked by a series of brass keys, the strip of paper passing from a wheel through a narrow brass galley and under a constant pressure over the little slots through which the knives work. The length of the slit indicates the letter to a small fraction of an inch. The strip of paper, whose marks are not those of a punch, but cut slits in a rapidly moving strip, is then placed in a machine connected with a battery, and moves quickly through it. Two constantly revolving wheels with sharp but not keen edges fall readily into the slits—upper and lower alternately—of the paper, and thereby make an electrical connection with a receiving instrument at another office, with a set of knives similar to those in which the original slip is placed. The knives in the second machine cut slips of a length corresponding to those in the original and can be read by an expert, although they can be printed in the fourth machine with such rapidity as to make handwriting comparatively tedious and useless. This last instrument prints on somewhat the same principles as the gold and stock automatic telegraph, but the letters are printed from the cut slip without any interference than that of the power, by which the machine is run. These messages record themselves, and the presence or absence of an operator at the receiving end is of no consequence. They can be sent with all the rapidity of which perfect mechanism is capable, and will, it is claimed, average 200 to 250 words per minute, or approximate 15,000 words per hour of constant work. All delay will be in preparing the instruments, and the work then can be accomplished by operators at such times as the wires are occupied from other stations. Perhaps the most remarkable feature of the system and the one which will strike operators and electricians as the most improbable is the simplest. It is that all messages can be sent to any particular station and to no other, and without being heard or repeated at any other. The "call" is so arranged in its automatic way that while the machinery is in movement in every office, the knife-like wheel only fills the call slits on the tape in the office for which it is intended, giving an automatic reply, and the similarly moving wheels in every other office, failing to fit the slits, have no impression. 28

2.24

THE AMERICAN FAST SPEED AUTOMATIC TELEGRAPH.

28

SOME trials have recently been made on the Postal Telegraph wires of a fast speed automatic telegraph system, the invention of Mr. T. M. Foote, of Brooklyn, and F. Anderson, of Peekskill, America. Although on the longest circuits the system failed to attain the speed given by the Wheatstone instruments, yet on short circuits very high results were given, and the system therefore merits a description.

As in the Wheatstone instrument, the currents in the transmitting portion of the apparatus are controlled by a perforated slip of paper; the latter is shown by fig. 1.

A peculiarity in the system consists in the fact that each signal is formed by either one positive or one negative current, and that two currents of a like sign never immediately follow one another—that is to say, a positive current always follows a negative, and a negative a positive current.

The perforated slip is passed over a metallic roller, W (figs. 2 and 3), which is divided into two insulated halves, which are respectively connected to the zinc and copper poles of a split battery earthed in the middle. Two brushes, *b*, b^1, both connected to line, press on the two halves of the rollers and make contact with one or other half as they drop through the perforations in the paper slip when the latter is moved over the roller.

At the receiving end of the line a chemically prepared paper (as in the Bain system) passes under two metallic styles which press on the roller, W; one style being connected to line and the other to earth, as shown in fig. 3. According, therefore, as a positive or a negative current flows to line a mark is made on the upper surface of the paper by one style or the other.

Let us now suppose the slip represented by fig. 1 is turned round and passed from left to right over the roller, W, and under the brushes, *b*, b^1, then the brush, *b*, first drops through the first perforation and sends a short zinc current, which represents the first dot of the letter A. The brush, b^1, next drops through the first of the two perforations on the upper edge of the slip, fig. 1, and sends a short copper current to line, which is immediately followed by a second short copper current from the brush, b^1, making contact through the second per-

foration; two dots close together are thus formed, but the condenser, C (fig. 3), being charged by the current, discharges itself when the brush is passing over the small interval between the two dots, and this discharge current at the receiving end practically turns the two dots into a dash.

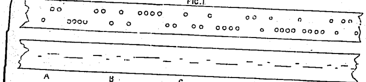
Inasmuch as the dash is not formed by a current left on for a lengthened period, but by two successive currents filled up between, as it were, the condition of the line when the brush leaves the second perforation is the same as it would be if the brush had only passed over a single perforation; thus, after a dash has been formed the line is perfectly clear to receive another signal. After the letter has been completed a dash formed by four perforations close together is produced, which spaces the letter from the succeeding letter.

Now, supposing that it were required to signal two letter A's one after the other, then if we look at the left-hand end of the perforated slip, fig. 1, we can see that if the relative positions of the dot and dash perforations were the same in both cases two distinct signals would have to be formed by similar currents immediately following one another, thus we should have two A's formed as follows:— . ˙˙ . . . . . ˙˙ If, however, we wish positive and negative currents to succeed one another alternately, we should require to have the perforations arranged as follows, . ˙˙ . . . . ˙ . .; in other words, we require to have the position of the perforations representing the second letter A reversed. Now, if all the letters were formed by an *odd* number of signals the reversals of the currents would always take place correctly, but inasmuch as some letters are formed by an even number of signals and some by an odd number, it would be necessary that the perforations representing these letters be reversed continually. The mechanism by which this end is effected is highly ingenious and effectual, though complicated. The perforations are made and arranged by means of mechanism actuated by a key-board similar to that of a Hughes type printer.

Although the system has not been entirely successful in this country, in America it has been worked to a speed of 1,500 words a minute, but this has been obtained with a circuit on an independent line of poles, and with a wire of a large gauge.

The Wheatstone apparatus in England, up to the present, has by no means been worked up to its greatest possible capacity; in fact, no attempts have been made to obtain a greater speed than 250 words a minute. With greater driving power and lighter moving parts a greatly increased speed is undoubtedly possible. The great advantage of the Wheatstone apparatus lies in the fact that in the transmitter, signals cannot be missed—that is to say, the perforated slip cannot move forward to cause a second contact until the mechanical action causing the first contact to be made has acted properly. Where a brush is used to make contacts there is a tendency for the former to jump across from one side of a perforation to the other, instead of dropping down between and making a firm contact.

FIG. 1.



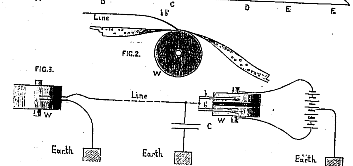


FIG. 2.

FIG. 3.

The Magnet - Sept. 15 - 1880

Electric Signals for Railroads—Successful Operation of the Union Electric Signal Company's Apparatus.

THE electric signal for railroads is no new invention, but of late it has been greatly improved. The improvements in the Union electric signal over any other safety signal yet adopted were shown yesterday upon the section of the Eastern road, below Salem, where it is now in use. It seems to be especially valuable from its extreme simplicity, and the more important fact that but one wire is used, thus making it safer, more reliable and less expensive. It only requires a single cell of the gravity battery to operate all the signals reliably through a mile section of track, and this arrangement may enable almost any road to place the cell in a switchman's house so that there can be possibly no danger of freezing in the coldest weather. The rails being connected by a wire fastened to a pin and firmly driven into the rail a few inches from the joint, makes a perfect and constant rail circuit system, and any breakage of the current, by moving a switch, breaking of a rail or laying a rail across the track, will instantly set the danger-signal and prevent derailment or collision. There is also an over-lapping system, by which the train, as it enters a section, sets the danger signal in front of the engineer, so that he may know that it is in operation. After passing on to the third section, at least 1,400 feet, the engine reaches a relay signal that at once releases the first danger signal, thus practically keeping one whole section behind unoccupied, and if by any cause a car breaks away and remains standing upon a section, the danger signal remains set behind, so that it is impossible for a collision to occur. The usual attachments of crossing, warning and station bells are used. By this arrangement the bell rings when the train enters the section, and stops ringing when it stops at the station. To these admirable arrangements for safety can be added an interlocking switch system that would seem sure to prevent collisions no matter whether the switchman was forgetful or whether the switch was criminally tampered with. By an ingenious and at the same time plain and practical piece of mechanism, the switch is so locked that when a train is upon the section moving in either direction the switch bar remains immovable; even the destruction of the entire switch frame will not release the bar so that the rails can be moved out of position. When the switch is changed a distant danger signal is set, as also when a draw is opened, and by a little repeater in the switch-house the man in charge knows that that distant signal is operating and he is protected. These are among the most important features of this new system of electric signals, and, devoid of all technical terms, the whole system resolves itself into what may be called a perfect constant circuit system, easily and cheaply maintained, furnishing in all weather a full flow of electricity with a sufficient reserve force for unusual demands, and at the same time, when from any cause whatever the circuit is broken, a danger signal is at once set and remains set until the circuit is closed. This system can be managed by hand also. It has been tested and is now in use on the Fitchburg, Old Colony, Pennsylvania Central, Michigan Central, Chicago, Burlington and Quincy and other western roads, and everywhere gives perfect satisfaction, as it works just as well in snow and ice as in the heat of summer. A party consisting of some newspaper men, President Phillips of the Eastern road and some of his subordinates; J. Gardner Sanderson, general manager of the signal company, Oscar Gassett, superintendent; Mr. Bates, foreman, and several railroad men yesterday rode to the section between Salem and Beverly, witnessed the practical operation of the signal, and examined the system carefully. Upon the return trip a visit was made to the Eastern railroad car-shops at Salem, and upon reaching Boston, the shop of the signal company was visited, and a model of the whole mechanism was inspected.—*The Boston Daily Globe.*

Menlo Park Scrapbook, Cat. 1043

No. 29. "Telegraphy - Facsimile"

This scrapbook covers the years 1874-1880, but most of the clippings are for 1879. The material relates primarily to facsimile (autographic) telegraphy. There are also a few clippings about vote recorders. The book contains 138 numbered pages.

Blank pages not filmed: 2-5, 30-138.

1043

Telegraphy Fac Simile

29

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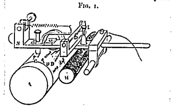
MEYER'S AUTOGRAPHIC APPARATUS.

Caselli, the abbot, was the first to reproduce at a distance, by telegraph, the exact facsimile of the despatched message. His electro-chemical instrument, used for many years in France, was on view at the 1867 Universal French Exhibition.

About that date M. Meyer, without recourse to chemical decomposition, succeeded in reproducing the facsimile in ink upon ordinary paper. His apparatus greatly simplified Caselli's, which it substituted from the year 1868. Its description is as follows:—Upon a brass or wooden table is placed a clockwork movement. On one side of it are a cylinder and slider, mediums for transmission; on the other side are the spiral cylinder and endless paper for the reception of messages. The motor is a weight, and the motion is regulated by the vibrating pendulous stem whose function is to establish a regular and synchronical action between the sending and receiving stations. There are therefore three portions to describe, viz., the transmitter, the receiver, and the synchronism system.

The Transmitter.—The sender writes his message with an insulating ink upon a certain limited surface of metallic paper, sometimes as large as 1 decimetre, but more generally for the public, 30 square centimetres. As to the metal-paper, it is the usual tin or silver paper of commerce. The despatch, design, or whatever may be on the paper, is wound round the cylinder A, which is 1 decimetre in circumference, and turns with a speed of 75 revolutions a minute. Upon a support, parallel to the cylinder's axis, slides the slider, furnished with the style, or platinum point, C. I is a screw whose point

Fig. 1.



enters into the thread of the endless screw H, which in turning moves the slider from right to left. When the cylinder A makes one revolution the slider advances ¼ of a millimetre and the style C describes a complete helical turn. The cylinder continuing to revolve, the style performs upon its circumference a helical line whose spirals are distant ¼ of a millimetre from each other. Now, as the message to be transmitted occupies the surface of the cylinder, all the points* of the message are successively in contact with the style, which, in its course, alternately touches an inked and a metallic surface in an irregular order, according to the contents of the message. The current passes during the passage of the style over the metallic-paper surface; it is interrupted on the insulated ink part, and it is this succession of makes and breaks which

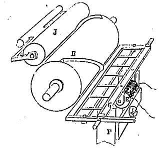
* Excepting a very fine spiral line, ¼ m.m., or nearly 1-100th of an inch, broad.

constitutes the autographic transmission. The current from the battery divides in the sending portion of the instrument into two branches; the one by the line wire, and the other to earth through the slider and the brush, D, which rubs against the metallic sheet of the message.

The result of this arrangement is that the battery always works, and it is the position of the style C which determines the distribution of the current by one or the other circuit. When it rests upon the metal the local circuit is closed; all the current goes to earth through the style, the metallic surface, and the brush: and the line—on account of its great resistance—receives only a branch current which may be neglected. On the contrary, when the style passes over the inked portion, the local circuit is interrupted, and the whole battery charge goes to line. There is therefore an emission of the current on the line every time that the style passes over the writing, and a breakage of the current or discharge to earth every time the style touches the metal-paper.

The Receiver.—We now shall describe how these successive currents reproduce, in an exact form, the transmitted message. The principal part is the

Fig. 2.



helix B—a cylinder having upon its surface a metallic helical band, 1 decimetre in length, and embracing the whole of the circumference. Above it a roller, saturated with an oily ink, freely revolves, and moistens the projecting band of the helix. Below it is placed a lever, G, in the form of a printer's frame or chase. The edge of this chase, during its oscillations, strikes against the inked band of the spiral. In order to receive the printings an endless band of paper is made to unroll around this edge. The paper follows the movements of the chase. It is 1 decimetre in size, and the width of the cylinder B. The paper band, pressed between two revolving cylinders, unrolls itself ¼ m.m. per turn of B. It has been shown that the style advances the same quantity for each revolution of the cylinder. Consequently the surface of the paper band run out in a given time is the same as the surface traversed in the same time by the style. When the cylinder B makes one turn its band traces upon the paper a straight transverse line in ink, which is repeated for each turn. These successive transverse lines, distant from each other ¼ m.m., for all purposes touch and form upon the band of white paper a blue ground. Thus the cylinder B is the writing medium of the apparatus. At the lower part of the lever G is screwed E, a small straight electro-magnet, whose soft iron bar serves for an armature to F—a permanent horse-shoe magnet. When the coil is traversed by a current the extremities of the core take the same polarities as the poles of the permanent magnet, and the lever G is then repulsed. The edge of the chase quits contact with the cylinder, and some white appears on the paper,—in size according to the length of time the current traverses the coil of the electro-magnet E. On the cessation of the current the core of the magnet E is attracted by the permanent magnet F, and the paper is again pressed against the cylinder.

We have previously described how, at each passage of the style on the ink, the battery current flows to line. This current works a relay at the receiving station.

Now the cylinders A and B perform their revolutions in the same time. The slider C describes then as many spirals upon the cylinder A, and equally spaced, as the cylinder B traces parallel dashes. Thanks to the synchronic movement which animates the two apparatus, the course of the slider rigorously coincides with the rotation of B, and when the style is found at the commencement, in the middle, or two-thirds of the circumference of the cylinder A, B presents to the surface of the paper a point at the commencement, or in the middle, or two-thirds, of the paper band in the direction of its breadth. Consequently all the inked parts which meet the style during the first revolution are interpreted, at the receiving end, by dashes corresponding in length with the duration of the passage of the style over the ink. The same takes place for all succeeding turns.

The success of the invention depends on the mechanism by which the movements of the instruments at the receiving and sending stations are controlled. The regularity, as before mentioned, is obtained by the use of a conic pendulum, which is a stem supporting a ball of a certain weight. When two pendulums thus constructed are set in motion to the same pitch, they describe sensible isochronous amplitudes, maintaining the concordance of the two apparatus for several minutes—a time sufficient to traverse the whole of the cylinder.

July '76

FAC-SIMILE TELEGRAPHY.

THE one thing wanted in telegraphy by which a message may be practically transmitted over a wire and appear at the distant terminus in the *exact handwriting of the sender*, has at last been accomplished by an American electrician, Mr. W. E. Sawyer. The field opened to the telegraphic world by this invention is almost without limit.

The instruments are wonderfully simple in construction and easily comprehended.

The system is capable of transmitting over a single wire from 50 to 150 words per minute, against a possible 30 to 40 by the Morse system, which is that now in common use. But by this system a person's own handwriting is transmitted by telegraph the same as though sent by mail, and, in brief, simply accomplishes letter writing by telegraph. In order to render its operation fully understood it may be described as follows:

First, the sender of a message writes it upon ordinary white paper; the written message is then laid upon a metallic plate and passed between two rollers, with the effect of transferring the copy to the plate, which may be done any time within ten hours after writing. Then the plate containing the copy is placed upon a semi-cylindrical holder which traverses a little track, and the instrument is set in motion, the whole operation up to this point having been accomplished in less time than it takes to write it; whereas, by the Morse system, quite a number of minutes elapse before the message reaches the operator. The metallic plate is a conductor of electricity, while the lines of writing are non-conductors. Over the cylindrical plate are carried metallic points upon revolving arms; whenever the point is upon the metallic surface, the electric current passes through to the wire; the instant the point touches a line of writing, the connection is broken and a dot is made upon chemically prepared paper, placed upon a similar instrument at the receiving point. The two instruments operate synchronously—*i.e.*, the moment a point is passing over the surface of one instrument, it is followed exactly by the point on the other instrument. An ingenious mechanical arrangement perfects the transmitting powers and prevents the possibility of one instrument gaining over the other. At the same time the points are moving over its surface, the plate is moved slowly horizontally, so that the entire surface is traversed. The transferred message is, of course, in reverse, but is brought straight by running the receiving instrument in an opposite direction. Each instrument is fitted to either receive or transmit, at pleasure. The rate of speed varies according to the closeness of the writing; the points traversing the entire surface of the copy, it is immaterial as to the number of words, only the space they occupy requiring a given time to be gone over. Ordinary writing will be transmitted at the rate of from 50 to 100 words per minute.

The message, as received, is ready at once for delivery, and appears in close, dark blue dotted lines, on white paper. There is no loss of time in counting the words at the sending station, as is now the case, nor delay in getting to the hand of the operator; but, in a quarter of a minute's time from its being received, it is silently speeding its way to its destination, and automatically preparing itself for delivery. The wonderful facilities of the system render it peculiarly adapted to a large and hurried business. It is the fruit of many years' close application, hence the perfection with which it makes its appearance.

The writer of a message is, of course, as usual, supplied with blanks. In the system proposed—and which is now being perfected by the company already formed to utilize this great invention—for whatever may be written upon the blank he will pay an invariable sum of money, if under 250 miles; if over, double that amount in stamps, to be furnished by the company, and used the same as postage stamps. Whatever is written upon the blank, whether five words or fifty, will be sent for the same amount. It is so much blank passing through the instruments, and no cognizance is taken of its contents.

A company called "The United States Postal Telegraph Company" has been incorporated under the laws of the State of New-York for the purpose of constructing lines and operating under the letters-patent granted to Mr. Sawyer. President, John R. Cecil, of New-York; Vice-President, A. M. Allerton, of New-York; Secretary, George R. Williamson, of New-York; Treasurer, C. A. Kittle, of New-York; General Superintendent, James G. Smith, of Hackensack, N. J.; Electrician, W. E. Sawyer, of New-York. They will start with a capital stock of $2,000,000, which is to be increased to $10,000,000, as the extension of the lines may require.—*Boston Journal of Commerce.*

2351. TELEGRAPHIC CIRCUITS, *A. M. Cla k, Chancery-lane.—Dated 25th June, 1875.*

This invention is more especially designed to be applied to *fac simile* or autographic telegraphs, for which the inventor obtained former letters patent: but it is obvious that they may be applied to most other telegraphs, such, for instance, as the Morse and the automatic. The main principle consists in a division of the transmitting battery current, and the placing of that battery at the receiving end of a line.

TELEGRAPHIC FAC-SIMILE TAPE.

Jan 77

L. YOUNG, of New York city, has invented a new tape, as follows:

Instead of paper, I use a strip of tin-foil, or other metallic surface, made smooth, and washed over with varnish of bees-wax, or other non-conducting substances. Upon this prepared tin-foil or smooth metallic surface, washed over with a non-conducting substance, the message is written with a fluid composed of colored caustic soda. After the message is written, a wet sponge easily washes away the varnish from the letters or message, leaving the writing metallic on a non-conducting surface of varnish. The tin-foil or metallic plate is in communication with one pole of the battery or instrument; the opposite pole of the battery passes over the surface of the tin-foil or metallic plate in the shape of a steel point, or a number of points passing over the plate or foil covered or washed with the non-conducting varnish. The electrical current or connection is broken; but in passing over the letters or symbols written on the plate or tin-foil the current is instantly connected. This connection is instantly indicated on the receiving-instrument by blue marks on a prepared paper soaked in prussiate of potassa, transmitting the exact shape or form of the written characters or symbols. Any caustic alkali may be used as the writing fluid.

ELECTRIC ENGRAVING MACHINE.

We may here mention another and more important modification of Caselli's invention than that of M. D'Arlingcourt—more important, at any rate, when considered, as we ought to consider every phase of scientific progress, in its connection with the wants of everyday life. We did not see this instrument at work at the Exhibition, nor is it altogether new. Several of the machines we refer to were shown at work at a scientific *soirée* at the Conservatoire des Arts et Métiers. These machines would be expensive additions to the workshop, unless a large number of copies of one design was required. The electro-magnetic engraving machine will be easily understood from the previous description. Instead of a cylinder covered with tinfoil, a large cylinder, having a circumference equal in surface area to the

FIG. 4.

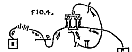


FIG 3

utensil to be engraved, is used. The design to be reproduced is carefully inlaid in brass upon the surface of the cylinder. A good conducting material is used to make the cylinder. An electro-magnet at the working end acts or does not act upon the graving tool, allowing it to cut or not as the current passes through what may not inappropriately be termed the line wire, which contains the electro-magnet, or a short circuit. Whenever the point touching the revolving cylinder comes into contact with the brass, the graving tool is withdrawn, and ultimately the whole surface, except that represented by the brass design, is cut, and the design stands out in relief on the tray or on the other object worked. A little ingenuity spent on the machine would make it work quite automatically, so that one man could look after several of the machines; in fact, we see no great difficulty in connecting several graving tools with one cylinder, and thus reproducing the design three or four times at once.

D'ARLINCOURT'S AUTOGRAPHIC TELEGRAPH.

In the number of the Journal for Dec. 15th we gave some illustrations of results obtained by means of this ingenious form of telegraph instrument. We now give some details of the arrangements by which the apparatus is worked.

The general principle of the system is similar to that of the copying telegraph of Bakewell. The principle of this latter instrument is as follows :—

The apparatus at the transmitting and receiving stations are similar; at each there is a metallic drum, which is caused to rotate at a uniform rate of speed by clockwork mechanism. A toothed wheel fixed to one end of the cylinder gears into a pinion fixed on an axis which runs parallel with the axis of the cylinder, and which has a fine screw thread cut on it from end to end ; a nut works on this screw, and has attached to it an arm with a metal style at the end, which presses against the surface of the drum. It is evident that the continuous rotation of the drum will cause the style to be carried along parallel to the axis of the former, and consequently to trace a continuous spiral line on the surface of the drum. Similar forms of apparatus being at the two stations, the drums are connected to the ends of the line wire, the style at the transmitting station being connected to the

positive pole of a battery, whose other pole is to earth ; and at the receiving station the style is connected to earth.

At the sending station, the message or design to be transmitted is written on tin foil with an insulating ink, and wrapped round the drum, whilst at the receiving station a sheet of paper wetted with a chemical solution, as in the Bain apparatus, is placed on the drum. As the two drums are caused by mechanism to rotate synchronously, and as the styles at any period of the revolution must therefore have the same relative positions on the tin foil and chemically prepared paper, and further since the current will only flow and decompose the solution during the time the style touches the tin foil, it is evident that the successive makes and breaks of the current will cause successive decompositions of the solution on the prepared paper, and thereby produce, by a succession of broken lines, a facsimile of the design or writing traced on the tin foil, the design appearing in white, and the ground in a colour corresponding to the nature of the chemical solution used. This, if the latter be ferrocyanide of potassium, the ground work will be of a blue colour. The success of the arrangement obviously depends upon the absolute synchronism of the revolution of the two drums, and this, in the apparatus subsequently invented by Caselli, was attained by means of electric pendulums; the arrangement, although successful, being somewhat complicated. A point of novelty in the latter system consisted in causing the style, whilst pressing on the portions of the metallic paper, to short circuit the battery, so that a current only flowed to line when the style passed over the insulating ink. This caused the facsimile on the chemically prepared paper to appear in colour, whilst the ground remained white. Instead of using the rotating drum, the style was caused to traverse backwards and forwards over the surface of the paper.

M. D'Arlincourt in his system employs the rotating drums and traversing style of the Bakewell instrument, and the battery short circuiting method, adopted in the Caselli instrument, but his mechanism for synchronizing the revolution of the two drums is a noticeable point in the invention. Fig. 1 shows generally the principle of the apparatus. a, a', are drums provided with styles s, s', as in the Bakewell apparatus. Ebonite pieces, b, b', flush with the surface and running the full length of the drums, are fixed to the latter, so that when the styles rest on them the latter are insulated. m, m', are electro-magnets, which have their armatures normally attracted by means of permanent magnets attached to their cores, as in the Hughes' type printer. The arms of these electro-magnets, when normally attracted, arrest the rotation of the drums when the latter are in the position shewn in the figure. c, c', are cams fixed to the axes of the drums, and which have each a projection and a depression, the former of which raise the levers 2, 2′, to the positions indicated in the figure, and which cause them to be in contact with studs 1, 1′. The depressions in the cams when the drums commence to rotate, allow the levers to change to the positions where they make contact with the studs 3, 3′. Finally when the drums rotate further, so that the levers press against the continuous surfaces of the cams, their position will be such that they make contact with the studs 2, 2′. f, f' are levers actuated by the same clockwork which rotates the drums, and which replace the levers n, n', on to the cores of the magnets m, m', after the drum has fairly commenced to rotate, when released by a current sent through m or m' as the case may be.

The clockworks which rotate the drums are so arranged that one drum can be caused to rotate at a rate one tenth less than the other. This is accomplished by the device shown in fig. 2.

a, b, are two crown wheels, which can slide along, but be rotated by the axle f f, which axle is geared indirectly to the drum on which the style presses. c, d, are two wheels on the axis g, which is connected to the speed regulator, which latter can only rotate at a certain definite velocity. In the position shown in the fig., wheels a and d gear together, but if the crown wheels are shifted to the left, the wheel b gears with wheel c. Since the relative sizes of the wheels are such that when a gears with d, the rate of revolution of f with g, is one-tenth less than it is when b gears with c, and since g at both stations can only rotate at one definite speed, therefore if at one station a gears with d, and at the other, b gears with c, then one drum will rotate with a velocity one-tenth less than the other. A small wheel w is attached to a spring fixed to the tubular axis on which a and b are mounted, for the purpose of keeping the wheels firmly in either position to which they may be shifted.

The working of the apparatus may now be made clear :—Supposing B to be the transmitting, and A the receiving station, then the metallic surfaced paper, on which the design or writing is traced, is put on drum a', and the chemically prepared paper on drum a. The papers are so wrapped round the cylinder that they cover the whole surface, except the ebonite portions. The clockworks are so geared that a' rotates faster than a; also by means of a switch, 2′ and 3′, are connected together. The clockwork at A is now started by throwing n permanently out of gear, and drum a commences to rotate; as it does so, lever 2′ drops from the projection into the depression in the cam and makes contact with 3, this causes a current to pass out to station B where it enters by lever 2′, passing to 1′, and through m' to earth ; lever n' is thereby immediately released and rises up under the influence of a spring, thereby allowing drum a' to start off ; immediately it does so, lever 2′ drops down to 3′ and then up to 2′, where it remains during the remainder of the rotation of the drum ; l in the meantime has risen to 2, so that even if n had been in gear the contact made by 2′ with 3′ would have produced no effect. The two levers being now at 2 and 2′ respectively, the marking currents are duly transmitted between the drums. As a' rotates faster than a, before the lever 2′ is again affected, a' will have completed its rotation and have been brought to a stop by n', which, as has previously been explained, has been replaced by f' ; and lever 2′ will again have been brought to the position shown in the figure. Drum a then, when it has completed its rotation and continued it, again moves lever 2 to 3, again starts off a', and so on ; thus drum a rotates uniformly and continuously, whilst drum a' rotates also uniformly but a little faster than a, and is brought up sharp and started off again at each revolution. Practically then a' rotates synchronously with a' and being checked at

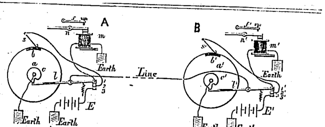


FIG 1.

each revolution can never be more than a tenth of a revolution out, and inasmuch as this one-tenth is distributed over the whole time of the revolution, no appreciable erratic effect is produced in the copy.

As it is very essential that the drum, which is checked at each revolution, should start off with its full velocity when the electro-magnet releases it, the clockwork by which it is turned gears friction tight with it, so that the train continues to run although the drum is stopped, and thus, when the

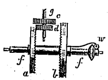


FIG. 2.

latter is released, it at once moves off with the same velocity at which the train is running. As the inertia of a drum, although light, tends to stop the motion of the train, a second train of clockwork quite independent of the first is connected rigidly to the drum, so that the latter is helped to start off quickly.

The motion of the clockwork train that moves continuously is controlled by means of a thick spiral spring governor, like that now employed on the Hughes apparatus. When working long distances a relay is employed, and there are means provided for neutralizing the effect of the static discharge which comes to be felt on long lines, and which would otherwise render the signals highly irregular and prolonged.

Un nouveau télégraphe écrivant

Nous lisons dans la *Nature* de Londres et dans l'*Engineering*, l'annonce de la découverte d'un nouveau télégraphe imprimant aussi curieux que le téléphone. Il paraît que l'écriture tracée à une extrémité de la ligne se reproduit instantanément à l'autre extrémité à l'aide d'une plume qui exécute des traits identiques. On dirait, ajoute la *Nature*, que cette plume est tenue par une main invisible.

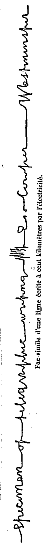
Ce journal publie même, dans son numéro du 6 février, le *fac-simile* d'un message transmis de la sorte à Brighton et que nous lui empruntons en lui laissant bien entendu toute la responsabilité de ses assertions.

Comme il est facile de le voir, cette dépêche n'est pas fabriquée à l'aide d'une série de points comme celles du télégraphe d'Arlincourt, mais par une ligne continue.

L'inventeur est un mécanicien fort connu de l'autre côté du détroit, qui se nomme M. E.-C. Cowper.

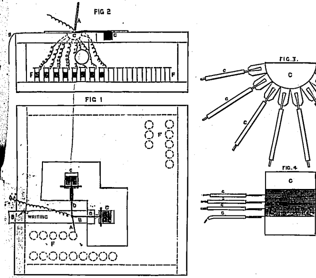
Ce nouvel appareil doit être exposé à la Société des ingénieurs télégraphistes.

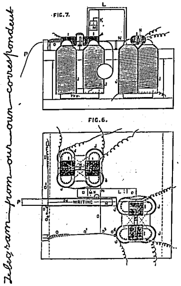
Dans son dernier numéro, la *Nature* n'en fait aucunement mention.



Fac simile d'une ligne écrite à cent kilomètres par l'électricité.

COWPER'S ELECTRIC WRITING APPARATUS.





Telegram from our own correspondent

HORACE must have had in his mind when writing his well-known song, the honest thinker of the present day, who

> "Si fractus illabatur orbis
> Impavidum ferient ruinæ."

We are becoming so accustomed to hear of new applications of electricity, that we cease to wonder at the increase of the record. If we add to these discoveries, those in acoustic science, and remember the rumours a few years since that an instrument was devised by means of which the voice could be conveyed over many miles of wire and then reproduced; and then this was followed by another instrument that would mock your every sound when spoken to, to be again surpassed by something that would enable the scratch of a brush or the tramp of a fly to be transmitted from one spot to another far away—remembering these successes of the human mind, what can surprise us? The invention before us is worthy of a place amongst the inventions of England, and like all valuable discoveries is remarkable for its exceeding simplicity. The inventor is a well-known engineer, and may, therefore, be presumed to have made a special study of mechanical science. One of the subjects treated at length in almost all text-books is that of the resolution of forces—and it is an application of this law to electricity that has enabled Mr. Cowper to perfect his instrument. We are not aware how the evolution of the apparatus came about, and no doubt Mr. Cowper hardly knows himself, but we feel certain that it might have originated somewhat as follows: Two forces acting upon a body at any angle produce a certain and easily calculated effect upon that body. This calculated effect is generally known as the resultant of the forces. Now if by any means we can obtain constantly varying forces acting upon a body, the effect will as constantly vary. We need enter into no further details as to the resultant effect of such forces—are they not to be found in the satchel of every schoolboy? Mr. Cowper's forces were electrical, his body influenced a pen or style, and the motions of his pen are regulated by the variations he gives to his forces. Before describing his apparatus we will roughly show his method of working. Suppose two series of small metallic plates, placed at right angles to each other, and each series connected by means of a line wire to a similar series at a distance. Sliding on the top of a series, suppose a metallic plate large enough to touch two or three or more of the series as it passes over. Each member of the series is to be insulated from its immediate neighbour, and connected to line by wires of different resistance. If now by means of this sliding disc we connect the line to a battery, a current goes from the battery through the disc, through the plates it touches, and through the connecting wires into the line, and the current increases or diminishes according as the disc touches more or less of the plates with less or greater resistance between them and the line. Similarly with the second series of plates and the second line wire. The series at the receiving end being similar to those of the sending end, it will at once be seen that variations of electrical force can be obtained. The two sliding discs can be rigidly connected to a pen, and on motion being given to the pen, motion is given to the discs, and variations of current immediately commence in each line. These variations of current produce variation of force in electro-magnets at the receiving end, and if these electro-magnets act on a body the effect varies. All this Mr. Cowper actually does, and, simple as it now seems, great credit is due to him for having shown us the best way to produce an electro-writing telegraph.

The accompanying illustrations will enable the reader to see exactly how Mr. Cowper attains his object. Fig. 1 is a plan of the sending instrument, Fig. 2 being an elevation of the same. The writer holds the pen, which is rigidly connected to the travelling contacts, and also as shown at a^1 a^2 to the batteries. The slip of paper on which the message is written is moved somewhat in the same way as in a Morse instrument; in fact, the Morse clockwork can be easily used for the purpose. Thus the paper travels under the pen instead of, as in ordinary writing, the pen travelling over the paper. Two sets of thin metal plates *c c* form the contact apparatus, *d d* are the light connecting rods, the ends of which make contact with the plates; *f f* are the resistance coils connected to the contact plates, one coil for each plate, except the first of the series, which is connected direct to line. It will be noticed that the strength of the current entering the line depends upon the plate with which contact is made by the connecting rod. As the rod travels from the first of the series the resistance increases, the current having to pass through $n-1$ resistance coils, as well as the line wire, n being the number of plates from the first of the series to the point at which contact is made. Generally, however, as one contact piece travels from the first of the series, the other travels towards the first of its series, and thus, while the current decreasingly varies in one line, the variation is increasing in the other. A slight knowledge of co-ordinate geometry will enable the student to plot the curve of any letter, and to calculate the variations in the strengths of the currents. Figs. 3 and 4 show respectively an elevation and plan of the thin metal plates, which are insulated the one from the other by paper soaked in paraffin. The receiving instrument, shown in plan and elevation in Figs. 5 and 6, differs from the sending instrument; *h, h*, are light soft iron bars on delicate bearings, having the ends surrounded by the coils *i, i*, to which the bars form a movable core. Through these coils the varying currents of the line are sent, which, of course, have a varying action on the core. *j, j, j, j*, are four permanent or electro-magnets, between the poles of which the coils just named are placed; *k* is a syphon pen. Mr. Cowper prefers, but does not restrict himself to the use of, the well-known syphon pen of Clark. The pen is adjustable from the bridge *l*, and the ink reservoir is shown at *m*. The light connecting rods *n, n*, transmit the motions of the movable cores to the pen; *o, o*, are springs to enable the pen to resist the pull of the magnets, the connections are shown in o^1, o^2, o^3, the latter being attached to a fixed post o^1.

"As the currents sent through the line wire by the sending instrument vary in strength or power, and cause the light bar of soft iron to move with varying power by its attraction to the stationary magnets; and in order to cause it to take its proper position according to each variation in power, a varying resistance is opposed to it, such as a spring which requires more power to compress it the more it is compressed, that the action of the soft iron bar, combined with that of a precisely similar bar actuated by the second line wire, will cause the position of the pen in the receiving instrument to follow the position of the pen in the hand of the operator at the sending instrument, and thus form the letters. The total strength of the spring or varying resistance can be regulated at will, so that the letters formed by the pen shall be of the same proportionate height and width as the letters written by the operator at the sending instrument. One convenient way of applying the varying resistance to the light bar of soft iron is by placing a very light spring to pull at the end of the bar in the direction of its length, but allowing of the motion of the bar which will thus cause the spring to act with more and more leverage as it moves more out of line with the spring. When so arranged there is required another spring to keep the connection with the pen tight, if such connection is flexible, so that the pen may go backwards as well as forwards over the paper, as the light bar of soft iron moves either one way or the other. But the spring or variable resistance may be made to act both to give the increasing resistance and the power to draw back the pen as well, if the spring is made to pull by a flexible or jointed connection at a fixed point, the line of such pull being parallel, or nearly so, to the light bar of soft iron, while another rigid or flexible connection from the end of the bar to the connection to the spring has the pen attached to it at about the middle of its length, which arrangement will give the same result as the two springs before described.

The accompanying is a specimen of the writing obtained. This specimen was obtained from the first instrument made, but since then slight alterations have aided towards the perfection of the instrument, so that it is now more rapid and capable of working through longer distances. As we have previously hinted, the apparatus will undoubtedly add to the reputation of the inventor. We must leave for another opportunity the consideration of the commercial and electrical value of this instrument as compared with those we already possess. Whether, however, it finds a place or not in our telegraph offices, the ingenuity shown in its construction remains the same, and should be duly acknowledged.

P. LE NEVE FOSTER.

By the sudden death of Mr. Peter Le Neve Foster, M.A., the Society of Arts has sustained a severe loss. During the past two months Mr. Foster has suffered much from gout, but it was thought that the disease had left him, as he was recently enabled to resume his duties at the society. On Thursday last, however, immediately on his return to Wandsworth, where he resided, he was seized with a sudden attack of heart disease (angina pectoris). He had been left sitting alone reading, when a member of his family, returning after a short absence, found him fallen back in his chair and dead. No anxiety had been felt in respect to his health, as may be known from the fact that he had completed his ordinary day's work at his office, and had walked up from the railway station to his own house. Mr. Foster was born on the 17th August, 1809, and was the son of M. Peter Le Neve Foster of Lenwade, Norfolk. He was educated under Dr. Valpy, at the Norwich Grammar School, whence he went up to Trinity Hall, Cambridge. After having taken his degree as thirty-eighth wrangler in the mathematical tripos of 1830, he was elected Fellow of his college. He was called to the bar at the Middle Temple in 1836, and seems to have practised as a conveyancer till he became secretary to the Society of Arts in 1853, on the resignation of Mr. Grove, who became secretary of the Crystal Palace. Mr. Foster was intimately associated with all the earlier great exhibitions. He was appointed to carry into effect the provisions of the Act for the protection of inventions in the exhibition of 1851, and was also named treasurer for payment of all executive expenses in the original commission. During his secretaryship the Society of Arts has flourished, and extended its sphere of operations and usefulness very largely, and owing in no small degree to his exertions it has quadrupled its number of members and increased its resources in a still greater proportion. Much of the work of the society was originated by Mr. Foster, and all was carried out by him. Even the regular working of such a society involves a large amount of labour and responsibility, but besides this the society has been instrumental in promoting a great many public objects, and in all of these it was necessarily upon the secretary that the burden of the work fell.

From his boyhood upwards Mr. Foster evinced very great interest in several branches of science. He was one of the first to take up and practice the art of photography, and on this subject he has written a good deal in the pages of the photographic and other periodicals. He was one of the founders of the Photographic Society, and was on its council for many years. He was president of the Quekett Microscopical Club for a year, and also served from 1863 to 1866 on the council of the British Association, the meetings of which he has attended regularly for the past twenty years. For many years he acted as secretary of the mechanical section of the association. He read several papers before the Society of Arts, notably one "On Aluminium" in 1859, and one "On Bonelli's Electric Loom" in 1860, and was, of course, a constant contributor to its "Journal," the whole series of which, from the middle of the first volume, was published under his direction. His varied occupations and his frequent contributions to the Journal of the society precluded the possibility of his paying particular attention to, or writing upon any subject in particular, but through his agency many questions of great importance have been placed before the world, and discussed to advantage, that would otherwise not have been secured. Mr. Foster was of a genial and kindly nature, and, as may be supposed, leaves behind him a very numerous body of friends. He passed a large proportion of his time in his office, and many have reason to remember generous advice and help, which was at the service of all applicants, known or unknown, who came to the office in the Adelphi. Mr. Foster married in 1838 Miss G. Chevallier, daughter of the Rev. C. Chevallier, Fellow and Tutor of Pembroke College, Cambridge. On the occasion of his completion of twenty-five years' service as secretary of the Society of Arts, a committee was formed to present Mr. Foster with a testimonial. The list for this was just about to be closed, the amount subscribed being over £1200. Under present circumstances a fresh effort will be made to increase this amount, so that a fitting memorial may be presented to Mrs. Foster. Mr. Foster has left eight sons and two daughters.

14

thing of the labours of Morey and Livingston, althoug[h] others have most probably never heard of them befor[e]. We are not certain whether Professor Thurston has eve[r] seen Marestier's book, which abounds with interestin[g] information. The chances are that he has not, for th[e] work is now exceedingly scarce. Morey had so much to do with the rise of steam navigation that it is a pity his name should be lost in oblivion. This is what our author says concerning him :—

"In the United States several mechanics were now at work besides Fitch. Samuel Morey and Nathan Read were among these. Nicholas Roosevelt was another. It had just been found that American mechanics were able to do the required shop work. The first experimental steam engine built in America is stated to have been made in 1773 by Christopher Colles, a lecturer befor[e] the American Philosophical Society at Philadelphia. The fir[st] steam cylinder of any considerable size is said to have been ma[de] by Sharpe and Curtenius, of New York City. Samuel More[y] was the son of one of the first settlers of Oxford, N.H. He w[as] naturally fond of science and mechanics, and became somethin[g] of an inventor. He began experimenting with the steamboat i[n] 1790, or earlier, building a small vessel, and fitting it with paddl[e] wheels driven by a steam engine of his own design, and con[structed] by himself. He made a trial trip one Sunday mornin[g] in the summer of 1790, a friend to accompany him, from Oxford, up the Connecticut river, to Fairlee, Vt, a distance of severa[l] miles, and returned safely. He then went to New York, and spent the summer of each year until 1793 in experimenting with his boat and modifications of his engine. In 1793 he made a trip to Hartford, returning to New York the next summer. His boat was a 'stern-wheeler,' and is stated to have been capable of steaming five miles an hour. He next went to Bordentown, N.J., where he built a larger boat, which is said to have been a side-wheel boat, and to have worked satisfactorily. His funds finally gave out, and he gave up his project after having, in 1797, made a trip to Philadelphia. Fulton, Livingston, and Stevens met Morey at New York, inspected his boat and made

...somewhat as follows: Two forces acting upon a body at any angle produce a certain and easily calculated effect upon that body. This calculated effect is generally known as the resultant of the forces. Now if by any means we can obtain constantly varying forces acting upon a body, the effect will as constantly vary. We need enter into no further details as to the resultant effect of such forces—are they not to be found in the satchel of every schoolboy? Mr. Cowper's forces were electrical, his body influenced a pen or style, and the motions of his pen are regulated by the variations he gives to his forces. Before describing his apparatus we will roughly show his method of working. Suppose two series of small metallic plates, placed at right angles to each other, and each series connected by means of a line wire to a similar series at a distance. Sliding on the top of a series, suppose a metallic plate large enough to touch two or three or more of the series as it passes over. Each member of the series is to be insulated from its immediate neighbour, and connected to line by wires of different resistance. If now by means of this sliding disc we connect the line to a battery, a current goes from the battery through the disc, through the plates it touches, and through the connecting wires into the line, and the current increases or diminishes according as the disc touches more or less of the plates with less or greater resistance between them and the line. Similarly with the second series of plates and the second line wire. The series at the receiving end being similar to those of the sending end, it will at once be seen that variations of electrical force can be obtained. The two sliding discs can be rigidly connected to a pen, and on motion being given to the pen motion is given to the discs and ...

... is moved somewhat in the same way as in a Morse instrument; in fact, the Morse clockwork can be easily used for the purpose. Thus the paper travels under the pen instead of, as in ordinary writing, the pen travelling over the paper. Two sets of thin metal plates c c form the contact apparatus, d d are the light connecting rods, the ends of which make contact with the plates; f f are the resistance coils connected to the contact plates, one coil

THE EDISON LIGHT.—Our junior contemporary has, in his [last n]umber, made some invidious remarks concerning the ex[clusive] information we gave our readers on this subject a fortnight a[go]. It is not our fault, though our too impressionable contempo[rary] feels it his deep misfortune, that he has been anticipated in [this] respect. We would remind him of a sage observation (sligh[tly] altered) of a well-known English author—

Order is Heaven's first law, and that confest,
Some must, and will, be earlier than the rest.

Our contemporary tells his readers of a somewhat mysterio[us] acquaintance, Mr. Thelwell, who carries no address upon h[is] card. We can only say that we are neither directly nor indirect[ly] indebted to him for the information, the appearance of whic[h] has made our contemporary so irate.

Zeb[?]

15

PROFESSOR THURSTON is one of the leading scient[ific] authorities in the United States; and he has written mu[ch] and well on mechanical subjects. The work before [us] will maintain his reputation if it does not add to it. [It] possesses the more interest for English readers, that [it] supplies a good deal of information concerning the r[ise] and progress of the steam engine in America, which [is] not generally possessed here. A history of the steam eng[ine] in the full sense of the word has yet to be written, eve[ry] book on the subject that has yet been published bear[ing] as much relation to a real history as Pinnock's Ro[me] does to Gibbon's *Decline and Fall of the Rom[an] Empire*. The history of the steam engine in t[his] country, in so far as the principal facts are concern[ed], is pretty well known. Indeed, every treatise [on] the steam engine contains what pretends to be or [is] a synopsis of that history; but concerning the grow[th] of the steam engine in France, Germany, or Ame[rica] little has found its way into English literatu[re], and yet it is certain that earnest, thoughtful, clever m[en] existed for years in the countries we have named, [and] did great things in the way of improving and develop[ing] the young giant whom Newcomen, Watt, and Trevith[ick] called into existence. But, even as regards the hist[ory] of the steam engine in this country, histories are imperfect and incomplete. The crude, disjointed "L[ife] of Richard Trevithick," written by his son, and publis[hed] by Spon in 1872, gives but an inadequate idea of the [rise] and progress of the high-pressure non-condensing eng[ine] in Cornwall. Until the other day, when, thanks to [Mr.] Fletcher, the facts were brought before the world, [not] one engineer in a thousand knew anything of the He[athcoat] engine, one of the most remarkable pieces of ste[am] machinery ever produced. It will, we venture to say, [be] news to most of our readers that rotative engines w[ere] made on Newcomen's system, with injection in [the] cylinder. One such engine is at work at this mom[ent] winding coals from a considerable depth at an old colli[ery] in the North. Stuart's remarkable book, "Anecd[otes] of the Steam Engine," Smiles's "Life of Watt," an[d a] few other works have formed the stock from which n[ew] writers have drawn their materials, and until this sys[tem] has been abandoned and authors go afield for themse[lves] and dig in the rich treasures of old drawings and ma[nu]scripts which still exist, the work of history-making m[ust] be imperfect.

When we say that Professor Thurston has been at l[east] as successful as any one else who has touched [this] attractive subject, we have said nearly all that can [be] said in the way of praise of his "History of the Gro[wth] of the Steam Engine." His style is light and easily r[ead]. He troubles himself little with controversies or ve[xed] questions. He has followed the well-beaten road w[ith] which we are so familiar, and his excursions to the r[ight] and left have supplied little to the wares which his [book] contains. The very first engraving in his book show[s] Hero's Æolipile as "The Grecian Idea of a St[eam] Engine." The first chapters, devoted to what [the] author calls the "Period of Speculation," tell us [all] that has been told before about Hero, and Car[dan] and Besson, Ramelli, Porta, David Ramseye, and oth[ers]. In the second section, the "Period of Application," we [meet] Worcester, Papin, and Savary all over again. As the w[ork] is really a revised and enlarged edition of certain lect[ures] delivered by the author to students in the college [of] which he is a professor, it is not remarkable that [this] matter has been introduced; but it is none the [less] certain that it might have been omitted from its p[ages] without detriment. The story of Watt and Boulto[n is] told again for the hundredth time, and the same ma[y be] said of Stephenson. It is not until we reach the 2[...] page in an octavo containing in all 490 pages, that [we] come upon matter which is in any sense new to [the] English reader. Here begins a sketch of the intro[duc]tion of the locomotive into America. We could [not] attempt within the space at our disposal to give ov[er a] synopsis of this sketch, but the following extract fro[m it] will give a good idea of the way in which Prof[essor] Thurston has treated the subject :—

"In the United States public attention had been directed t[o the] subject, as has already been stated, very early in the present [cen]tury, by Evans and Stevens. At that time the people o[f the] United States, as was natural, closely watched every impo[rtant] series of events in the mother country; and so remarkabl[e a] striking a change as that which was taking place in the tr[...]

76

ELECTRIC VOTE RECORDERS.

TO THE EDITOR OF ENGINEERING.

SIR,—It was with considerable interest that I perused your article on electric voting in your previous issue. The subject of mechanical voting occupied a considerable share of my attention about three years ago, and resulted in the patenting of a ballot voting machine in October, 1876. This machine is suitable for any number of candidates, and is designed to meet the requirements of parliamentary, municipal, and school board elections.

A small working machine representing voting in a three-cornered constituency, formed one of the British Association exhibits in 1876. The machine was subsequently brought before the Philosophical Society of Glasgow in 1877, and as the subject of electro-mechanical voting is at present before your readers, a short description of the model machine may not be out of place.

The external and working parts of the machine consist essentially of voting handles, mechanical counters, and continuous register. At one side of the machine are four handles or bell-pulls. Over each of these handles is a candidate's name. At the opposite side of the machine are mechanical counters to indicate the number of votes which each candidate receives, also a counter to indicate the total number of votes given. Through the glass panel can be seen two rollers, upon one of which is placed a strip of paper sufficiently long to register all the votes that are intended to be given in that booth in which the machine is placed. The other roller receives the paper after it is printed and punched. On the end of the machine is a crank-handle, also a counter to indicate the number of voters. The machine is placed in a private apartment of the booth, with a crank-handle passing through the partition. Before polling begins it is the duty of those persons who are in charge of the booth to see that all the counters indicate or "are at" zero, after which the dials of the candidates' counters should be covered and locked. The *modus operandi* in voting is as follows: The first voter enters the booth and receives a ticket numbered 1, and which number should be placed opposite his name in the voter's roll. The voter then gives his ticket to the person in charge of the voting machine, who immediately turns the crank-handle one revolution, which will cause the counter on the end of the machine to indicate 1. The voter then enters the apartment and pulls out either of the candidates' handles until a bell rings, and allows it to go back to its former position. When the bell rings a vote is recorded on the candidate's counter who received the vote, also a hole is punched in the strip of paper in one of the squares opposite the voter's number and in line with the candidate's name. The voter can give two votes, *not more*, although he should pull the handle more than twice. The person who turns the crank-handle cannot turn it more than one revolution at a time, neither can he turn it back. By unlocking the cover of the candidates' dials, the state of the poll can be seen and made known in a few seconds. Should a scrutiny of the voting be required, the machine-made register, together with the voters' roll, will show how every elector voted.

The machine can be made to suit any election, but is specially adapted for three-cornered constituencies, as by its use three members could be returned to Parliament with the minimum number of votes, as well as under the open system of voting.

Feb 79

I am, Sir, yours respectfully,

Glasgow. ALEX. TURNBULL.

COWPER'S WRITING TELEGRAPH.—Mr. Cowper's new "Writing Telegraph" will be brought before the Society of Telegraph Engineers at their next meeting on the 26th inst.

Feb 79

Apropos of the claim made in favor of Prof. Dolbear, to have anticipated Mr. Cowper in the invention of the ingenious writing telegraph which bears his name, the London *Telegraphic Journal* of late issue declares that there is no valid ground for the claim, and that while the two inventions have the same object in view, the methods by which the object is attained are essentially different. May 79

CLERAC'S ELECTRIC VOTE RECORDER.

CONSIDERING the amount of time lost in reckoning up the results when voting is carried on by ballot, or by any of the older methods, and the inaccuracy to which these are liable, it is not surprising that various automatic systems giving at once correct and rapid registration of votes should have been invented. In France, especially, much attention has been paid to this subject, and we find that as early as the year 1860, M. Saigey, inspector of telegraphs proposed to the senate of that country to apply electricity to this purpose; but the death of that gentleman prevented his ideas being practically carried out. Later, in 1870, M. Clerac, director of telegraphs, Paris, and now well-known in connexion with the Edison-Hughes controversy respecting the microphone, as the first discoverer of the principle of the variable resistance of finely divided carbon under pressure, in conjunction with M. Guichenot, civil engineer, presented to the Corps Legislatif, Paris, a complete electric system of automatic voting. Later still, in 1874, M. E. A. Jacquin, an employé of the French Telegraph Service, proposed to the National Assembly a purely mechanical arrangement, having the same object in view.

The system of MM. Clerac and Guichenot is now used for voting in the Chamber of Deputies, Paris. It possesses many notable advantages over the old methods. For example, it permits the whole assembly to see the progress of the ballot going on, and consequently, to cast up the results for themselves even before they are proclaimed; it collects the votes and totalises them instantaneously; it records them by permanent marks, and it gives to each deputy the means of assuring himself that his vote has been properly received and recorded. There is no room for false voting.

On each side of the speaker's chair are placed two large presses or cabinets divided into as many compartments as there are members in the assembly. One of these voting presses is intended to receive the *ayes* and the other the *noes*, or as they are termed in France, the *contres* and the *pours*. Each deputy possesses a compartment or box for *contre* in the negative cabinet, and one for *pour* in the positive cabinet, and he records his vote in one or the other without leaving his seat, by means of an electro-magnetic arrangement. On his desk, in front of him, are placed two press-buttons (t t, Fig. 2), which are connected to the two boxes in the cabinets at his service by wires in circuit with a voltaic battery kept in a side room of the assembly-hall. On pressing one or other button, he records his vote *pour* or *contre* in its proper box, and he is enabled to see for himself that it has been faithfully done.

This is effected as follows: Fig. 1 is a plan representing the interior of a compartment or box of the voting cabinet s. The apparatus there shown consists of an electro-magnet E, having an armature A which acts as a detent, holding back a small metal shutter V which is painted a showy colour, and at the same time restraining a stout arm b which is movable round an axis a. The curved tube T, which has a slight inclination downwards, contains a number of ivory balls, one for each question to be voted (twenty are generally sufficient). It has a hole in its side, at the lower extremity, which will only allow one ball to escape at a time, when it is pushed through into the chamber l. A small window pane f is fitted into the front of the box which faces the assembly. D is a shaft which runs along all the boxes in each vertical row of a cabinet, and it carries a small lever c in each box. Its purpose will appear presently.

Now, when the member to whom the box belongs presses the corresponding button on his desk, the battery circuit is completed, and a current flows through the electro-magnet E in the box; the armature A is consequently attracted, it thereupon releases the painted shutter v, which wheels round into the position v^1 shown by dotted lines, urged by a powerful spring r, and presents itself as an indicator in front of the glass pane f, thus informing the voter of the accuracy of his voting. At the same moment the arm b, obeying also the impulse of the spring r, pushes a single ball through the lateral aperture into the chamber l which conducts the ball into a long vertical tube into which it falls. This tube, which is so narrow as to hold only a single row of balls, one above the other, is a general collecting tube for the whole cabinet. It is of glass thickly graduated, and each gradation is exactly the height of a ball, so that members can read off the number of collective votes by the top of the column of balls as the voting goes on. When first invented, in 1869, there were only seventy deputies in the French National Assembly, and one tube was sufficient to hold all the balls; but as there are now seven hundred and fifty members, three tubes are necessary. It is worthy of mention, that instead of casting up the total by *counting* the balls, it may be done by *weighing* them.

When the votes have been taken upon any question the apparatus is re-set for another voting operation, by turning the shafts D from the outside of the cabinet. This has the effect of raising the shutter v into its first position under the hold of the detent A and withdrawing the push-lever b from the tube T. All the balls are alike, but those belonging to each deputy have his number or his name engraved on them. Each box is independent of the others.

Fig. 1.

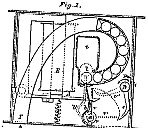
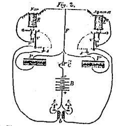


Fig. 2.



MM. Clerac and Guichenot, however, not content with the arrangement described by itself, have aimed at recording the votes on paper as they are made; a consummation which they have effected by means of electro-chemical printing. The same current which causes the indicator to appear and the balls to fall is made to print the name of each deputy and the nature of his vote on a paper register. The printing press is very simple. It consists of a printing tablet composed of a matrix of hard rubber insulator, in which are set rows of small metal blocks, each particular block having its upper face carved in relievo with the name of a particular deputy, or the number of his bench, and thus forming a block of type. Over this printing tablet a plate of zinc is made to fold, but between this plate and the face of the tablet a sheet of chemically prepared paper is inserted. Blotting or other absorbent paper, impregnated with potassium ferrocyanide and ammonium nitrite, and moistened with water, answers very well for this purpose. Wires are led from each metal type block to the battery and press buttons or signalling keys of each deputy (t t^1, Fig. 2), and from the zinc cover, so that when the printing circuit is completed by closing the contact of the press buttons, the current flows from the type blocks through the prepared paper to the zinc cover, and thence back to the battery, decomposing the chemical solution in its passage, and printing the paper with the name on the type block, whatever it may be. As this impression is lasting a durable record is obtained of the vote. If each deputy has two blocks for his use, one of iron and the other of copper, the iron one will give a blue mark on the paper, and the copper one a brownish-red impression. In this way blue lettering may be obtained for his *pour* votes, and red for his *contre* votes, thus distinguishing their character. A single press may, by this plan, serve to operate along with the two cabinets; but MM. Clerac and Guichenot, for the sake of greater distinctness, prefer to employ two separate presses, one for the *pour* cabinet and one for the *contre* cabinet. On each of these presses there is a type block for every deputy, in connexion with this particular press button and voting-box in the cabinet; the block in the *pour* press may be of iron, and yield a blue stain, while that in the *contre* press may be of copper, and give a red stain, but with two presses this condition is not essential. Fig. 2 represents the complete vote recorder of MM. Clerac and Guichenot, combining the printing press and the ballot; t t, as we have before seen, are the press buttons installed on the deputy's desk; and, in order to guard against error as much as possible, a small galvanoscope is placed between the buttons, so that the deputy can tell whether or not the current is flowing properly in the circuit, and the printing and balloting is being effected. If by any cause the current is interrupted, the deputy will know how to correct the default by giving a notice to the scrutineer of votes. The central organ C of the figure is a commutator, placed upon the speaker's desk, for the purpose of enabling him to place the automatic voting apparatus only at the disposal of the assembly during the time of the ballot. It will readily be seen that on closing either of the press buttons t t the circuit is completed through the electro-magnet of the deputy's ballot-box, in one or the other cabinet, according to the button pressed; the armature is attracted and liberates the shutter v, while at the same time a ball is allowed to fall into the collecting tube. The shutter v, in closing, makes contact with the stop S or S¹ of the printing press, and completes the branch circuit through the corresponding press P or P¹, thus printing the deputy's name on the prepared paper. The galvanoscope being wound with a very few turns of wire, it gives but a very small deflection at first, while the current only flows through the electro-magnet; but when, in the act of printing, the branch circuit through the press is closed, a larger deflection of the needle is obtained, and thus the latter indicates both acts of the voting, the balloting and the printing. A single large Marie-Davy element suffices for each deputy.

This arrangement permits of secret voting being carried on, by covering up the cabinets with blinds, and substituting blank blocks in the printing press for those bearing the marks of the deputies. This can easily be effected by a special construction of the apparatus. The printing press, indeed, need not be limited to voting; it may also be usefully employed as a means of calling the roll, and for other similar purposes. The multiplicity of electro-magnets and other apparatus necessary appears to give an objectionable complexity to the system, but it should be remembered that every electro-magnet is contained in its own compartment and has its own independent circuit, so that the individual apparatus of each deputy do not interfere with one another. However, the automatic ballot-boxes are not absolutely essential, for voting can be correctly carried on by the electro-chemical press itself, thus saving all the expense of the former more intricate device. The electro-automatic voting apparatus we have described is one of those ingenious contrivances which, although their usefulness and economy are apparent to all who understand the subject, are not readily adopted in practice, partly because of the limited field for their application, the force of established habits, and the unscientific training of those who are intended to use it.

In conclusion we should remark that the system of M. Jacquin, which is later than that of MM. Clerac and Guichenot, closely resembles the latter, and consists of an automatic ballot-box, actuated by electro-magnetism, but without the addition of an electro-chemical printer. The only important difference between the two systems is that instead of the chemical printer M. Jacquin provides a pointer or style also actuated by the electro-magnet, which marks the votes on strips of paper, but in a manner which renders them invisible to the assembly.

18

COWPER'S WRITING TELEGRAPH.

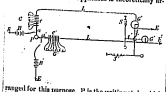
THE most recent of the brilliant series of telegraphic marvels which has from time to time, and especially of late, engaged the attention of the world, is the "telegraphic pen" of Mr. E. A. Cowper, the well-known engineer of Great George-street, Westminster. This ingenious apparatus, which constitutes the first real telegraph, was publicly shown by its inventor at the meeting of the Society of Telegraph Engineers on Wednesday, February 20, before one of those overflowing audiences which only assemble there on great occasions, such as the exhibition of the telephone, the phonograph, or the

microphone attracted. The telephone enables us to talk to a distance by wire; but words are fleeting things in spite of phonographs; and an instrument which permits us to *write* at a distance is a valuable addition to telegraphy.

There had been no lack of *copying* telegraphs hitherto. We have Bakewell's, Caselli's, Meyer's, and D'Arlincourt's, so recently tried at our General Post Office by Mr. Preece. All of these instruments telegraph an almost perfect *copy* of the writing or sketch submitted to them by means of synchronous mechanism. But the process is necessarily complex and slow; whereas by the new device a person may take the writing pencil in his hand, and himself transmit his message in the act of writing it, so that could his eyesight reach so far he would see the duplicate pen at the distant end of the line tracing out the facsimile characters as he formed them, just as if his arm had been lengthened out to that extent. The simple speaking telephone displaced a number of more complex tone telephones; and so it is also highly probable that Cowper's writing telegraph will in time supersede the older copying telegraphs we have mentioned.

The principle which guided Mr. Cowper to a solution of the problem which he has successfully overcome, is the well-known mathematical fact that the position of any point in a curve can be determined by its distance from two rectangular coordinates. It is upon a similar principle that a ship's course at sea is plotted upon the chart by means of latitudes and longitudes. It follows, then, that every position of the point of a pencil, stylus, or pen, as it forms a letter, can be determined by its distance from two fixed lines, say the adjacent edges of the paper. Moreover it is obvious that if these distances could be transmitted by telegraph and recombined so as to give a resultant motion to a duplicate pen, a duplicate copy of the original writing would be produced. But inasmuch as the writing stylus moves continuously over the paper, the process of transmission would require to be a continuous one, that is to say, the current traversing the telegraph line, and conveying the distances in question (or what comes to the same thing, the up and down, and direct sidelong ranges of the stylus) would require to vary continuously in accordance with the range to be transmitted.

Mr. Cowper effects this by employing two separate telegraphic circuits, each with its own wire, battery, sending and receiving apparatus. One of these circuits is made to transmit the up and down component writing of the pencil's motion, while the other simultaneously transmits its sidelong component. At the receiving station these two components are then recomposed by a pantograph arrangement of taut chords, or levers, and the resultant motion is communicated to the duplicate pen at that place. The plan adopted by Mr. Cowper to transmit each continuously varying component is to cause the resistance of the circuit to vary very closely with the component in question. The annexed diagram shows how the apparatus is theoretically ar-



ranged for this purpose. P is the writing style which is held in the writer's hand in the ordinary way, while he shapes the letters one by one on paper pulled uniformly underneath by means of clockwork. To P are attached, at right angles, two arms *a a*, one for each circuit; but as it is only necessary to consider one of the circuits, say that sending up and down motions, we will confine our attention for the present to the arm *a*. One pole of the sending battery B is connected to the arm *a*, the other pole being connected to earth. Now the arm *a* is fitted with a sliding contact at its free extremity, and as the pencil P is moved in writing, *a* slides lengthwise across the edges of a series of thin metal contact plates C, insulated from each other by paraffined paper. Between each pair of these plates there is a resistance coil C, and the last of these is connected through the last plate to the line L. It will be seen that as *a* slides outwards across the plates the current from the battery has to pass through fewer coils, since *a* short-circuits a number of coils proportional to its motion. But the fewer of these coils in circuit the stronger will be the current in the line; so that the extent of the motion of the arm *a* in the direction of its length, that is to say the direct component of the motion of the pencil along the line of the arm *a*, is attended by a corresponding change in the current traversing the line. If the pencil makes a long up and down stroke there will be a strong current in the line, if a short one there will be a weak current, and so on. A precisely similar arrangement is used to transmit the sidelong motion of the pencil along the line L.

The current from the line L flows at the receiving station through a powerful galvanometer G to earth. The galvanometer has a stout needle, one tip of which is connected to a duplicate pen P, by a thread *t*, which is kept taut by a second thread stretched by a spring *s'*. The current from the line L' flows through a similar galvanometer G' to earth. The needle of G' is also connected to the pen P by a taut thread *t'*, stretched by means of the spring *s*. Now, since the needle of each of these galvanometers deflects in proportion to the strength of the current flowing through its coil, the points of these two needles keep moving with the varying currents. But since these currents vary the motions of the sending pen, the receiving pen controlled by the united movements of the needles will trace out a close copy of the original writing. We annex a

Telegram from our own correspondent

facsimile of a sentence written by Mr. Cowper's telegraph, samples of which were distributed at the meeting last Wednesday.

The receiving pen is a fine glass siphon drawing off aniline ink from a small glass holder. There are thirty-two coils C in each circuit with a corresponding number of contact plates *c*, so as to get accuracy of working. A few Daniell's cells are sufficient to operate the apparatus, and writing has been already sent successfully over a line 40 miles in length. The writing may be received either of the same size or larger or smaller than the original as the case may be. At present the writing must not be too hurried, that is, unless the characters are bold and well formed; but further improvement will of course quicken the working of the apparatus.

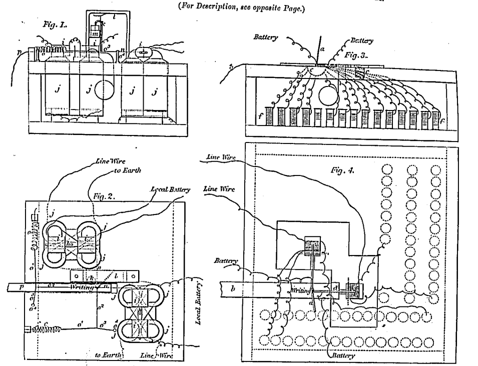
Cowper's writing telegraph is destined to supplement the telephone as a business telegraph, its great merit over the latter alone, consisting, as was before pointed out, in the fact that it gives a written record of the message, and if need be, a record written in the very handwriting of the correspondent. This property of allowing any one who can write to manipulate it, will also render it useful as a field, military, and a private and confidential telegraph. It will, of course, admit of all kinds of general orders from commanding officers or code and cypher dispatches being sent, and it will prevent cabalistic signs, unintelligible to any except those in the secret. In the same way, shorthand reports may be sent direct to newspaper offices by "our own correspondent."

The engravings, Figs. 1 to 4, on the opposite page, illustrate the actual apparatus. Fig. 4 is a plan of the sending instrument with the writing pencil *a*, the travelling paper *b*, the light connecting rods or arms *d* (which correspond to *a* in the theoretical diagram above), the series of metal contact plates over which these arms slide, the resistance coils connected to these plates, and the battery and line wires. It will be seen that each arm *d* is connected to its particular battery, and each set of contact plates to its particular line. Fig. 3 is an elevation of the sending instrument, in which *a* is the pencil as before, *c c* the contact plates over which the arms *d d* slide, *f f* the coils, and *b* the travelling slip of paper.

Fig. 2 is a plan of the receiving instrument, in which *h h* are the light pivotted needles surrounded by coils of fine insulated copper wires *i i*, and controlled in their zero position by the electro-magnets *j j j j* placed underneath, the whole forming a pair of galvanoscopes or current detectors, one for each line. It will be understood that the varying currents from the lines are allowed to flow through the coils *i i*, so as to deflect the needles, and that the deflections of the needles follow, so to speak, the variations of the currents. The electro-

THE COWPER WRITING TELEGRAPH.

(*For Description, see opposite Page.*)



magnets are magnetised by a local battery; permanent magnets might, however, take their place with a gain in simplicity. Now the writing pen *k* is connected to the nearest tip of the needle *h* of each galvanoscope by threads *n n*, which are kept taut by the fibres $o_1 o_2 o_3$, the springs *o* and the pins o_4. In this way the motions of the needles are recombined in the motion of the duplicate pen upon the paper *p*. Fig. 1 is an elevation of the receiving instrument, in which *i i* are the coils as before, *j j j j* the controlling electro-magnets, *k* is the writing syphon dipping with its short leg into the ink-well *m*, and *l* is the bridge from which the writing syphon is suspended by means of a thread and spring. The long leg of the syphon reaches down to the surface of the paper *p*, which is pulled along beneath it in contact with the film of ink filling the point of the tube. When the syphon is at rest its point marks a zero line along the middle of the paper; but when the receiver is working, the syphon point forms each letter of the message upon the paper as it passes.

THE PROGRESS OF THE ELECTRIC LIGHT.

IN the face of the most determined opposition, and notwithstanding the extravagant and ill-founded rumours started into circulation by the gas companies, and kept alive by interested as well as by ignorant parties, the electric light continues its onward progress with extraordinary rapidity and success. It could only have been expected by business men as well as by all who, by watching the times, are able to take a calm common sense view of things, that so mad a scare as was occasioned a few weeks ago in the share market on no more solid foundation than a few unscientific and unauthenticated newspaper paragraphs, would, of necessity, be followed by a great reaction, and that when the depressing action of extravagant claims had subsided, the inherent resilience of the share-market would come into play, and a similarly opposite effect would be produced. On the other hand, but few observing commercial men can have been blind to the fact that although under the forcing atmosphere of a passing excitement, scores of so-called "new" systems for electric lighting had sprung up in the night, only to wither and disappear in the daylight of common sense and experience, the electric light on a whole was marching steadily onward, gaining rather than losing strength by opposition, and surely asserting its right to be considered for its own legitimate purposes, as the light of the immediate future.

One of the principal stumbling-blocks in the way of the public taking a reasonable view of the electric light question, and which has undoubtedly contributed more than anything else to the commercial agitation to which we have referred, is the ignorance which exists as to what is and what is not the legitimate field in which electric illumination, as it exists at present, may be advantageously employed; and newspaper writers, with a few exceptions, have much to answer for in increasing rather than dispersing that ignorance. A great deal of nonsense has been spoken and written in condemnation of the electric light because it has failed, or at all events has not accomplished hitherto, the supplanting of other illuminants in our dwelling-houses and in small rooms; and even its inapplicability to the lighting of inferior streets has been urged against it, as if that and the illumination of dwelling-houses were what its promoters claim as among its principal advantages. Nothing is easier than to conjure up a giant for the sole purpose of laying him flat, unless it be the latter operation itself, and it is interesting to notice how persistent is the inapplicability of the electric light to purposes for which, in its present stage, it is obviously inappropriate, not more on account of its cost than by reason of its great power. Similar objections might be raised, for interested motives, against lighthouse apparatus for the reason that a first-order dioptric apparatus is inapplicable to the illumination of a dining-table, or against public bells because "Big Ben" could hardly, without inconvenience, take the place of a dinner gong. Within its proper domain the electric light, in good hands, has no competitor worthy of its steel, and although we would be far from saying that electricity will *never* at any period produce the light of the future, even for the illumination of private dwellings, still that is to all intents and purposes as far off as it was fifty years ago, and unless some discovery be made which will be little short of a revolution of the whole science of electricity, gas shareholders need not have their rest disturbed on that score for a single moment. They have far more to fear from other quarters, and perhaps the philosopher's dream of "bottling up" sunlight and using it in the hours of darkness, may yet prove not so visionary after all, at all events there are upon the scientific horizon in this direction indications of the rising of a little cloud no bigger than a man's hand which may yet come to be regarded as not altogether insignificant.

Without overstepping the boundary line which encloses its special domain, the electric light has a great immediate future before it; its perfect applicability to the lighting of great halls, theatres, and other public buildings, as well as to the illumination of shops, factories, docks, squares, streets, and extensive building operations carried on at night, to say nothing of its special application to lighthouses and ships, and to naval and military operations, give to it an impregnable commercial position, and one which menaces the gas interest in some of its most valuable strongholds, and it is little but short-sighted folly for the gas companies to content themselves with issuing to their shareholders, or publishing in the public press, unscientific and absurd reports which can only have the ultimate

20

THE ELECTRO-PANTIGRAPH. 79

HAMILTON, OHIO, April 5.

To the Editor of the Journal of the Telegraph:

I NOTICE in the last number of the JOURNAL OF THE TELEGRAPH a description of Cowper's Writing Telegraph system, and editorial remarks on the efforts to claim credit. I am never a claimant for things I *intended* to do, and do not wish to be classed as such.

I, with many others, may have given thought to subjects tending toward a certain end, but when some one else presents thoughts in a material shape, he and he only is entitled to credit. *We* have *talked* of what we would do, what we could do, and what we wanted to do. What good does that do the world? Mr. Cowper presents the world with something *done*, not *talked* about. It should be understood by those who flood the world with evanescent thought from massive minds, that he who first presents a tangible and useful something is the proper person to receive any applause the subject may merit.

The device presented by me to the Electrical Society of the Ohio Valley is interesting and plausible, and worth study, and the idea of presenting the thing to the Society was suggested by the announcement of Mr. Cowper's *work*.

J. W. SEE.

THE WRITING TELEGRAPH. June 79

COWPER'S writing telegraph has been placed on the London and South-Western Railway, and has been working most successfully from Woking to Waterloo, a distance of 26½ miles, writing off the messages in ink, one after the other, in a perfectly legible manner, whether regular line messages or messages made up in order to give the instrument more work to do. On some days more resistance coils of wire have been introduced into the two line wires, in order to represent greater distances, and thus 62½ miles and 99½ miles have been worked through in a most satisfactory manner, it only being necessary in such cases to add a few more cells of the battery, which in no case was as powerful as is very often used on the same line. The effect of the currents through the multitude of other line wires, in close proximity to the two in use for the writing telegraph, was closely observed, and the effect of induction was so exceedingly small, as only to produce occasionally a slight roughness in a straight line, when the pencil of the operator was quite stationary, but such effect was hardly ever perceptible in the writing itself, and never to affect its legibility. We understand improved instruments are now being constructed, and will shortly be at work. The fact of this instrument requiring no clerk to receive the message, translate and write it down, seems to be much appreciated, as a half-a-dozen such instruments may be telegraphing their yards of messages into one office without the least assistance from the clerk, who may from time to time cut off and send out the ready written messages; so that not only is the time of "calling"—as with ordinary instruments—saved, but the time of waiting till the clerk can attend at the other end of the line to receive the signals, which very often amounts to a much longer interval than is required for the whole message to be transmitted, especially in offices fitted with many instruments. There is also a great advantage in having an absolute record of what has been sent by the writing telegraph at the transmitting station. Another very important feature is the facility with which all that it is necessary to learn to use the instrument may be found out in five minutes. Every operation is exceedingly simple, and there are practically no fine adjustments anywhere. Variation in the power of the battery is of no importance, as its effect may be overcome by simply pushing the levers, carrying the springs against which the needles pull, a little farther in or out, as may be necessary. The pen, which is a very small glass capillary syphon tube, is, though of glass, very strong—it may fall several feet on to a bare floor without breaking—and is very easily adjusted. The writing telegraph presents facilities and advantages which, we believe, will make its adoption rapid and extensive.

21

EDISON OUTRIVALLED.

April 79

TALKING BY THUNDER AND LIGHTNING.

A NEW AUTOGRAPHIC TELEGRAPHIC SYSTEM, BY MEANS OF WHICH A MAN CAN TRANSMIT HIS OWN HAND-WRITING HUNDREDS OF MILES AWAY.

At the last meeting of the Electrical Society of the Ohio Valley, held at their rooms in this city, on the evening of March 10th, Mr. James W. See presented a detailed description, illustrated by photographs, of his new autographic telegraphing system, which he terms the Electro Pantograph. Mr. S. has had his European specification in London over two years, and as the public presentation of the subject before the above-named society, of which he is a member, was the direct result of an article appearing in our columns some days ago, to the effect that a similar system was soon to be made public in London, we have felt called upon to go over the papers read before the Electrical Society, and digest it for the benefit of our readers.

By means of this system one may walk into a telegraph office, pick up a lead pencil, stick its point through a hole in the end of a pointed rod attached to the instrument, and write his message, or letter, or check, or note of hand, in any language, short-hand or long-hand, good writing or bad, and as he does so a similar pencil at a station hundreds of miles away follows every movement, and this pencil coincidently produces a perfect duplicate of the author's writing. This affair opens up fine questions as to what constitutes a legal note of hand. There can be no doubt but what such a note is actually written by the maker. No intermediate process intervenes between the maker and the distant note, and the law does not say how long or how short a pencil must be, or whether it is to be made of wood and black-lead, or of wire and batteries, and retorts and electro-magnets and mechanism.

Mr. See's system is based on the theory, fully demonstrated in his paper, that lines, no matter how complex they may be, possess but two essential elements—direction and length; and that there are but four fundamental directions; and that all possible directions are formed by a combination of two of these fundamental directions. The fundamental directions are down, left, right, and up. The effect of a combination of two directions is fully defined by the well-known philosophical laws of resultant forces, the fundamental elements of all lines being the components.

The instrument consists of four keys closing four electric circuits. These keys are opened by the rotation of toothed pinions, and the pinions are rotated by toothed racks, having articulated rods attached. The pencil socket is at the puncture of these rods. A movement of the pencil in one direction will affect a series of breaks in one circuit and not affect the other three. The number of breaks is in proportion to the length of the line. If the pencil be moved in a curve it will result in a series of breaks in two circuits, and the relative number of breaks will depend on the relation between the two component directions of the curved line The receiving features of the instrument are similar to the portions just described, save that instead of rotating pinions breaking a circuit breaks in the circuit are caused to rotate the pinions. This is accomplished by means of four electro magnets whose armatures at each break in the circuit rotate the pinion as far as the pinion which broke the circuit rotated.

The instrument thus possesses vast executive powers. It analyzes the writing as it is produced, separates it into its component elements; transmits one of these elements over one circuit and another over another circuit at the same time; and as a receiver it receives separately the component elements of lines; properly combines them, and delivers them exactly as received. The author at the sending end places his pencil at the top of his sheet of paper; the weird pencil at the receiving station takes its position at a corresponding spot upon its sheet of paper; the author finishes a line and returns to commence a new one; the receiving pencil returns to commence its new line, and when the sender finishes and gives the final flourish to his signature, the obedient receiving pencil passively does the same, and waits for more influences from abroad. When the sender lifts his pencil from the paper and returns to cross a t or dot an i, the receiving pencil lifts, moves mysteriously through the air, crosses its t, &c., and goes on as the sender does.

This lifting of the pencil is effected by means which have not yet been described. The pencil at the receiving office, stands normally away from the paper, but is held down to the paper by an electro-magnet as long as a fifth circuit is closed. This fifth circuit is kept closed by the sender's pencil being down. If the sender lifts his pencil this circuit opens; the electro-magnet loses its force, and the receiving pencil lifts from the paper to return only when the sending pencil does.

But a single instrument is employed, it being both a sender and a receiver, and any number of them may be placed in a single line. The normal condition of the instrument is "out of action." The usual signals are employed upon any one of the circuits, and upon a station being called, a response given, the sheet placed in position, the pencils placed in unison, and the receiving lever turned; the pencil begins its magic journey.—*Cincinnati Enquirer*, March 23d.

VOL. XII. NEW YORK, JUNE 16, 1879.

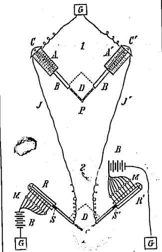
THE WRITING TELEGRAPH.

PROF. A. E. DOLBEAR, Tufts College, Mass., communicates the following description of his writing telegraph to the *New England Journal of Education:*

When a current of electricity is sent through a hollow coil of wire the latter is made a magnet, and will attract into it a short rod of iron. If the helix be held vertical, the rod of iron may be supported in the air without touching anything, through the strength of the attraction. If the iron rod be placed end to end of the coil, it will be attracted into it with a force proportional to the strength of the current of electricity in the coil. I have utilized this in making a galvanometer, the iron rod or core being supported by a spiral spring; the distance the cord is drawn into the spiral is the measure in weight of the strength of the electrical current. This same device is also employed in the receiving instrument of the writing telegraph (see 1 in the diagram).

Let *A* be a hollow coil of wire, and *B* the core of soft iron held in place by a spiral spring within the helix. At *P* is a marker attached by a light rod to the end of *B*, so that any movement made by *B* toward *C*, the bottom of the helix, would cause *P* to make a straight line in the same direction. Now let a current of electricity enter the helix by the wire, *l*, and at once *B* will move into the coil a certain distance; a stronger current would make it to move still further in, and a weaker one would allow the spring to push it back again; the marker then would make a straight line. At *A'* and *B'* is another fixture, precisely like the one described; they are at right angles to each other, and their common junction is at *P*, so that any motion made at *B'* will make *P* record the direction. When these two act conjointly, the place that *P* will have will depend solely upon the distance each of the cores, *B* and *B'*, is drawn into its helix, and when the helices can turn upon pivots at *C* and *C'* it is plain that the point, *P*, may take any position inside the space indicated by the dotted lines; that is, any kind of a figure may be drawn by *P* inside those limits. This instrument is called the receiver.

The transmitter (see 2 in diagram) is a separate instrument, and unlike the receiver. At *R* is a narrow strip of wood having a groove in it, in which *S* may slide. On one side of the groove are a series of wire terminals of the battery, B. The end, *S*, of the slide is metallic, and it is in connection with the wire, *l*; and when it is thrust a little way into the groove it touches one of the wire terminals of the battery and permits a current of electricity to flow into the wire, *l*, and so through helix, *A*, drawing *B* in and causing *P* to make a short mark. If *S* is thrust into *R* still further, a stronger current is thrown on the line, *l*, and so on the further it is down the groove. At *P'* is a marker corresponding to the marker in the receiver, so it will be understood that *P* will duplicate the motion of *P'*. In like manner as in the receiver, there is a second part in the transmitter, at right angles to the first, and its slide, *S'*, is in connection with the marker, *P'*, and with the terminals of the battery, B', so a current over the line, *l'*, will move *B'* in the receiver. The other terminals of the batteries, G and G', are in the earth. It is evident that *P'* may be at any point within the limits of movement of *R* and *R'*, and also that any new position will vary the current on one or both lines, *l* and *l'*; hence any movement of *P'* will be duplicated by *P*. For writing a strip of paper moved by clockwork under the point, *P*, will give a facsimile of what is written at *P'*. A profile or portrait, or indeed any kind of marking whatever, at *P'*, will be duplicated by the receiver. The arrangement for varying the current from the battery, B, consists of a series of coils of wire having different resistances, as shown at *M M*.



PROF. DOLBEAR'S WRITING TELEGRAPH.

The main part of this invention was made by me some years ago, and it is alluded to in the book on "The Telephone and Phonograph," by George B. Prescott (p. 261). A device quite similar to this has lately been invented and described by Mr. Cowper, of England. His receiver, however, consists of two electro-magnets at right angles to each other, and the varying current acts so as to twist a light needle very much as in a common galvanometer. This transmitter is identical with mine. My instrument was made and shown to a good many persons when Cowper's was first made public here.

Sc. Am. Aug 9 1879

Sc. Am. Aug 9 1879

The Writing Telegraph.

Cowper's writing telegraph has been placed on the London and Southwestern Railway, and has been working most successfully, says the *Engineer*, from Woking to Waterloo, a distance of 26½ miles, writing off the messages in ink, one after the other, in a perfectly legible manner, whether regular line messages or messages made up in order to give the instrument more work to do. On some days more resistance coils of wire have been introduced into the two line wires, in order to represent greater distances, and thus 62½ miles and 99½ miles have been worked through in a most satisfactory manner, it only being necessary in such cases to add a few more cells of the battery, which in no case was as powerful as is very often used on the same line. The effect of the currents through the multitude of other line wires, in close proximity to the two in use for the writing telegraph, was closely observed, and the effect of induction was so exceedingly small as only to produce occasionally a slight roughness in a straight line, when the pencil of the operator was quite stationary, but such effect was hardly ever perceptible in the writing itself, and never to affect its legibility.

We understand improved instruments are now being constructed, and will shortly be at work. The fact of this instrument requiring no clerk to receive the message, translate, and write it down, seems to be much appreciated, as a half-dozen such instruments may be telegraphing their yards of messages into one office without the least assistance from the clerk, who may from time to time cut off and send out the ready written messages; so that not only is the time of "calling" (as with ordinary instruments) saved, but the time of waiting till the clerk can attend at the other end of the line to receive the signals, which very often amounts to a much longer interval than is required for the whole message to be transmitted, especially in offices fitted with many instruments.

There is also a great advantage in having an absolute record of what has been sent by the writing telegraph at the transmitting station. Another very important feature is the facility with which all that it is necessary to learn to use the instrument may be found out in five minutes. Every operation is exceedingly simple, and there are practically no fine adjustments anywhere. Variation in the power of the battery is of no importance, as its effect may be overcome by simply pushing the levers, carrying the springs against which the needles pull a little further in or out, as may be necessary. The pen, which is a very small glass capillary siphon tube, is, though of glass, very strong—it may fall several feet on to a bare floor without breaking—and is very easily adjusted.

The writing telegraph presents facilities and advantages which, we believe, will make its adoption rapid and extensive.

22 24

La Lumière Electrique

TÉLÉGRAPHE AUTOGRAPHIQUE

DE M. COWPER. July 15 1879

Lorsqu'à l'Exposition universelle de 1851, on exposa pour la première fois une dépêche écrite en écriture ordinaire par un appareil télégraphique, on ne voulut pas y croire, tant on trouvait ce résultat merveilleux, pourtant le fait était parfaitement, vrai et l'inventeur de ce système télégraphique était M. Backwel. Plus tard, M. Caselli le perfectionna assez pour le rendre applicable sur les lignes télégraphiques, et depuis une vingtaine d'années les appareils de ce genre qui ont été imaginés successivement ont été si nombreux, que, dans la description que j'ai dû en faire dans mon exposé des Applications de l'électricité, j'ai dû les répartir en cinq catégories, comprenant :

1° Les télégraphes autographiques électro-chimiques ;
2° Les typo-télégraphes électro-chimiques ;
3° Les typo-télégraphes à maquette ;
4° Les télégraphes autographiques électro-magnétiques ;
5° Les télégraphes pantographiques.

C'est à ce dernier genre d'appareils qu'appartient le télégraphe de M. Cowper dont on a beaucoup parlé dans ces derniers temps et dont nous allons donner une description complète.

Si l'on considère que tout mouvement peut être produit par la combinaison de deux mouvements rectangulaires, on arrive à conclure immédiatement que si, par un dispositif électrique quelconque, on peut gouverner régulièrement dans deux sens rectangulaires la marche d'un crayon ou d'un style quelconque, on pourra faire parcourir à ce crayon un chemin sinueux qui pourra être contourné en forme de lettres. Il s'agit donc d'obtenir électriquement ce double mouvement pour résoudre mécaniquement le problème des télégraphes pantographiques. Or, c'est ce problème qu'a résolu pour la première fois M. Lacoine, aujourd'hui directeur des télégraphes à Constantinople. Depuis lui, plusieurs inventeurs se sont également efforcés de résoudre le même problème, entre autres MM. Garceau, Leuduger-Fortmorel, Bienaymé et Hasler, mais les résultats obtenus n'ont jamais été assez satisfaisants pour que l'on songeât à tirer parti de ce système pour les transmissions télégraphiques, et c'est M. Cowper qui a pu reproduire assez nettement l'écriture par ce moyen pour fixer l'attention, et montrer que ce problème était parfaitement soluble. Toutefois, les dispositions délicates et compliquées de ce système ne semblent pas faire présager qu'il soit susceptible de devenir pratique sur nos longues lignes, mais dans tous les cas c'est une invention extrêmement curieuse qui mérite bien l'attention et l'intérêt qui l'ont accueillie. Voici maintenant la description que nous envoie de ce système M. Hospitalier.

TH. DU M.

L'ingénieux appareil imaginé par un ingénieur anglais, M. Cowper, reproduit à distance, à l'aide de l'électricité, tous les mouvements d'une plume ou d'un crayon placé au poste expéditeur *au moment même* où ces mouvements se produisent. Le mouvement pantographique du poste expéditeur et du poste récepteur sont obtenus par une application du procédé géométrique qui détermine la position d'un point sur un plan par la valeur de ses deux coordonnées.

Le déplacement du point produit des variations dans la longueur de chaque coordonnée, et ces variations sont transmises par deux fils de ligne, un pour les abcisses, l'autre pour les ordonnées, en faisant varier l'intensité du courant sur chacune de ces lignes proportionnellement à la valeur de chaque coordonnée.

Les gravures qui accompagent cet article et que nous empruntons au *Télégraphic journal* représentent : (fig. 1) le diagramme théorique du transmetteur et (fig. 2) le plan du récepteur.

Transmetteur. Deux leviers *a* et *a'* (fig. 1) à angle droit présentent à leur point de rencontre P un trou dans lequel on introduit un crayon ordinaire qu'on manœuvre à la main pour écrire le message et qui produit ainsi le déplacement des leviers. Considérons par exemple le levier *a*. Le déplacement dans le sens horizontal du crayon placé en P a pour effet de faire glisser *a* sur une sorte de peigne R composé de 32 lames de laiton séparées par des feuilles de papier enduites de paraffine, chaque lame étant reliée à la suivante par une bobine de résistance convenablement équilibrée. Le courant arrivant de la pile B traverse le levier *a*, un certain nombre de bobines (représentée chacune sur le diagramme par une simple boucle) et va par le fil de ligne au poste récepteur. Un déplacement à droite ou à gauche du point P a donc pour effet d'introduire dans le circuit ou d'en retirer un nombre de bobines de résistance en fonction de ce déplacement. Il en résulte un affaiblissement ou un accroissement d'intensité proportionnel aux déplacements de P. Dans l'appareil que nous avons vu et fait fonctionner à Londres, la ligne étant représentée par 400 ohms de résistance, soit 40 kilomètres environ, la résistance des bobines est graduée de telle sorte que la première, à droite, ayant seulement 30 ohms de résistance, la dernière à gauche en a 600.

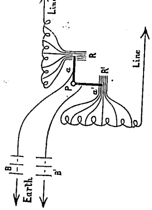


Fig. 1.

25

Le point P étant dans sa position extrême de gauche, les 31 bobines reliées aux 31 lames de laiton introduisent une résistance additionnelle de 10,000 ohms.

Ce que nous venons de dire s'applique aux déplacements dans le sens vertical transmis par un second fil de ligne et un second jeu de bobines de résistance correspondant au peigne R' et à une seconde pile B'.

Les leviers a et a' ne devant jamais quitter leurs peignes respectifs, les déplacements du point P sont limités par un petit cadre carré de 20 millimètres de côté environ et une bande de papier entraînée par un mouvement d'horlogerie se déroule régulièrement de droite à gauche sous ce cadre. La main restant immobile, le crayon ne peut se déplacer que de 2 centimètres en tous sens, et le papier se déroulant régulièrement sous votre main, ces conditions inusitées de calligraphie constituent une petite difficulté vaincue après deux minutes d'exercice. Il suffit de remarquer que les mouvements de gauche à droite opposés au mouvement du papier doivent être très-petits, tandis que ceux de droite à gauche doivent être assez rapides, car on doit alors courir après le papier qui s'échappe sous la main.

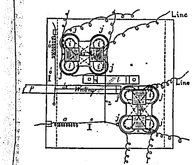


Fig. 2.

Récepteur. Le récepteur (fig. 2) se compose, pour chaque ligne, d'une paire d'électro-aimants verticaux i i, j j, dans lesquels circule le courant venant du transmetteur. Une aiguille de fer-blanc très-légère pivote autour de *h* entre les pôles de ces électro-aimants et est polarisée par le courant d'une pile locale circulant dans deux bobines horizontales qui entourent l'aiguille tout en lui permettant de se mouvoir horizontalement.

L'extrémité de chaque aiguille est reliée à un fil o2, o'2 sur lequel un faible ressort o, o' exerce une traction convenablement réglée. Au point d'intersection des fils o2 et o'2 reliés à chaque aiguille est fixé un syphon capillaire dont à une des extrémités vient s'appuyer une bande de papier p et tracer un trait continu sur cette bande qui se déroule régulièrement de droite à gauche par un mouvement d'horlogerie. L'autre extrémité du syphon *l* plonge dans un réservoir d'encre d'aniline qui sert à l'alimenter.

Les électro-aimants dont la puissance est proportionnelle à l'intensité du courant circulant dans la ligne qui correspond à chacun d'eux, produisent sur l'aiguille polarisée des déviations proportionnelles à ces intensités. La pointe du syphon écrivant suit tous les déplacements des aiguilles qui lui sont communiqués par les fils o2 et o'2 et reproduit sur la bande p tous les caractère tracés par le crayon du poste expéditeur.

Il n'y a donc pas besoin d'établir de synchronisme entre les appareils et il suffit que les mouvements d'horlogerie qui entraînent les bandes marchent régulièrement pour obtenir la reproduction de l'écriture au poste récepteur. Un déroulement trop rapide ou trop lent de la bande se traduit seulement par une *anamorphose* de l'écriture comme ci-dessous.

Si la bande se déroule trop vite, on obtient LONDRES.

Si la bande se déroule trop lentement, on obtient **LONDRES**.

Il va sans dire que le trait reproduit à la station est *continu*, aucune disposition spéciale ne relevant le syphon écrivant pour séparer les mots qui sont seulement distingués par les intervalles qu'on ménage entre eux.

La figure 3 représente un fac-simile d'une dépêche ainsi écrite et de la même dépêche transmise; comme on le voit, l'écriture à la transmission est beaucoup plus grande que celle obtenue à la réception, et cela doit être, pour que les variations de résistance du circuit soient réellement appréciables. En raison de cette différence de grandeur, nous n'avons reproduit dans le fac-simile que le premier mot de la phrase qu'on lit sur la dépêche reproduite, c'est le mot *écrit*. On peut voir, du reste, que la reproduction de l'écriture est parfaitement lisible.

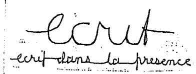


Fig. 3.

Applications de l'appareil. Le principe de cet appareil se prête à plusieurs applications intéressantes.

Dans les affaires, il pourra servir à transmettre des ordres écrits en supprimant toutes chances d'erreurs; les ordres secrets, les écritures cryptographiques et étrangères pourront ainsi s'envoyer instantanément par le même appareil.

Mais on ne pourra multiplier les applications de ce système, comme celles du téléphone dont il est en quelque sorte l'analogue pour la transmission de l'écriture, qu'après des modifications légales dont nous n'avons à apprécier ici ni l'importance ni l'opportunité.

Signalons enfin, à titre de curiosité, une modification possible de l'appareil, qui montre quelle puissance l'électri-

2 26

cité met en nos mains pour effectuer les choses les plus invraisemblables en apparence.

Ajoutons un troisième fil à l'appareil, un troisième peigne avec une troisième série de bobines de résistance, et obligeons la pointe du transmetteur à se promener régulièrement à la surface d'un médaillon, cette pointe se soulevant proportionnellement aux reliefs. Nous faisons ainsi de la géométrie à trois dimensions. En remplaçant le syphon du récepteur par une pointe très-fine, elle suivra tous les mouvements de la pointe du récepteur et nous reproduirons, *à une distance de plusieurs kilomètres*, un médaillon, un camée, ou toute autr objet analogue.

M. Cowper, par la solution élégante du problème de l'écriture à distance, nous montre, une fois de plus, quelle mine féconde l'électricité offre à ceux qui, pour l'exploiter, peuvent unir la science à l'imagination.

E. Hospitalier.

Le bruit qui s'est fait autour du télégraphe de M. Cowper a éveillé en Amérique certaines prétentions que nous voyons formulées dans le *Scientific American* du 14 juin 1879, à l'occasion d'un télégraphe du même genre imaginé par M. Dolbear et qui, suivant lui, aurait été décrit dans l'ouvrage de M. Prescott sur le téléphone et le phonographe.

Malheureusement pour M. Dolbear, il arrive, en admettant même l'exactitude de ses prétentions, le sixième sur la liste des inventeurs de ces sortes de télégraphes. M. Prescott aurait pu s'en apercevoir, puisqu'il a entre les mains tous les traités télégraphiques du monde entier et que j'ai décrit moi-même les cinq systèmes qui ont précédé ceux de M. Dolbear et de M. Cowper, dans les deux éditions de mon exposé des Applications de l'électricité; mais on n'aime pas, en Amérique, rappeler les invention: et les travaux étrangers. Dans tous les cas, voici en quoi consiste le système de M. Dolbear:

Dans ce système, les deux mouvements rectangulaires du style écrivant sont obtenus sous l'influence d'attractions de courants parallèles, c'est-à-dire sous l'influence de tiges de fer s'enfonçant dans des bobines électro-magnétiques proportionnellement à l'intensité des courants transmis. Naturellement ces tiges de fer sont disposées entre elles à angle droit, et la bande de papier se déroule au-dessous du style écrivant comme dans les télégraphes Morse ordinaires. Dans le transmetteur, les deux glissières à angle droit qui correspondent au style traceur sont terminées par un contact qui passe sous une série de ressorts mis en communication avec le même pôle d'une batterie, et dans le circuit desquels sont interposées une série de résistances, graduées de manière à fournir, d'une extrémité à l'autre, une variation de courants régulièrement croissants ou décroissants. Comme dans tous les systèmes de ce genre, il y a deux batteries et deux fils à la lignes, afin de pouvoir obtenir les deux mouvements rectangulaires nécessaires à la reproduction d'une figure. Or, suivant M. Dolbear, les mouvements produits par les noyaux magnétiques de l'appareil de réception se trouveraient être proportionnels à ceux exécutés par les glissières du style du transmetteur qui mettraient en jeu des courants d'intensité différente suivant leur position. Par conséquent, on pourrait obtenir la reproduction réduite (dans tel rapport que l'on voudrait) des mouvements produits par le style traceur de l'appareil de transmission.

Nous ignorons si ce système a été exécuté, mais nous croyons que cette proportionnalité des mouvements des noyaux magnétiques glissants dans des solénoïdes à l'intensité des courants transmis est au moins douteuse, car il y a dans ces sortes d'attractions un maximum qui se produit quand le milieu du noyau magnétique correspond au milieu de la bobine. Du reste, tous ces télégraphes sont, comme il a été dit en commençant, plutôt une curiosité que des appareils utiles.

Th. du M.

The Writing Telegraph.

Mining & Sci Press Aug 11

Cowper's writing telegraph has been placed on the London and Southwestern railway, and it works most successfully, says the *Engineer*, from Woking to Waterloo, a distance of 26½ miles, writing off the messages in ink, one after the other, in a perfect legible manner, whether regular line messages or messages made up in order to give the instrument more work to do. On some days more resistance coils of wire have been introduced into the two line wires, in order to represent greater distances, and thus 62½ miles and 99¼ miles have been worked through in a most satisfactory manner, it only being necessary in such cases to add a few more cells of the battery, which in no case was as powerful as is very often used on the same line. The effect of the currents through the multitude of other line wires, in close proximity to the two in use for the writing telegraph, was closely observed, and the effect of induction was so exceedingly small as only to produce occasionally a slight roughness in a straight line, when the pencil of the operator was quite stationary, but such effect was hardly ever perceptible in the writing itself, and never to affect its legibility.

The fact of this instrument requiring no clerk to receive the message, translate and write it down, seems to be much appreciated, as a half-dozen such instruments may be telegraphing their yards of messages into one office without the least assistance from the clerk, who may, from time to time, cut off and send out the ready written messages; so that not only is the time of "calling" (as with ordinary instruments) saved, but the time of waiting till the clerk can attend at the other end of the line to receive the signals, which very often amounts to a much longer interval than is required for the whole message to be transmitted, especially in offices fitted with many instruments.

There is also a great advantage in having an absolute record of what has been sent by the writing telegraph at the transmitting station.

Another very important feature is the facility with which all that it is necessary to learn to use the instrument may be found out in five minutes. Every operation is exceedingly simple, and there are practically no line adjustments anywhere. Variation in the power of the battery is of no importance, as its effect may be overcome by simply pushing the levers, carrying the springs against which the needles pull a little further in or out, as may be necessary. The pen, which is a very small glass capillary siphon tube, is, though of glass, very strong—it may fall several feet on to a bare floor without breaking—and is very easily adjusted.

Electrician Aug 30-1879

BRITISH ASSOCIATION.

THE WRITING TELEGRAPH.

On Monday, before the Mechanical Section, Mr. E. A. Cowper described details of the construction of his writing telegraph and the mode in which a pen at a distant station was made to write freely, as the operator at the sending station wrote with a pencil at the sending instrument. He explained the necessity that existed for causing the two currents of electricity that conveyed the power to the distant station to increase steadily and gradually, without any sudden large increase or decrease of resistance being opposed to such currents; the construction of the necessary resistances being practically that of one very long thin German silver wire, having 32 metal plates soldered to it at the proper intervals, such plates being all brought very close together with simply a thin sheet of paper with paraffin between them, so that a contact rod in connection with a battery with a small knob or projection on it could slide over the tops of the plates and make contact with each one in succession. Then two such contact rods joined to the pencil of the operator and placed at right angles to one another worked over the tops of the two separate sets of contact plates, each set affecting one line wire, so as to give latitude and longitude of the pencil of the operator at all times. The quick action or perfect response of the needles at the receiving instrument, which directly controlled the writing pen, was obtained by using exceedingly thin soft iron plates, both for the needles and for the magnets which affect the needles, so as on the one hand to have the least possible amount of momentum and *vis inertia* in the needles, and the least possible residuary magnetism in the magnets. The needles were slightly curved in their section to stiffen them, their thickness being only 1-110th inch, and were mounted on polished hard steel bearings, and were thus exceedingly free and lively, as a very small amount of friction or weight in this part of the instrument would be fatal to good writing. The power of the needles was ensured by fixed flat coils that surrounded them, brought into action by a local battery, whilst the two line wires were coiled around the fixed magnets that affected the needles and attracted them more or less as the strength of the currents varied. Then the needles being at right angles to each other, pulled the pen in the two directions, vertically and horizontally, and also pulled against two light springs, so that the pen took exactly the varying positions due to the varying strength of the currents, which again depended upon the position of the pencil of the operator. The paper on which the operator wrote and the paper on which the pen wrote at the opposite end of the line both moved along by clockwork, so as to write a long continuous message or telegram.

Mr. Cowper exhibited his machine, which was carefully examined, and showed how really ingenious the inventor had been. In answer to questions, he said that the instrument had worked perfectly at a distance of 99¼ miles. At present the operator could send messages at the rate of twenty words per minute, but he hoped that would be increased.

27

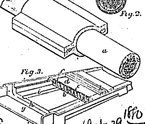
Cowper's Writing Telegraph.

Eng Mechanic Sept 5 1879

Mr. E. A. Cowper read a paper on his writing telegraph, and explained the necessity that existed for causing the two currents of electricity that conveyed the power to the distant station to increase steadily and gradually, without any sudden large increase or decrease of resistance being opposed to such currents; the construction of the necessary resistances being practically that of one very long thin German silver wire, having thirty-two metal plates soldered to it at the proper intervals, such plates being all brought very close together with simply a thin sheet of paper with paraffin between them so that a contact rod in connection with a battery, with a small knob or projection on it, could slide over the tops of the plates and make contact with each one in succession. Then two such contact rods jointed to the pencil of the operator, and placed at right angles to one another worked over the tops of the two separate sets of contact plates, each set affecting one line wire so as to give latitude and longitude of the pencil of the operator at all times. The quick action of the perfect response of the needles at the receiving instrument, which directly controlled the writing pen, was obtained by using exceedingly thin soft iron plates both for the needles and for the magnets which affect the needles, so as on the one hand to have the least possible amount of momentum and *vis inertia* in the needles and the least possible residuary magnetism in the magnets. The needles were slightly curved in their section to stiffen them, their thickness being only 1-110 inch, and were mounted on polished hard steel bearings, and were then exceedingly fresh and lively, as a very small amount of friction or weight in this part of the instrument would be fatal to good writing. The paper on which the operator wrote and the paper on which the pen wrote at the opposite end of the line both moved along by clock-work, so as to write a long continuous message or telegram.

1184. Apparatus for Insulating, Containing, and Protecting Surface and Underground Telegraph Wires: J. T. King, Liverpool. (*C. Linfold; Pittsburgh, U.S.A.*) [*6d. 8 Figs.*]—The object of the invention is to protect surface and underground telegraph wires from growth of fungus, admission of moisture, and want of durability, and to render them accessible for repairs. Fig. 1 is a perspective view of a telegraph cable and container. The cable *a* consists of cotton-covered wires held together by a strip of cotton wrapped spirally round them, the interstices are filled with melted paraffine or tar. The cloth wrapper is coated with an elastic impervious material, and, if desired, another strip of cloth is wound round in an opposite direction, and also coated with material. Fig. 2 shows a section of the cable. Fig. 3 shows a container with an iron box or bed, protected from rust by tinning or other treatment. The interior is

29R



Engineering Oct-29 1880

fluted at *b* to form receptacles for the wires, and the whole interior surfaces of them are coated with porcelain enamel, as at *c*, to prevent the passage of moisture to the interior. A cover *d* fits within the flanges *e*, and rests upon the shoulders *f*. The sections of the container are united by a coupling box *g*, which has a transverse groove *h* and longitudinal grooves *i*. The form of the coupling box is adapted to the shape of the bed, and is attached by screws. When the wires are placed in the grooves, the cover *d* is cemented down, the cement being fitted into the groove *k* and between flanges *e*. Cement is also poured into the coupling box, and fills up the grooves and recesses. (March 19, 1880).

28

COWPER'S WRITING TELEGRAPH.

[16183.]—I was surprised and disappointed to find in your issue for March 7 an account of an invention by Mr. Cowper, by which a telegraphic message can be automatically recorded in writing similar to that written by the sender. To accomplish this had been my chief object for the previous five months, and I had pretty nearly arrived at what I thought to be a solution of the problem, when the above information reached me, as I have said, through the medium of your valuable journal. I was struck with the similarity that exists between Mr. Cowper's invention and the latest arrangement which I had arrived at to effect the required object. The principle which I made use of was the same as that employed by Mr. Cowper, and therefore I need not mention it; but far stranger is the fact that the last transmitter I devised is so like the one described in the MECHANIC of the above date, that I don't know where to point to a difference. I had thought of many different modes of varying the resistance to produce required results: one consisted in attaching to the pencil two thin wires at right angles; these pass over pulleys and terminate in small metal balls, each of which passes into a tube with a metallic bottom, and partially filled with water; the bottoms of the tubes are connected by separate wires to the receiver, and the pencil to one pole of the battery. I have so arranged matters that when the pencil is moved *directly* away from one tube, and in a direction parallel to either wire then at right angles, the height of the ball in the other tube will not be affected.

As regards the receiver, I should like to know what would be the objections to one of the following type, which is the only difference between Mr. Cowper's invention and my idea, and which is so simple that I trust a figure is unnecessary. A long thin rod has a universal joint near one end; this joint, which works with next to no friction, I designed for the purpose, though it was probably known before. Two light armatures, attached by light rigid rods to the short end of the jointed one, are placed at right angles; an electro-magnet is placed near each armature. Two springs at right angles are also attached to the rod, so as to partially counteract the force of the magnets. One end of the wire of each magnet is connected with one line wire, the other two with the earth.

In Mr. Cowper's arrangement, the needles are deflected through distances which may be taken as proportional to the amounts of current received, owing to their small deflection; but in mine, in order to produce deflections proportional to the current, the springs must be of a certain tension, since the force of a magnet varies inversely as the square of the distance from it. Perhaps iron weights, moving in coils, and attached by strings to the short end of the rod, would give better results.

The siphon arrangement, for recording the movements of the rod, would, of course, be attached to the end of the long part of the rod.

I should like to point out, in conclusion, that I don't for a moment presume to have devised a better plan than Mr. Cowper for embodying an idea which occurred to both that gentleman and to me quite independently; but rather I give it for what it is worth, with the hope that someone may think it worth the trouble of trying.

In the mean time, I shall be glad to hear the opinions of any of your many able correspondents, for, while it seems to me quite as effective a plan, it obviously has the advantage of greater simplicity.

W. B. B.

Dunedin, New Zealand, June 30.

P.S.—Is not the necessity of having two line-wires a great drawback to the new invention?

George Bower, St. Neots.

13. Cowper's Writing Telegraph. The person sending a message by this instrument, writes with an ordinary pencil, which is jointed to two light connecting rods at right angles to each other, which transmit currents of variable strength, one for the up and down strokes, and the other for the right and left movements. These currents affect two magnets, which actuate two needles, to which a pen is connected, in the receiving instrument (which may be many miles distant from the sending instrument), and cause the pen to follow the motions of the pencil of the sending instrument, and so reproduce in ink the written message.

E. A. Cowper, C.E.

Messages will be sent from one part of the hall to another, through a coil of wire representing about 36 miles of ordinary telegraph line.

B. a a. S

29

parent *raison d'être* in phenomena.

Boston Journal of Chemistry May 1879

HANDWRITING SENT BY TELEGRAPH.

THE Hibernian who expected to send his letter along the telegraphic wire was perhaps only a little ahead of the times. "Autographic telegraphy," or the transmission of messages in the actual handwriting of the sender, is a subject which for some thirty years has been the study of inventors. As long ago as 1850, Mr. F. C. Bakewell, in England, devised an instrument for this purpose, which was probably the first practically successful one. The message was written with a gummy ink or varnish on metallic paper or tin-foil, and this writing was by the aid of mechanism used to actuate electric currents in such a way as to produce a record at the distant station by the chemical decomposition of a solution with which the receiving paper was damped. Both the written messages and the paper were fixed around cylinders of similar form and dimensions, one being placed in the transmitting and the other in the recording instrument, and the cylinders were caused to revolve with corresponding velocities. Each time the gummy, and consequently raised, lines of the writing were crossed by a pointer, under which the metallic paper was traversed in the transmitter, a mark corresponding in position was made on the prepared paper at the receiving end. It therefore followed that the sum of all

COWPER'S WRITING TELEGRAPH.

[16183.]—I was surprised and disappointed to find in your issue for March 7 an account of an invention by Mr. Cowper, by which a telegraphic message can be automatically recorded in writing similar to that written by the sender. To accomplish this had been my chief object for the previous five months, and I had pretty nearly arrived at what I thought to be a solution of the problem, when the above information reached me, as I have said, through the medium of your valuable journal. I was struck with the similarity that exists between Mr. Cowper's invention and the latest arrangement which I had arrived at to effect the required object. The principle which I made use of was the same as that employed by Mr. Cowper, and therefore I need not mention it; but far stranger is the fact that the last transmitter I devised is so like the one described in the MECHANIC of the above date, that I don't know where to point to a difference. I had thought of many different modes of varying the resistance to produce required results: one consisted in attaching to the pencil two thin wires at right angles; these pass over pulleys and terminate in small metal balls, each of which passes into a tube with a metallic bottom, and partially filled with water; the bottoms of the tubes are connected by separate wires to the receiver, and the pencil to one pole of the battery. I have so arranged matters that when the pencil is moved *directly* away from one tube, and in a direction parallel to either wire then at right angles, the height of the ball in the other tube will not be affected.

As regards the receiver, I should like to know what would be the objections to one of the following type, which is the only difference between Mr. Cowper's invention and my idea, and which is so simple that I trust a figure is unnecessary. A long thin rod has a universal joint near one end; this joint, which works with next to no friction, I designed for the purpose, though it was probably known before. Two light armatures, attached by light rigid rods to the short end of the jointed one, are placed at right angles; an electro-magnet is placed near each armature. Two springs at right angles are also attached to the rod, so as to partially counteract the force of the magnets. One end of the wire of each magnet is connected with one line wire, the other two with the earth.

In Mr. Cowper's arrangement, the needles are deflected through distances which may be taken as proportional to the amounts of current received, owing to their small deflection; but in mine, in order to produce deflections proportional to the current, the springs must be of a certain tension, since the force of a magnet varies inversely as the square of the distance from it. Perhaps iron weights, moving in coils, and attached by strings to the short end of the rod, would give better results.

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B.A.A.S

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the marks reproduced the writing itself. Mr. Bakewell successfully reproduced the writing in white on a blue ground, but the process failed to become one of public utility owing to the extreme slowness with which the apparatus worked, and the difficulty that was experienced in maintaining uniform and synchronous motion in the instruments. In 1856, the Abbé Caselli, in Italy, endeavored to solve the problem of autographic telegraphy in a similar manner. His apparatus, of which an illustrated description is given in Gaut's "Physics," was exhibited in England, and it was used practically between Paris and Marseilles, and Paris and Lyons. Plans, drawings, and autographic sketches were faithfully reproduced at distant places, but it was found that the apparatus had not only the defects of Bakewell's, but it was very costly and complicated. Two other subsequent workers in this direction were M. Meyer and M. Lenoir, who, quite unknown to each other, tried to accomplish the same results with ordinary ink.

The latest experiment in autographic telegraphy is that of M. d'Arlincourt, of Paris, which has lately been submitted to the English post-office authorities for trial. The London *Times* gives the following account of the instrument (which is on the same general plan as Bakewell's) and its workings:—

The distinguishing feature in M. d'Arlincourt's apparatus is the introduction of an extremely ingenious synchronous movement, by means of which the speed of travel of the cylinders is rendered uniform, both in the transmitting and the recording machine. The message to be sent, which may be either in the ordinary hand or short-hand, is written with a thick, gummy ink upon a strip of metallic-faced paper, about twelve inches long and two and one half inches deep, which is wrapped around the cylinder of the transmitting instrument. A strip of white paper, chemically prepared and of similar dimensions, is placed on the cylinder of the recording apparatus, and the instruments are placed in electrical connection and started. The raised writing, actuating the electric current, causes a reproduction of the original message in *fac-simile* on the paper in the recording instrument, which may be hundreds of miles away from the other. Upon the occasion of our visit the two instruments, although in the same room, were practically placed two hundred miles apart. The writing can be reproduced in either blue, brown, red, or black, according to the chemical preparation of the paper, but always on a white ground, and a number of copies can be taken from one original. In the same way, sketches, plans, or drawings may be faithfully transmitted; some sketches were, in fact, accurately reproduced on the occasion of our visit. Although the apparatus is perfect in its action, it still has one drawback, which was common to its predecessors,—that of slowness of reproduction. The time occupied in revolving the cylinder a sufficient number of times to allow the pointer to traverse the whole surface of the paper is seven minutes, and this rate of speed is far below that required and attained in practice for commercial purposes. The post-office authorities, to whom we are indebted for our inspection, do not, therefore, see their way to utilize M. d'Arlincourt's ingenious invention at present. It is, however, being worked in France in fortresses, and for similar military purposes, for use in which and in some special cases it is exceedingly well adapted.

J. C. JACOBSON, a wealthy brewer of Copenhagen, has set aside a million Danish crowns for the support of a laboratory for scientific results.

Menlo Park Scrapbook, Cat. 1044

No. 30. "Telegraph - Duplex, Quadruplex, Multiplex"

This scrapbook covers the years 1873-1889, but most of the clippings are for the mid-1870s. The material relates primarily to multiplex telegraphy. Several of the clippings for 1888 deal with Elisha Gray's telautograph and his claim to have invented the telephone. There are 138 numbered pages.

Blank pages not filmed: 2-3, 6-9, 98-138.

1044

Telegraphy

Duplex - Quad - Multiple

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LE QUADRUPLEX DE M. EDISON

Les systèmes de transmissions simultanées et multiples combinés dès l'année 1855 peuvent être répartis en quatre grandes catégories :

1° Les systèmes dans lesquels les correspondances peuvent être échangées simultanément en sens contraire des deux bouts de la ligne par l'effet de combinaisons particulières de circuits ;

2° Les systèmes dans lesquels des transmissions multiples peuvent s'effectuer simultanément dans le même sens à chaque station ;

3° Les systèmes dans lesquels on utilise les instants où plusieurs appareils transmetteurs introduits dans le même circuit à une station sont inactifs ;

4° Les systèmes où les dépêches, étant transmises simultanément par des appareils électro-harmoniques, permettent le triage des dépêches par le synchronisme des vibrations des appareils récepteurs.

A la première catégorie appartiennent les duplex aujourd'hui très-nombreux, combinés pour la première fois par M. Gintl et dont il a été déjà question dans un des précédents numéros du journal *l'Electricité*.

A la seconde appartiennent certains systèmes combinés, dans l'origine, par MM. Stark et Duncker et perfectionnés ensuite par MM. Bosscha, Maron, Wartmann, etc.

A la troisième se rattachent les systèmes de MM. Meyer, Baudot, Schaeffler, combinés dans l'origine par M. Rouvier.

Enfin, à la quatrième se rapportent les télégraphes harmoniques de MM. Paul Lacour, Elisha Gray, Graham Bell et C. Varley.

La combinaison des deux premiers systèmes devait conduire fatalement au quadruplex et même en adaptant les combinaisons du duplex aux deux dernières catégories d'appareils, on pouvait doubler le nombre des dépêches envoyées. C'est ainsi que le télégraphe harmonique d'Elisha Gray, qui n'était dans l'origine qu'un quadruplex à transmission dans le même sens, est devenu un octuplex. Toutefois, on s'en est tenu généralement jusqu'ici dans la pratique, aux duplex, aux quadruplex et aux systèmes multiples de Meyer, et, parmi les systèmes employés, ceux de MM. Stearns et Edison sont les plus importants. On peut même dire que c'est grâce au système de Stearns que le duplex a été rendu susceptible d'être appliqué sur les lignes, et c'est ce qui explique pourquoi cette invention, qui remonte à 1855, n'a été appliquée qu'en 1872.

Le secret de la réussite de M. Stearns gît, comme on le sait, entièrement dans l'introduction qu'il a faite d'un condensateur dans le circuit, afin de compenser les effets des décharges dues aux réactions statiques effectuées sur les lignes.

Il paraît que c'est seulement en juin 1873 que M. Olivier Heaviside fit remarquer le premier qu'en combinant au duplex de Stearns le système à transmission dans le même sens de MM. Stark et Bosscha, on pourrait doubler le nombre des transmissions effectuées par le duplex. En 1874, M. Edison chercha à réaliser cette idée sur les lignes de la Western-Union-Company de New-York et combina le système dont nous allons parler et qui a été l'une des plus intéressantes conceptions de l'inventeur américain.

Dans ce système, les transmissions simultanées dans le même sens sont basées sur la combinaison des systèmes de transmisson à courant double et à circuit ouvert. On sait que, dans le premier système, la batterie reste en communication permanente avec la ligne à la station de transmission, ses pôles étant renversés au commencement et à la fin de chaque signal, sans que jamais le circuit soit interrompu. Alors, le relais de la station de réception est polarisé et disposé de manière à n'être impressionné que par le sens du courant. Il en résulte, par conséquent, que les modifications dans la force du courant transmis restent sans action sur lui.

Dans le système à circuit ouvert, au contraire, le récepteur fonctionne sous l'influence de courants interrompus ou simplement affaiblis, et en conséquence son armature est en fer doux et soumise à une action antagoniste. Or, on conçoit que dans de pareilles conditions, deux appareils disposés, suivant ces deux principes, aux deux stations en correspondance pourront, étant convenablement réglés fonctionner isolément avec des transmissions simultanées, puisque l'un ne peut agir que sous l'influence d'une action à laquelle l'autre est insensible. Pour faire de ce système un quadruplex, il ne s'agissait que de lui appliquer la disposition du duplex. Toutefois, le choix de cette dispositon n'a pas été aussi simple qu'on l'aurait pensé, et après plusieurs essais faits entre New-York et Boston, sur une longueur de ligne de deux cent quarante milles, on reconnut que la disposition en duplex avec le pont de Wheatstone était préférable à la disposition en système différentiel, surtout quand la ligne était très-longue.

La disposition du quadruplex de M. Edison est indiquée dans la figure ci-contre. T^1 est un transmetteur de courant à inversions, mis en action par un électro-aimant, une batterie locale E^1 et une clef K^1. Sa fonction consiste à renverser le sens du courant de ligne à travers la plaque de terre et la ligne, chaque fois que la clef K^1 est abaissée. Les ressorts S^1 S^2 déterminent cet effet sans que la ligne soit pour cela interrompue.

De cette manière, les mouvements du second transmetteur T^2 effectués sous l'influence d'une petite pile locale e^2 et la seconde clef K^2, peuvent transmettre à travers la ligne les courants résultant d'une seconde pile de ligne E^2 qui s'additionnent quand la clef K^2 est abaissée à ceux de la pile E^1 ayant deux ou trois fois moins d'éléments. Toutefois, malgré cette action, la polarité de la ligne se maintient dans les conditions où l'a placée la première clef K^1.

A l'autre extrémité de la ligne se trouvent les deux appareils de réception R^1 R^2, l'un R^1 qui est un relais à armature polarisée, et qui n'est, par conséquent, impressionnable qu'aux courants renversés, l'autre R^2 qui est un relais à armature de fer doux, réglé de manière à n'agir que sous l'influence des courants renforcés, et par conséquent sous l'action de la clef K^2.

Le premier de ces relais réagit par l'intermédiaire d'une pile locale L^1, sur un résonnateur S^1 qui fournit les indications en rapport avec les transmissions effectuées par le transmetteur T^1. L'autre relais actionne un autre résonnateur S^2, mais dans des conditions un peu plus compliquées en raison des mouvements produits par l'armature du relais R^2 au moment des inversions des polarités de la ligne.

Pour éviter ces effets, il a fallu que l'armature du relais R^2 ne produise son contact de fermeture que sur son butoir d'arrêt, et c'est alors une seconde pile locale L^2 qui fait marcher le résonnateur S^2.

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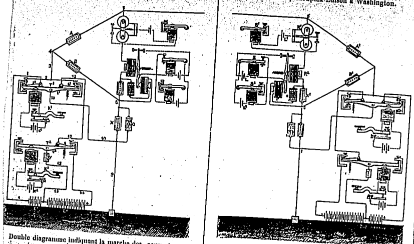
Poste de Boston
Station du quadruplex Edison à New-York.

Poste de New-York
Station du quadruplex Edison à Washington.



Double diagramme indiquant la marche des courants pour le quadruplex Edison.

Double diagramme indiquant la marche des courants pour le quadruplex Edison.

Avec cette disposition, il arrive que quand le relais R² a son armature attirée, le circuit du relais S se trouve coupé et celui du résonnateur S² se trouve complété; mais cette action ne peut être produite entièrement que quand le mouvement de l'armature du relais R² a duré un temps suffisant et, de cette manière, les petites oscillations de celle-ci dues aux permutations de polarité ne peuvent exercer une action effective.

En doublant les appareils aux deux stations en correspondance et les disposant comme on le voit sur la figure, de manière à constituer les éléments de combinaisons d'un pont de Wheatstone, c'est-à-dire en plaçant les systèmes transmetteurs à deux des angles opposés du losange, et les appareils récepteurs selon le fil de jonction reliant les deux autres angles, on dispose le système précédent en duplex; mais il faut 1° introduire dans les côtés du losange les rhéostats A, B, A', B'; 2° interposer d'autres rhéostats et condensateurs en X, C, Y, X', C'; 3° introduire quelques dispositions particulières dont nous allons maintenant parler.

Quand on appliqua ce système de transmission sur des lignes d'une grande longueur, on put reconnaître que les effets de démagnétisation du relais R², résultant des permutations des polarités de la ligne, se trouvaient grandement augmentés par l'action de la décharge statique, et il en résultait que l'intervention du relais additionnel S ne suffisait plus pour en empêcher l'action sur le résonnateur. Pour y remédier, on dut interposer un rhéostat en X¹ avec une dérivation correspondant à un fort condensateur *c* et à un second électro-aimant *r*, réagissant sur une armature placée à l'extrémité du levier-clef du relais R² et disposée de manière à ce que les deux actions fussent conspirantes dans le même sens. De cette manière, quand un courant d'une certaine polarité venait à s'annuler, le condensateur se déchargeait immédiatement à travers l'électro-aimant *r* qui le retenait attiré pendant le temps que le relais R² subissait les influences des permutations de polarités contraires.

Dans ce système, les combinaisons de courants sont les suivantes :

1° Quand la première clef est abaissée et la seconde élevée, on a....................	+ 1
2° Quand la seconde clef est abaissée et la première élevée, on a......	— 3 ou — 4
3° Quand les deux clefs sont abaissées..................................	+ 3 ou + 4
4° Quand les deux clefs sont élevées..................................	— 1

« Il résulte de cette disposition, dit M. Prescott, un avantage pratique important et qui est dû à ce fait que les forces requises pour la production des signaux sur les relais polarisés et sur les relais neutres peuvent être réciproquement augmentés ou diminués suivant les besoins, sans aucun inconvénient. Dans certaines circonstances, il arrive même que plus cette différence est grande, meilleurs sont les résultats que l'on obtient, et cela tient à ce que la disposition des combinaisons se rapportant au relais neutre augmente son effet proportionnellement au travail qui lui est demandé. Le rapport des courants respectifs a été varié de 1 à 4 avec des avantages correspondants dans les résultats fournis par la manipulation des appareils. »

Th. du Moncel.

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Telegraphic Journal — July 1. 75

THE QUADRUPLEX TELEGRAPH.*

By F. W. JONES.

JUST one hundred years ago George Louis Lesage, of Geneva, constructed a telegraph composed of twenty-four line wires, corresponding to the twenty-four letters of the alphabet, and by the use of frictional electricity and pith balls, succeeded in transmitting intelligible signals over the wires to a distance.

Numberless experiments by different philosophers followed in quick succession with a view of establishing means of rapid communication between widely-separated places, but none of the systems that were devised proved anything more than scientific toys.

It remained for Morse, in 1844, to establish a system which was to stand the test of actual experience.

During the same year considerable activity in experimenting was also manifested in England. The first line of any length was constructed between London and Gosport, on the London and South Western Railway, but it was two years later before lines were extended for commercial purposes.

In our own country, starting with one wire between Baltimore and Washington in 1844, we can now boast miles enough of telegraph wire, owned by the various companies, to encircle the globe about ten times. Chicago had its first wire in 1847, and now the Western Union Chicago office alone works 72 long circuits stretching in every direction to all parts of the country, besides 39 metropolitan and 60 private lines.

So far from adhering to first principles in the use of *twenty-four wires for the transmission of a single message*, the hour is at hand when *twenty-four messages can be transmitted simultaneously over one wire.*

At the present time four messages are sent at the same time a distance of nearly one thousand miles, with the utmost ease and certainty, at the rate of 120 words per minute.

The wonderful instrument performing this miracle in telegraphy is *The Quadruplex*, an invention of Messrs. Prescott and Edison, electricians. It is based on the same principle as the Bridge Duplex, comprising all its main features, and in order to render a description of the Quadruplex easier and more comprehensible, I will briefly review the duplex system. Authors do not agree in their account of the origin of the duplex; some refer it to Dr. Gintl in 1853. It is well established, however, that experiments were made by the Electric Telegraph Company, of England, in 1853, but their system did not prove of any advantage, and it fell into disuse. About the same time Gintl, Siemens, and Frischen directed their efforts towards perfecting a duplex, and many Russian stations were fitted up with their instruments; but, from the fact that no gain was realized over single transmission, the stations were refitted with the ordinary Morse. Mr. De Sauty, in 1855, successfully worked the Frischen-Siemens system between Manchester and Altringham. *He only accomplished ten words per minute against sixteen by the single Morse.*

In 1856 attempts were made to work the duplex between London and Birmingham, on the Magnetic Company's wires, and the signals were improved by using a condenser; but the experiments ceased, for the reason that Mr. Gordon, of the firm of R. S. Newall and Co., to whom the English patents belonged, did not deem the addition of condensers of sufficient value to warrant the expense of their construction.

In 1868 the duplex was revived by J. B. Stearns, of Boston, and was actually worked on one of the wires of the Franklin Company. His system, which I will now describe, does not differ materially from those that have preceded it, save in the application of an improved form of double pointed key or transmitter, and, more recently, condensers, whereby long line difficulties were entirely overcome, and the carrying capacity nearly doubled.

A relay is wound throughout with two separate wires, the outer end of one and the inner end of the other are brought directly to the double pointed key. One of the opposite ends of these wires is connected to the line, and the other to a rheostat and ground of resistance equal to the resistance of the line.

The transmitter, or double pointed key, is arranged to be in contact with battery when the lever is depressed, and with ground when elevated—one contact always taking place, through spring contrivances, before the other ceases; thus the line is always on battery or ground.

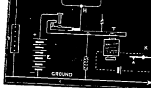
Supposing B, the distant station, to have his key open, the transmitter, which his key opens, keeps the line grounded through one wire of his relay. When Station A closes his transmitter, the current passes therefrom to the relay, and there divides in two directions; one part goes by one coil of the relay to line, and the other part by the second coil of relay to rheostat and ground. The resistances being equal in these two directions, an equal quantity of current flows through them; but, as they pass oppositely around the core no magnetic effect is produced, and the armature is not attracted from the back stop.

The current arriving at station B passes through one coil of his relay to transmitter and ground,

Electrical News aug 19 1875.

Improvements in duplex and multiplex telegraphs. Thomas Alva Edison, of Newark, New Jersey, U.S.A. February 2, 1875.—No. 384. This invention relates to improvements in telegraph instruments and circuits, whereby one wire can be used simultaneously by two operators at both terminal stations, one to send and the other to receive, usually known as a duplex telegraph; also one wire can be simultaneously used by two operators to transmit and two operators to receive at each end, called a quadruplex telegraph. A circuit preserving key brings into operation the whole battery or only a portion to operate one set of electro-magnetic instruments by the rise and fall of tension. Another key reverses the current without breaking the circuit, and a polarised relay magnet responds to the reversal. Rheostats, condensers, and induction-coils are inserted to neutralise static discharges, to equalise and neutralise the action of the currents sent on the receiving instruments at that station, and leave them free to respond to the currents from the distant station; also to establish artificial lines of equal resistance to the main line, and thereby to balance the electrical forces. The polarised relay and differential electro-magnet operate by local circuits the instruments that receive the messages, and indicate the same by sound or marks. At intermediate stations the instruments are arranged so as to work to either terminal station, or by connecting them a relay is effected, so that on long lines the operator at a terminal station works a relay at an intermediate station to send to the distant terminal station, and this is used either in the duplex or quadruplex telegraphs.

Telegraphic Jou



causing his armature to move forward and close the recording sounder. At this moment, should B close his transmitter he will divide his battery between rheostat and line, as was done at A, and feel no effect from it upon his own armature—one part exactly neutralizing the other; but currents being on the line, there is now double the quantity there was when B was open, consequently through the line coil of either relay, there is more current than there is flowing through the rheostat coils; therefore the cores of each relay become magnetized by this difference, and signals are recorded simultaneously at each station.

As soon as the system was tried on long lines a kick was experienced on the armatures, rendering the signals totally unreliable. This was caused by the discharge of return current through relay, and depended for volume on the static capacity of the line. A familiar illustration of this may be had by supposing a straight pipe to connect two points in the same plane, and at one end of the pipe water is forced through at a high pressure; if the pressure is suddenly removed and the pipe left open at each end, part of the water in the tube will return and empty itself, in preference to overcoming the friction of the distant portion of the tube.

Electricity, in a long and well insulated conductor of large metal cross section, will flow through to the distant end and to ground so long as battery contact is maintained; but let the battery be suddenly removed and a ground substituted, part of the charge at that instant left in the conductor will return to ground in preference to passing through the whole resistance of the line to the farther end. This return is the kick that causes so much vexation to telegraphers. By the use of condensers the kick has ceased to annoy, and five hundred mile circuits are now worked as well as those of one hundred.

It will be readily comprehended that the few coils of fine wire of which a rheostat is composed have not the static or charge capacity of a long line, the metal of one weighing only a few ounces, that of the other perhaps a hundred tons of a superior conducting metal, therefore no return charge or kick is felt from the rheostat; but by attaching to the rheostat a condenser whose static capacity is nearly equal that of the line a charge will be returned from it, at the same moment that the battery charge returns from the line, thus destroying all kick in the relay by neutralizing each other's tendency to magnetize the cores.

This system can be worked as well with the *same*

OVER

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line and ground, neutralizing all magnetic effect in the cores. Condensers must be used for static discharge the same as in duplex system. The distant station is now asked to dot on positive key, which sends a current attracting the corresponding armature at the home end, closing the local points and recording a signal. Then the distant station dashes on the negative key, closing the armature of home relay at the end opposite the one operated by the positive key, and recording a signal on sounder by contact. When both keys are closed at once the tensions of their batteries are doubled and of positive polarity. This causes a double force to act on the agreeing armature which presses forward a spring, thus closing not only its own sounder, but also the one in the connection with the opposite armature recording signals simultaneously. The weak points of this system seem to lie in the constant and uneven reversals of the current during transmission producing an unsettled condition in the cores; uncertainty of action between the armatures, and the imperfect mechanical contrivance for transferring the operation of the sounder from one tongue of relay to the other.

What may yet come of this system is a problem for future solution. It has worked moderately well on a rheostat circuit of 6,000 ohms, but has disappointed the expectation of its friends on an actual line circuit, probably on account of its infancy and want of a thorough test.

10

Telegraphic Journal July 1. 75

THE QUADRUPLEX TELEGRAPH.*

By F. W. JONES.

JUST one hundred years ago George Louis Losage, of Geneva, constructed a telegraph composed of twenty-four line wires, corresponding to the twenty-four letters of the alphabet, and by the use of frictional electricity and pith balls, succeeded in transmitting intelligible signals over the wires to a distance.

Numberless experiments by different philosophers followed in quick succession with a view of establishing means of rapid communication between widely-separated places, but none of the systems that were devised proved anything more than scientific toys.

It remained for Morse, in 1844, to establish a system which was to stand the test of actual experience.

During the same year considerable activity in experimenting was also manifested in England. The first line of any length was constructed between London and Gosport, on the London and South Western Railway, but it was two years later before lines were extended for commercial purposes.

In our own country, starting with one wire between Baltimore and Washington in 1844, we can now boast miles enough of telegraph wire, owned by the various companies, to encircle the globe about ten times. Chicago had its first wire in 1847, and now the Western Union Chicago office alone works 72 long circuits stretching in every direction to all parts of the country, besides 30 metropolitan and 60 private lines.

So far from adhering to first principles in the use of *twenty-four wires for the transmission of a single message*, the hour is at hand when *twenty-four messages can be transmitted simultaneously over one wire.*

At the present time four messages are sent at the same time a distance of nearly one thousand miles, with the utmost ease and certainty, at the rate of 120 words per minute.

Electrical News aug 19 1875.

Improvements in duplex and multiplex telegraphs. Thomas Alva Edison, of Newark, New Jersey, U.S.A. February 2, 1875.—No. 384. This invention relates to improvements in telegraph instruments and circuits, whereby one wire can be used simultaneously by two operators at both terminal stations, one to send and the other to receive, usually known as a duplex telegraph; also one wire can be simultaneously used by two operators to transmit and two operators to receive at each end, called a quadruplex telegraph. A circuit preserving key brings into operation the whole battery or only a portion to operate one set of electro-magnetic instruments by the rise and fall of tension. Another key reverses the current without breaking the circuit, and a polarised relay magnet responds to the reversal. Rheostats, condensers, and induction-coils are inserted to neutralise static discharges, to equalise and neutralise the action of the currents sent on the receiving instruments at that station, and leave them free to respond to the currents from the distant station; also to establish artificial lines of equal resistance to the main line, and thereby to balance the electrical forces. The polarised relay and differential electro-magnet operate by local circuits the instruments that receive the messages, and indicate the same by sound or marks. At intermediate stations the instruments are arranged so as to work to either terminal station, or by connecting them a relay is effected, so that on long lines the operator at a terminal station works a relay at an intermediate station to send to the distant terminal station, and this is used either in the duplex or quadruplex telegraphs.

11

plus, 50 minus and 200 plus, 200 minus and 200 plus, 200 minus and 200 minus, 200 plus and 200 plus.

These constant variations and reversals taking place through the relay coils tend to produce in them an unsettled magnetic condition, causing the movements of their armatures to be unsteady and unreliable for signals. To remedy this the bridge wire is supplied with a condenser which is charged by the same currents that work the relays, and so soon as they are withdrawn from relays the condenser discharges before a reversed current reaches them, thus prolonging the signals and preserving a magnetic equilibrium of the cores.

The condensers connected to the equating rheostat require the nicest adjustment to exactly neutralize the static discharge from line. Compared with the differential system the percentage of effective signalling current on the quadruplex is very low, and is divided between two relays in the same circuit, therefore the utmost care is necessary in balancing and arranging the different adjustments to bring out its full value. During actual service it requires great vigilance and an intelligent supervision, else it will fail to even duplex the capacity of a wire. When depended on to do the work of four wires it will be readily seen how grave would be the smallest delay, hence it behoves managers to familiarize themselves thoroughly with every part, in order to render the proper service of the quadruplex to the companies by whom they are employed.

Other methods of quadruplexy have been devised, but have proved of no practical value. That of M. Meyer, of the French Telegraph administration, exhibited at the Vienna Exposition, is the most notable, transmitting four messages over one wire in the *same* direction, but its best performance was only 110 ordinary messages per hour. Dr. H. C. Nicholson, of Mt. Washington, near Cincinnati, has also constructed a quadruplex for transmitting two messages in opposite directions over one wire at the same time. His system is on the differential principle. The outgoing currents passing in opposite directions around the home relay produce no effect on its cores. Two keys are used and are so arranged as to send current to line in the following order: When one key is depressed a positive current of given tension, when the other is closed a negative current of equal tension; when both keys are closed simultaneously a positive current of double the tension of that sent by a single key.

The relay has horizontally, and side by side, two straight cores wound differentially, and at either end are permanently magnetised armatures. One is placed horizontally on a tongue in front of the poles at one end, and the other armature swings vertically on an axis between two semi-circular extensions of the poles opposite those facing the first described armature. Both armatures are so polarized that when one is attracted by a current of certain polarity passing through the coils the other is repelled. In order to balance for work, the distant station is asked to open both keys. This removes his batteries and grounds the line through his instruments. At the home station dots are struck on either key, and the equating rheostat is so adjusted that an even division of current is made through the relay between

...appointed the expectation of its friends on an actual line circuit, probably on account of its infancy and want of a thorough test.

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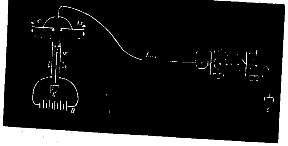
SIEUR'S DOUBLE TRANSMISSION TELEGRAPH SYSTEM.

The principle of this system is shown by the figure l_1 and l_2, are spring contact levers connected to the poles of a battery B. These levers normally make



contact with stops connected with the front contacts of keys K_1 and K_2. A cam C, connected to earth, is kept in very rapid rotation by means of clockwork, and the levers, by this means, are caused to oscillate alternately, with extreme rapidity, to and fro from their contact stops. The result of this arrangement is, that if key K_1 is depressed, a rapid succession of currents of one sign are caused to pass out to line; and if K_2 be depressed, a rapid succession of currents of the opposite sign pass to line; whilst if both keys be depressed, then both positive and negative currents succeeding one another with great speed, will flow.

The line wire leads to a pair of polarised relays R_1 and R_2 so connected up, that one responds to positive and the other to negative currents, each operating a local battery connected with receiving instruments I_1, I_2.

As the positive and negative currents alternate, the one set of signals does not interfere with the other set, and as the succession of impulses of either sign is rapid, the effect on each receiver does not practically differ from that produced by a continued current of the sign for which the receiver is adapted.

Several modifications of the arrangement just described are proposed by M. Sieur; thus, the relay tongues may normally be held over to their insulating stops by the succession of currents, the depression of the keys being made to cut off the currents of either sign. The receiving apparatus also, may be a single relay provided with two tongues oppositely polarised. Again, two batteries may be employed to give the opposite currents, the cam in this case putting earth on to each battery alternately; indeed, the modifications of which the principle is susceptible are very numerous, as must be evident.

By duplexing the arrangement in the ordinary way, quadruplex working is obtained.

We understand that M. Sieur's system is in successful operation on the Continent.

The apparatus is shown in the Telegraphic Annexe of the Paris Exhibition.

13

~~which case of course the height of the water in the tube would not be a true measure of the strain on the wire under test. With this instrument tests can be made very rapidly, as the breaking strains are read off in pounds from a scale attached to the glass tube. The results are also obtained with great accuracy, as the instrument cannot possibly get out of order.~~

~~Of course there is nothing new in the principle of this apparatus, as it is simply that of the old hydrostatic bellows.~~

~~The elongation is measured thus:—A small scale is attached at its one extremity to the piece of wire under test, and near its other extremity there is attached to the wire a small pointer, which moves over the scale as the wire stretches. This is much better than measuring, as is frequently done, the distance between the clamps before and after testing, as this latter method frequently gives erroneous results from the slipping of the wire in the clamps~~

MULTIPLE TRANSMISSION BY THE SAME WIRE.

By M. MAYER,
Of the French Telegraph Administration.

This system of apparatus, based on the division of work, has for its end the utilisation of all the currents which in a given time can be made to succeed each other in a wire, so that several *employés*, each sending twenty to thirty messages per hour, may transmit them by the same wire, as is now effected by separate wires.—that is to say, each can, at will, receive or transmit, or rest; each can at any instant interrupt the transmission of his correspondent, without the least inconvenience to his neighbours. This may be attained without detriment to the methods ordinarily in use; and whilst the number of *employés* remains the same, the number of wires is reduced for the same amount of work. It may be accepted as a principle that the system reducing the number of wires to the least possible is the system showing the greatest progress.

The number of transmissions that a telegraph line will carry varies naturally with its conductibility. It is generally admitted that with a speed of twenty-five messages per hour, on a Morse instrument, about five emissions of the current occur per second. Consequently, n being the sum of the currents which in a second can succeed each other in a conductor, $\frac{n}{5}$ represents the number of receivers which it is possible to establish upon a single wire, or the number of *employés* that can work at the same time. The multiple apparatus about to be described is constructed for four transmissions, and is served by four clerks. It revolves with a velocity of 75 turns per minute, presenting four letters at each turn. It records 100 messages in the hour, with 20 emissions of the current per second. This is less than a maximum result; for we learn by experience that all telegraph lines admit of many more than 20 emissions per second, to about a maximum of 500 per second.

As the apparatus is arranged for transmission, four keys are placed with their receivers upon a table, each receiver having its paper band. The printing arrangement is a quarter-spiral on which

(over)

[…]longated spiral. The helix of the receiver and [t]he rubbing-contact of the distributor make their [r]evolutions in the same time. An inking-wheel [r]evolves freely on each of the helices. The letters [a]ppear transversely upon the paper band (*i.e.*, at [r]ight angles to the ordinary Morse characters), the [p]aper being raised to the writing-helix by the ar[m]ature of the electro-magnet over which it passes. [T]his transversal disposition of the letters presents [a] double advantage: it avoids confusion between [c]onsecutive letters, and reduces considerably the [l]ength of the paper band used for each dispatch.

The multiple transmission, then, depends upon [t]he identical revolutions in the same time of certain [p]ortions of the apparatus at distant stations. This [i]s effected by the aid of a conical pendulum and a [r]egulating system, by which a correcting current is [t]ransmitted every second. Further, it is arranged [t]hat the line should be put to earth at both ex[t]remities after each emission of the current.

The apparatus has been in use for some time in [F]rance, between Paris and Lyons, every day from [1]1 o'clock in the morning until 6 in the evening, [u]nder the direction of an official Commission, with [t]he following results:—The maximum per operator [h]as been 28 messages per hour, with, a maximum [f]or the four operators of 110 messages the hour; [w]hile a Morse gives only 18 messages per line, and [a] Hughes' type printer 22 messages the hour. And [t]hat relatively the work done by this apparatus is [t]o that of the Morse as 4 : 1, and of the Hughes [a]s 2 : 1.

A multiple transmitter is shown in action at the [V]ienna Exhibition this year.

Tel Jour May 15. 73

Simultaneous Transmission.—[M. Wenbkebach, an old telegraph engineer, has made the following communication to the *Journal Telegraphique* as a resolution of the problem of simultaneous transmission. As the solution indicated by the author is entirely theoretical, and has not been confirmed by experiment, the paper is published as an idea susceptible of enlargement.]—Many have sought more simple means of double transmission. I have also sought this solution, but by an entirely different process. It is a generally known fact that frictional electricity is propagated along an insulated conductor, in which, at the same time, a galvanic current is passing. This consideration has led me to utilise this kind of electricity. Consequently I have connected one of the extremities of the line to a Morse apparatus, and the other to an ordinary electrical machine and Leyden jar, with the idea that the sparks produced would pierce the band of paper. The frictional electricity might be made to pass to the printing point direct, and prevented circulating around the electro-magnet.

[This idea has been superseded by several English inventors, and at best is a clumsy contrivance.—Ed.]

14

Tel Jour Nov 1, 76

On some Modifications in the Electric Communications of the Meyer Multiplex Apparatus. By M. MOREL.

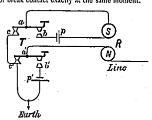
THESE consist in (1) the employment of two distinct relays for reception at the receiving station and control at the sending one; (2) in a new arrangement which M. Meyer gives his key so that the two stations can work with the same pole of the battery. M. Morel also indicates a means of remedying the inequality of duration of the emissions meant for formation of the dot and the dash.

Tel Jour May 15 76

DESCRIPTION OF A SYSTEM OF SIMULTANEOUS TRANSMISSION IN OPPOSITE DIRECTIONS.

By M. GIOVANNI MARINI,
Of the Italian Telegraphic Administration.

THE system of double transmission that I am about to describe is based upon the following principles:—A relay with two bobbins is fixed to a permanent magnet in such a way that the armature acts by repulsion, and not by attraction. The wire of one of the bobbins is distinct from the wire of the other bobbin, and the two wires thus form two distinct circuits—the one a local circuit, the other a line circuit. The soft iron cores of these two bobbins of the relay are fixed, the one to the north pole, and the other to the south pole of a permanent magnet. The transmitting key is of the ordinary Morse form very slightly modified; to the front part of it two contacts insulated from one another are added, which serve for the two circuits above mentioned. These contacts should be so adjusted that by the movement of the key they should make or break contact exactly at the same moment.



The fig. represents the arrangement of this system of double transmission. R represents the relay, N the bobbin with the north pole, S the bobbin with the south pole, T the double key, *a* and *a'* the two levers of the key, formed of little flat springs, to which springs the two outer ends of the wires of the bobbins are connected; *c* and *c'* are two metallic contacts fixed at the extremities of the levers and in connection with the earth. In the normal position of this double key the levers rest on these contacts, and are thus in connection with the earth; *b* and *b'* are two little metallic plates connected to the positive poles of two batteries—the local battery *p*, and the line battery *p'*. The connections being thus arranged, the following results are obtained:—

It is first of all necessary that the strength of the local battery, which sends a current through the south pole bobbin, be so regulated that it may transmit a current exactly equal in power to the one sent out by the line battery through the wire of the other bobbin and out to line to the corresponding instrument at the further station. This equality can be arrived at by observing the deviations given by a good galvanometer, which can be switched either into the line or the local circuit—the battery of the latter being varied, so that the deflections in both cases are the same. When the batteries are in good condition this equilibrium may be maintained for several days unless accidental circumstances interfere.

For a line of a given resistance the relation between the local and line batteries is in the proportion of about 1 to 8. If, now, the key at one station be depressed, the levers *a a'* are put simultaneously in communication with the contacts *b b'*, and at the same instant the communication of the levers *c c'* with the earth is interrupted. The current of the local battery *p* traverses the south pole bobbins to get to earth, and produces in the soft iron core a contrary magnetism to that which is given it by the permanent magnet; that is to say, the current tends to diminish the attractive force of the core for the armature; but, at the same time, the current of the line battery *p'* traverses the north pole bobbin, and out to line, and increases the attractive power of the core of that bobbin; for at the transmitting station this current produces in the soft iron core a magnetism equal to that which the local battery takes away, consequently the armature remains attracted against the poles.

At the other station, the arrival current entering by the outer extremity of the wire of the north pole bobbin, goes to earth through the lever *a'* and the contact *c'*, and produces in the soft iron core a magnetism contrary to that which is given it by the permanent magnet; the attractive force on the armature being thus diminished, the armature rises off the poles under the influence of an antagonistic spring. Immediately on the cessation of the current the core regains its magnetism, and the armature is again attracted.

Finally, if the keys at both stations are simultaneously depressed, the currents going out to line being equal and contrary, annul one another, and thus the north pole bobbins of the two relays are not influenced by the currents. The south pole cores, then, being both under the influence of the local batteries, have their magnetic powers diminished, and the armatures at both stations consequently rise.

If in this last position one station allows his key to rise, the current from that station ceases to be emitted by him; but the connection of the line wire to earth is not interrupted, and the armature though no longer under the influence of the local current, but under the influence of the current from

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15

THE TELEGRAPHIC JOURNAL.
VOL. V.—NO. 101.

QUADRUPLEX TELEGRAPHY.

WE are not aware that a quadruplex circuit exists in England at present, although we are assured that since 1874 quadruplex telegraphy has been an established fact in America, and that its employment there has been eminently successful. Statistics are nevertheless wanting to establish its practical value; and, notwithstanding the valuable communication by Mr. G. B. Prescott, read before the Society of Telegraph Engineers at their last meeting, we seem to be still as much in the dark as ever as to the real advantages of quadruplex telegraphy. Without entering at all minutely into the system, it is sufficient to state that the difficulties inherent to the adoption of quadruplex telegraphy are greater than at first sight would be imagined. As a scientific problem, its success cannot be questioned. From the days when Gintl demonstrated the possibility of sending two communications in opposite directions simultaneously on the same wire, and Stark and Bosscha showed that the same thing might be done in the same direction on the same wire, quadruplex telegraphy, or, for the matter of that, theoretically, any multiple telegraphy, may be said to have been established. But for twenty years this appears to have remained a barren scientific fact; and it was not until the impulse given to further investigation in the field of duplex telegraphy by the successful labours of Stearns drew forth again the quadruplex question, that its practical introduction was seriously thought of. To America, unquestionably, belongs the credit of having revived the question, and, so far as we can judge, of having solved it with at least some degree of success. It is well to recognise and admit this fact, for in these days of fierce competition the rival claims set up by different countries for the introduction of anything that is new would undoubtedly soon extend to quadruplex telegraphy as well.

Quadruplex telegraphy being admitted as a scientific fact, there arises the question of to what extent is it likewise a practical success—in other words, what saving in money is actually effected by its introduction, for to this narrow limit all practical successes must eventually reduce themselves. On this point, as we have stated at the outset, statistics are unfortunately wanting; and, consequently, we are unable to form any opinion on the subject. It may, however, be well to remark, what was pointed out by Mr. Kempe the other evening, that the *primâ facie* case is not all upon one side. Quadruplex telegraphy, judging from the extremely elaborate and intricate diagrams which illustrated Mr. Prescott's paper, means very nice adjustment and consequent liability to derangement. If this is to be kept in order, intelligent and well-trained—which means at the same time comparatively highly paid—labour must be employed. We cannot say how far this applies to the United States. It is often urged that the technical training of the staff in the details of their apparatus is so well looked after there that little trouble is experienced with that comparatively fruitful source of trouble in every other country—adjustment.

Then, again, the reduced carrying power of the wire is a factor which ought not to be lost sight of. Rival inventors of duplex systems are often heard to urge that by employing their particular system the working becomes an easier matter than when the line is worked singly. We shall not be surprised to hear the same assertion made about the quadruplex system, although on the face of it there appears to be nothing to support the assertion, but, on the contrary, every reason against it, even so far as duplex telegraphy is concerned. Furthermore, working a quadruplex system—that is, four circuits upon one wire—to meet the requirements of busy centres of commerce, looks very much like entrusting too many of the eggs to one basket, and in the event of interruptions could not fail to be attended with the most serious inconvenience.

Mr. Preece very wisely, we think, in the discussion which followed the reading of Mr. Prescott's paper, refrained from saying a single word either way until he had had an opportunity of examining personally for himself and forming on the spot an opinion as to the value of the quadruplex system. Mr. Preece and his fellow-commissioner, Mr. Fischer, leave for America to-day, and not the least interesting fact that they will have to tell on their return will be what they find to be the true value of quadruplex telegraphy.

ON A NEW SYSTEM OF DUPLEX TELEGRAPHY.

By J. J. FAHIE, Assoc. Soc. Tel. Engineers.

THIS system is based upon two very simple facts, as follows:—

1st. When, in an arrangement such as that shown in fig. 1, the resistances A, B, E, and R are proportional, that is when

$$\frac{A}{B} = \frac{E}{R}$$

earth may be applied at the point P without affecting the deflection of the galvanometer needle G.

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16 Telegraph Journal
aug 12 1875

UNITED STATES.

Duplex Telegraphs.—M. Gally, Rochester, N.Y., February 9, 1875.—1. The combination, with the main line of a branch containing both the receiving instrument and a magnetic key or switch for connecting main line with battery, or for breaking its direct connection with ground, substantially as specified.—2. The combination, with circuit D, having a magnetic switch therein, of circuit A A' the one being open while the other is closed, and *vice versa*.—3. The combination, with the main line, of sub-line A' and switch *f*, for cutting out the main battery when not in use for transmitting, substantially as specified.—4. A receiving magnet, provided with ordinary electro-magnet or magnets, and an additional magnet or magnets, all acting upon the same armature-lever for equalising its stroke under different conditions of currents, substantially as specified.—5. A compound electro-magnet, consisting of a number of cores and helices, a part of which are stationary, the armature being adjusted to them by means of a spring, the others being in themselves adjustable, to be moved to or from the armature, substantially as specified.—6. An armature having magnetic extremes and non-magnetic centre, the extremes to be affected by electro-magnets as a polarised armature, and the centre as a common armature, substantially as specified.—7. The combination, with the main line passing through one or more of the magnets of the receiver of the compensating circuit passing through the same magnet or magnets, and also through another magnet or magnets not affected by the main line current, but all acting upon the same armature lever, substantially as specified.—8. The combination, with a main line and its battery, of one or more circuits, each having a section of union with the main line, and an independent battery maintaining intact its own circuit current, the magnetic or neutral condition of each section of union changing with any change of the direction of the main current, substantially as specified.—9. The method of reducing the resistance of a wire or helix to a given current, by passing through it, in whole or in part, the current of another circuit or circuits.

Electrical News
July 15 1875

Employment of the Tuning Fork in Electric Telegraphy.—M. La Cour.—In ordinary telegraphy only two simple signals are produced, either by opposite currents, or by prolonging, more or less, the duration of one current. M. La Cour produces a great number of simple signals with one wire. A tuning fork is caused to open and close an electric circuit at each vibration; and these pulsations of current act electro-magnetically on a second fork in unison with the first, putting it in vibration. In this receiving instrument, the branches of the fork are each enclosed (with freedom for oscillation) in a bobbin; the bobbins receive the intermittent current, which then passes to an electro-magnet so placed that its two poles are close to the two opposite poles produced in the branch-extremities of the fork. Thus the current produces an attraction (when it passes), which opens the branches of the fork; when it ceases, the branches approach each other, and so on repeatedly. The vibrations quickly reach such an amplitude that one branch touches a slip of metal, closing the circuit of a local battery and giving a signal. The intermittent current makes only that fork speak which is in unison with the sounding fork. Thus, with a number of different forks at one station, and an equal number of receivers corresponding, we may produce an equal number of simple signals, each requiring only a simple movement; and each signal corresponding to a letter, figure, &c., dispatches may be sent more quickly than by the ordinary method. A signal may be sent to one of several stations without the others perceiving it. Several signals can be produced simultaneously by the same wire. Other advantages may suggest themselves.

Electrical News
Sept 30th 1875

165,728. *Transmitters for Electro-Harmonic Telegraphs.* Elisha Gray, Chicago, Ill. Filed June 28, 1875.—For securing greater uniformity of action of the magnets upon a steel reed vibrating to produce a certain note, and to transmit upon the line electrical impulses corresponding to the number of vibrations necessary to produce such note. 1. The combination, substantially as hereinbefore set forth, of the vibrating electrotome and magnets arranged on opposite sides thereof, of such relative capacity as to impart impulses of equal force at equal intervals upon each side of the vibrating electrotome alternately, whereby its isochronous vibration is secured. 2. The combination, substantially as hereinbefore set forth, of the vibrating reed, its counterpoise magnets, a local circuit, and the shunt-wire, whereby the current is automatically changed, to each set of magnets.

Electrical News Sept 30 1878.

166,095. *Electric Telegraphs for Transmitting Musical Tones.* Elisha Gray, Chicago, Ill. Filed January 19, 1875.—Depends primarily on fact that the core of a magnet expands and contracts, causing vibrations as it is made and unmade. Currents corresponding in number to the vibrations necessary to produce any particular note are transmitted, causing corresponding vibrations in core of magnet, which are transferred to a sounding-box placed in the magnet. The combination of a telegraphic circuit, a series of circuit-breakers capable of producing musical tones of different pitch, a series of keys for simultaneously or successively throwing said circuit-breakers into or out of operation, and an electro-magnet receiver, which is thrown into operation by the transmitters, whereby tones of different pitch may be reproduced at the receiving end of the line by the employment of a single circuit.

Electrical News Sept 23 1875

165,263. *Duplex Telegraphs.* G. Smith, Astoria, N.Y. Filed December 22, 1874.—1. The two batteries *a* and *b* of unequal power, connected with the same poles to the line, in combination with the adjustable rheostat between the larger battery and the line, the receiving instrument between the smaller battery and the line, and the key for simultaneously opening and closing the circuits from both batteries, substantially as specified. 2. In a duplex telegraph the arrangement of the batteries *a* and *b*, receiving instrument *f*, and rheostat, substantially as specified, so that the batteries shall neutralise each other at the receiving instrument and act together on the line, substantially as set forth.

17

ON QUADRUPLEX TELEGRAPHY.*

By F. L. POPE.

(From the *Journal of the Telegraph.*)

The simultaneous transmission of two telegraphic communications in opposite directions upon the same wire, now known by the name of duplex telegraphy, dates back to the year 1853. The first to conceive of its possibility, as well as the first to carry the conception into practical effect, was Dr. Wilhelm Gintl, Director of State Telegraphs in Vienna, Austria. He described his method in a paper read by him before the Vienna Academy of Sciences on the 9th of June, 1853, and in July of the same year, it was put in practical operation between Prague and Vienna.

In March of the following year, Carl Frischen, a telegraphic engineer of Hanover, Germany, im-

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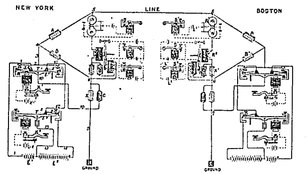
The labors of Frischen, and of Siemens and Halske of Berlin, who during the same year, independently but subsequently worked out a method almost precisely similar to Frischen's, brought the system of simultaneous transmission in opposite directions to a state of perfection which answered a very good purpose upon the comparatively short

applicable either to a single or a double telegraph in one direction. In the first published description of his method, dated at Vienna, October 31, 1855, Stark concludes as follows:

"With the method of double transmission in the same direction, we may also combine that of counter-transmission (*gegensprechen*), and hence arises the possibility of simultaneously exchanging four messages upon one wire between two stations, which will however hardly find any application in practice."* This is unquestionably the earliest published suggestion of what is now known as the quadruplex system.

Dr. Bosscha, in a description of his system read before the Royal Academy of Sciences of Holland, on the 27th of October, 1855, and published in Transactions, vol. iv. p. 101, not only makes the same suggestion, but sets forth in detail a method of accomplishing the result. Having described his method of double transmission in the same direction he says: "Now, if we wind each of the receiving relays with two wires, and divide the



lines, and at the slow rate of transmission in vogue at that day.

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Thus Stark and Bosscha, as early as 1855, both recognised the indisputable fact, that the production of a successful method of quadruplex transmission depended solely upon the successful solution of the problem of double transmission in the same direction. If this could be accomplished, it becomes a mere matter of mechanical detail to combine with it Frischen's or any other system of counter-transmission.

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* Brix's Journal, II, 224.

Telegraph Journal
aug 12 1875

UNITED STATES.

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Electrical News
July 15 1875

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Electrical News
Sept 30th 878

165,728. *Transmitters for Electro-Harmonic Telegraphs.* Elisha Gray, Chicago, Ill. Filed June 28, 1875.—For securing greater uniformity of action of the magnets upon a steel reed vibrating to produce a certain note, and to transmit upon the line electrical impulses corresponding to the number of vibrations necessary to produce such note. 1. The combination, substantially as hereinbefore set forth, of the vibrating electrotome and magnets arranged on opposite sides thereof, of such relative capacity as to impart impulses of equal force at equal intervals upon each side of the vibrating electrotome alternately, whereby its isochronous vibration is secured. 2. The combination, substantially as hereinbefore set forth, of the vibrating reed, its counterpoise magnets, a local circuit, and the shunt-wire, whereby the current is automatically changed, to each set of magnets.

Electrical News Sept 30 1878.

166,095. *Electric Telegraphs for Transmitting Musical Tones.* Elisha Gray, Chicago, Ill. Filed January 19, 1875.—Depends primarily on fact that the core of a magnet expands and contracts, causing vibrations as it is made and unmade. Currents corresponding in number to the vibrations necessary to produce any particular note are transmitted, causing corresponding vibrations in core of magnet, which are transferred to a sounding-box placed in the magnet. The combination of a telegraphic circuit, a series of circuit-breakers capable of producing musical tones of different pitch, a series of keys for simultaneously or successively throwing said circuit-breakers into or out of operation, and an electro-magnet receiver, which is thrown into operation by the transmitters, whereby tones of different pitch may be reproduced at the receiving end of the line by the employment of a single circuit.

Electrical News Sept 23 1875

165,263. *Duplex Telegraphs.* G. Smith, Astoria, N.Y. Filed December 22, 1874.—1. The two batteries *a* and *b* of unequal power, connected with the same poles to the line, in combination with the adjustable rheostat between the larger battery and the line, the receiving instrument between the smaller battery and the line, and the key for simultaneously opening and closing the circuits from both batteries, substantially as specified. 2. In a duplex telegraph the arrangement of the batteries *a* and *b*, receiving instrument *f*, and rheostat, substantially as specified, so that the batteries shall neutralise each other at the receiving instrument and act together on the line, substantially as set forth.

SIR CH

(*From a Photograph*

of a Voltaic Circuit" we are a

Electricians from time to time.

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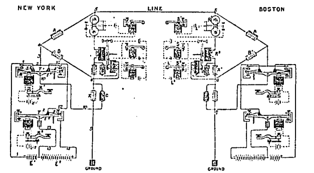
proved upon Gintl's plan, by making use of a branch current from the main battery for compensating the effect of the outgoing current upon the home relay, instead of the local current employed by Gintl. This is unquestionably the most important improvement which has been made in duplex telegraphy from the time of its original invention by Gintl, down to the time of the addition of the condenser by Stearns, in 1872. Frischen used a differential relay having helices composed of two equal and opposing wires, and an artificial or rheostat line equal in resistance to the main line, substantially as they are used at this day. His first practical experiment was made between Hanover and Gottingen on the 26th of May, 1855.

The labors of Frischen, and of Siemens and Halske of Berlin, who during the same year, independently but subsequently worked out a method almost precisely similar to Frischen's, brought the system of simultaneous transmission in opposite directions to a state of perfection which answered a very good purpose upon the comparatively short

applicable either to a single or a double telegraph in one direction. In the first published description of his method, dated at Vienna, October 31, 1855, Stark concludes as follows:

"With the method of double transmission in the same direction, we may also combine that of counter-transmission (*gegensprechen*), and hence arises the possibility of simultaneously exchanging four messages upon one wire between two stations, which will however hardly find any application in practice."* This is unquestionably the earliest published suggestion of what is now known as the quadruplex system.

Dr. Bosscha, in a description of his system read before the Royal Academy of Sciences of Holland, on the 27th of October, 1855, and published in Transactions, vol. iv. p. 101, not only makes the same suggestion, but sets forth in detail a method of accomplishing the result. Having described his method of double transmission in the same direction he says: "Now, if we wind each of the receiving relays with two wires, and divide the



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16 Telegraph Journal
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Electrical News

number of inventors during the year 1855. The ingenious and active German electricians, recognizing that the accomplishment of this result was the key to simultaneous quadruplex transmission, had diligently laboured at the problem. Let us now consider the results of their labours.

In any system of simultaneous double transmission in the same direction, two keys are required at the sending station, and at least four different electrical conditions of the line must be provided for, one for each of the four following cases:

1. When the first key is closed and the second key open.
2. When the second key is closed and the first key open.
3. When both keys are closed.
4. When both keys are open.

The methods of Stark, Siemens, and Bernstein (No. 1), though varying in detail, were arranged upon one general principle, the four electrical conditions of the line being as follows:

1. A positive current having a strength of 1.
2. A positive current having a strength of 2.
3. A positive current having a strength of 3.
4. No current.

The methods of Bernstein (No. 2), Bosscha, and Kramer, and at a later date those of Schreder (1860), and Maron (1862), were arranged upon another and better principle, as follows:

1. A positive current having a strength of 1.
2. A negative current having a strength of 1.
3. A positive (or negative) current having a strength of 2.
4. No current.

There are two serious difficulties, leaving minor ones out of consideration, which are inherent in every system of simultaneous double transmission in the same direction. In the first place, when either key is passing from its front to its rear contact, it causes a momentary interruption of the signal which is at the same time being transmitted by the other key. Neither Stark nor Siemens suggested any means of overcoming this difficulty. Bosscha and Kramer made use of a device originally invented by Gintl,* *viz.*, that of keeping the battery constantly in the main circuit, but shunted by the key, so that when the latter was depressed the short circuit was broken and the current flowed to line, but when raised the battery was again short-circuited. This plan effectually disposed of the difficulty in question, but was injurious in its effect upon the batteries. Bernstein, however, hit upon the method now in use, that of providing each of his keys with a spring, so arranged as to close the front contact at or before the time of interrupting the rear contact. This difficulty was, therefore, effectually removed as early as 1855. The second difficulty is a still more serious one, and arises in the following manner: In the simultaneous operation of the apparatus there must, of necessity, frequently be a change from a positive to a negative condition, or *vice versa*, of the line, and of the relays or receiving instruments, consequent upon the movement of a single key; yet it is evident that the reversal of the magnetic polarity of a receiving instrument by the action of one key must interfere with a signal which is being given upon it at the same time by the action of the other key. This difficulty is met with, in some form, in every arrangement of the receiving instruments. Stark employed three neutral relays adjusted to varying degrees of sensitiveness in one arrangement, and two polarized and one neutral relay in another, as also did Bosscha and Kramer. Bernstein used a single relay with three armatures of varying adjustment. Neither Stark nor Siemens suggested any method of remedying this serious defect, and judging from his published paper on the subject, the latter evidently considered it an insurmountable one. Bosscha, Bernstein, and Kramer, by making use of different modifications of the same principle, that of operating the recording instrument or sounder by the opening of a shunt circuit, as the first and last had already done with the main batteries, and by working from the rear instead of the front contact of the receiving relay, theoretically succeeded in surmounting this obstacle. Practically, however, the method of operating a register or sounder by closing and breaking a shunt, is a very unsatisfactory one. It not only exhausts the local battery with great rapidity, but the demagnetization of the iron cores takes place with far less rapidity when the battery is cut off by a shunt even of very small resistance, than when it is completely interrupted by breaking the circuit in the usual way, and this renders it impossible to receive and record the telegraphic signals with the rapidity that is necessary in modern telegraphy.

When these methods came to be tried on lines of a length exceeding 100 or 150 miles, the interference of the static discharges was superadded to the already existing difficulties, and for these reasons the results were on the whole so unsatisfactory that the subject remained in abeyance for many years. The subsequent labors of Schreder, Wartmann, Maron, Schaak, and Zetsche, between 1855 and 1865, though exhibiting great ingenuity and research, added little or nothing of practical value to what had already been done by the earlier inventors in the same field.

The revival of the duplex system in America, and its extensive introduction into practical use, both in this country and in Europe, resulting from the improvements of Joseph B. Stearns,—notably his method of compensating the effects of the static discharge from the line by the application of the condenser, which was made known in the winter of 1871-2—once more turned the attention of electricians to the problem of simultaneous transmission in the same direction.

In a paper published in the *Philosophical Magazine* of June, 1873, Oliver Heaviside, of Newcastle-on-Tyne, England, pointed out, as Stark and Bosscha had done before him, that the invention of a system of simultaneous transmission in the same direction furnished at the same time the solution of the problem of quadruple transmission. He says: "It is theoretically possible to send any number of messages whatever simultaneously in one and the same direction upon a single wire. Now by combination with a null duplex system it becomes obviously possible to send any number of messages in the other direction while the opposite correspondences are going on, and without interference. Thus the working capacities of telegraphic circuits may be increased indefinitely by suitable arrangements. * * * From experiments I

* Brix's Journal, II. 135.

have made I find it is not at all a difficult matter to carry on four correspondences at the same time, namely, two in each direction, and if we may suppose the growth of telegraphy will be as rapid in the future as it has been in the past, it seems not improbable that multi-telegraphy will become an established fact."

During the summer of 1874, T. A. Edison, of Newark, N. J., while engaged in conjunction with George B. Prescot, electrician of the Western Union Telegraph Company at New York, in experimenting upon Stearns's duplex apparatus with a view of introducing certain modifications and improvements therein, devised a system of simultaneous transmission in the same direction which differed materially in principle from any of its predecessors, and which was destined to furnish the basis of the first practical solution of the curious and interesting problem of quadruplex telegraphy.

The distinguishing principle of this method consists in combining together two distinct and unlike methods of single transmission, in such a manner that they may be carried on independently upon the same wire, and at the same time without interfering with each other. One of these methods of single transmission is used principally in England, where it is known as the double-current system, and the other is the single-current or open circuit system, used on the continent of Europe. In the double-current system the battery remains constantly in connection with the line at the sending station, its polarity being completely reversed at the beginning and at the end of every signal without breaking the circuit. The receiving relay is provided with a polarized or permanently magnetic armature, but has no adjusting spring, and its action depends solely upon the reversals of polarity upon the line, without reference to the strength of the current. In the single-current system, on the other hand, the transmission is effected by closing and breaking, or increasing and decreasing the current, while the relay has a neutral or soft iron armature, provided with a retracting spring. In this system the action depends solely upon the strength of the current, its polarity being altogether a matter of indifference.

It will therefore be apparent that by making use of these two distinct qualities of the current, viz., polarity and strength, two sets of instruments may be operated, at the same time, on the same wire. This method possesses, moreover, the important practical advantage that the action of each of the two receiving relays is perfectly independent. Each receiving operator controls his own relay and can adjust it to suit himself without interfering with the other, a peculiarity that none of the former methods possessed. As soon as this method was practically worked out, it became at once obvious that any of the different methods of simultaneous transmission in opposite directions already in use might be applied to it, as Stark, Bosscha, and others had long ago pointed out, the result of which would be a practical system of quadruplex transmission. This was shortly afterwards done upon the lines of the Western Union Telegraph Company between New York and Boston, a distance of 240 miles, and both the bridge and the differential system of duplex working were tried in combination with it, with excellent results. When, however, the apparatus was experimentally tested on a circuit of about 450 miles, the effects of static induction became very strongly marked, and it was found that these could be more conveniently compensated in the bridge than in the differential system. The former was, therefore, decided upon as being better suited to the usually existing conditions than the latter.

The diagram shows the quadruplex apparatus as arranged upon the bridge plan.

t^1 is a double current transmitter or pole-changer, operated by an electro-magnet, local battery e^1, and finger key k^1, in a manner well understood. The office of the transmitter t^1 is simply to interchange the poles of the main battery E_1 with respect to the line and ground wires, whenever the key K_1 is depressed; or, in other words, to reverse the polarity of the current upon the line by reversing the poles of battery E_1. By the use of properly arranged spring contacts s, s_1, this is done without at any time interrupting the circuit. Thus the movements of the transmitter t^1 cannot alter the strength of the current sent out to the line, but only its polarity or direction. The second transmitter t^2 is operated by a local circuit and key K^2 in the same manner. It is connected with the battery wire 12, of the transmitter t^1 in such a way that when the key K^2 is depressed, the battery E^1 is enlarged by the addition of a second battery E^2 of two to three times the number of cells, by means of which it is enabled to send a current to the line of three or four times the original strength, but the polarity of the current with respect to the line of course still remains as before, under control of the first transmitter t^1.

At the other end of the line are the two receiving instruments R^1 and R^2. R^1 is a polarized relay with the permanently magnetic armature, which is deflected in one direction by positive, and in the other by negative currents, without reference to their strength. This relay consequently responds solely to the movements of key K^1, and operates the sounder S_1, by a local circuit from battery L_1 in the usual manner. Relay R^2 is placed in the same main circuit, and is provided with neutral or soft iron armature, and responds with equal readiness to currents of either polarity, provided they are strong enough to induce sufficient magnetism in its cores to overcome the tension of the opposing armature-spring. The latter, however, is so adjusted that its retractile force exceeds the magnetic attraction induced by the current of the battery E_1, but is easily overpowered by that of the current from E_1 and E_2 combined, which is three or four times as great. Therefore, the relay R^2 responds only to the movements of key K^2 and transmitter t^2.

The same difficulty which had baffled former inventors arises, however, in this connection. When the polarity of the current upon the line is reversed during the time in which the armature of R^2 is attracted to its poles, the armature will fall off for an instant, owing to the cessation of all attractive force at the instant when the change of polarity is actually taking place, and this would confuse the signals by false breaks if the sounder were connected in the ordinary way. By the arrangement shown in the figure, the armature of the relay R^2 makes contact on its back stop,* and a

* The figure shows a second local battery in this circuit, but it is an evident error.—Ed. *T. J.*

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1b Telegraph Journal
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second local battery L_2 operates the receiving sounder S_2. Thus it will be understood that when relay R^2 attracts its armature, the local circuit of sounder S_2 will be closed by the back contact of local relay S; but if the armature of R^2 falls off it must reach its back contact, and remain there long enough to complete the circuit through the local relay S, and operate it, before the sounder S_2 will be affected. But the interval of no magnetism in the relay R^2, at the change of polarity, is too brief to permit its armature to remain on its back contact long enough to affect the local relay S, and through the agency of this ingenious device the signals from K_2 are properly responded to by the movements of sounder S_2.

By placing the two receiving instruments R and R_1 in the bridge wire of a "Wheatstone balance," according to Stearns's patent of Nov. 12, 1872, and duplicating the entire apparatus at each end of the line, the currents transmitted at either station do not affect the receiving instruments at that station. Thus in figure 1 the keys K_1 and K_2 are supposed to be at New York, and their movements are responded to only by the receiving relays R_1 and R_2 at Boston. The duplicate parts which are not lettered operate precisely in the same manner, but in the opposite direction with respect to the line.

In applying this system of quadruplex transmission upon lines of considerable length, it was found that the interval of no magnetism in the receiving relay R^2 (which, as above stated, takes place at every reversal of the polarity of the line current), was greatly lengthened by the action of the static discharge from the line, so that the contrivance of the local relay S was not sufficient to overcome the difficulties arising therefrom. A rheostat or resistance, X_1, was therefore placed in the bridge-wire with the receiving instruments R^1 and R^2, and shunted with a condenser *c*, of considerable capacity. Between the lower plate of the condenser and the junction of the bridge and earth-wire an additional electro-magnet, *r*, was placed, acting upon the armature lever of the relay R_2, and in the same direction. The effect of this arrangement is, that when the current of one polarity ceases, the condenser *c* immediately discharges through the magnet *r*, which acts upon the armature lever of relay R_2, and retains it in position for a brief time before the current of the opposite polarity arrives, and thus serves to bridge over the interval of no magnetism between the currents of opposite polarity.

It will be seen that the combination of transmitted currents in this method differs materially from any of those used in previous inventions. They are as follows:

1. When the first key is closed and the second open . . . . . -1
2. When the second key is closed and first open . . . . $+3$ or $+4$
3. When both keys are closed . . -3 or -4
4. When both keys are open . . . $+1$

Here we discover another very important practical advantage in the system under consideration, which is due to the fact that the difference or working margin between the strengths of current required to produce signals upon the polarized relay and upon the neutral relay respectively, may be increased to any extent which circumstances render desirable. Within certain limits, the greater this difference the better the practical results, for the reason that the range of adjustment of the neutral relay increases directly in proportion to the margin. The ratio of the respective currents has been gradually increased from 1 to 2 to as high as 1 to 4, with a corresponding improvement in the practical operation of the apparatus.

From what has been said, therefore, it will be seen that before it became possible to produce a quadruplex apparatus capable of being worked at a commercial rate of speed upon long lines, it was essential that its component parts should have arrived at a certain stage of development. When in the early part of 1872, simultaneous transmission in opposite directions was for the first time rendered practicable upon long lines by the combination therewith of the condenser, the first step was accomplished. It now only remained to invent an equally successful method of simultaneous transmission in the same direction, which, as we have seen, was done in 1874. The application of one or more of the existing duplex combinations to the new invention to form a quadruplex apparatus followed as a matter of course.

Thus it is clear that the merit of the invention of 1874 consists in its having furnished us with a new, and what is more important, a practical method of simultaneous transmission in the same direction, applicable to long lines, and not in the mere application thereto of one or more of the known duplex systems, to form a quadruplex, which in itself would no more constitute an invention in the sense contemplated by the patent law than would the application of the duplex principle to the printing or dial instrument used instead of the Morse, with which it was first used.

As its use becomes more and more extended, the quadruplex is constantly undergoing modification and improvement in its minor details, with a view to render its manipulation more simple and easy, and to enable it to be worked direct between the most widely separated points with the utmost speed and certainty. Some of these modifications are very ingenious and interesting, and will probably form the subject of a future article.

ON A SYSTEM OF TELEGRAPHY.

A COURSE OF LECTURES, DELIVERED AT THE SCHOOL OF MILITARY ENGINEERING, CHATHAM.

By W. H. PREECE, Member Inst. C.E., &c.

LECTURE III.—COMMERCIAL TELEGRAPHY—PART II.

(Continued from vol. iii, page 244.)

THE speedy restoration of communication upon busy circuits is a matter of such importance that it is a question for great consideration whether it is not advisable to erect, on important trunk lines, a spare wire for the sole purpose of restoring communication when faults occur upon any of the working circuits. Certainly all important centres should and are connected by a sufficient number of wires to leave a margin for pressure due to possible breaks down which cannot always be prevented even on the best organized systems.

But daily tests also effect a second purpose, and that is, they supply the superintendent with a constant record of the condition of the circuits, so as

18

Engineering Aug 11th 1882.

A Train Telegraph.

A trial was made recently on the Atlanta and Charlotte Railway, in America, of a new plan for enabling a railway car in motion to communicate by telegraph with the stations on the line. It is the invention of Captain C. W. Williams, U.S.A., and consists of a telegraph line laid along the track but interrupted at frequent intervals, and the ends of the break brought to key blocks mounted upon the sleepers or "cross ties." The key blocks carry two metal rollers, to which the ends of the line are connected, and when these rollers are depressed they interrupt the circuit of the line. When in their normal position the circuit of the line is complete. The bottom of the special car, which is selected as a telegraph office, has a projecting shoe covered with two metal strips or bars which, as the car passes along the line, make contact with the rollers and depress them, thus interrupting the circuit at that point, and thereby throwing the telegraphic apparatus of the car into the circuit at that point. This is effected by having the apparatus connected up between the two strips. These are made of sufficient length to keep the car always in circuit with the line by the rapidly succeeding key blocks and rollers. The current enters the car through one roller and strip, and after passing through the telegraph instrument on board returns to the line through the other strip and roller. The advantages of this system may be considerable in certain American districts, or in case of accident. It enables a station-master to clear the position of a train on the way; or two trains to inform each other of their whereabouts. The establishment of such a system would, however, entail considerable expense in this country owing to difficulties of insulation. In the trial at Atlanta some 200 yards of track were adapted to the apparatus; the key blocks being placed every 40 ft. Messages were received in the car when at rest and in motion, the highest speed tested being 25 miles an hour.

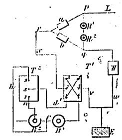
Electrical news July 22 1875

ON QUADRUPLEX TELEGRAPHY.

We are indebted to Professor Zetzsche for a paper on the subject of "Quadruplex Telegraphy." In it Professor Zetzsche quotes, from a work of his published in 1865 ("On Copying Telegraphs, &c."), by way of showing that the possibility of such telegraphing has been for some time in contemplation in Germany, an object both of theoretical inquiry and practical experiments. Of this the Americans seem not to have been aware.

Referring to Dr. Nicholson's method, he remarks that the three different strengths of current employed are in the same relation to each other as in M. Maron's system, only that the latter experimenter employs the current strengths +S, −S, and −3S. M. Maron also uses only one relay, but with *three* permanent magnetic armatures.

"Characteristically new, on the other hand," he proceeds, "is the way in which Prescott and Edison produce the three requisite strengths of current, inasmuch as they give to the line the constant current (Ruhestrom) +S, and use, in telegraphing, −S, +2S, and −2S. Of the key and battery arrangement for this, unfortunately, F. W. Jones gives* no information. The arrangement which I have sketched in the annexed figure meets the conditions perfectly. In the state of rest of both keys, T_1 and T_2, the copper pole of battery B_1 is in metallic connection, through the working contact, 6, and the rest contact, 3, of the double key, T_1, with the key-axis, 2, and through the wire, x, with the angle-point, r, of the Wheatstone bridge, in whose diagonal, $p\,q$, the two relays, R_1 and R_2, are inserted; while the end-points, p and q, of the diagonal, are connected, on the one hand, with the line L, and on the other, through the rheostat, W, and wire, u, with the



earth. The zinc pole of this battery, again, is connected through f and h, with the rest contact, 9, of the key T_2, with the key-axis, 8, and through the wire, d, with the working contact, 1, and the rest contact, 4, the key-axis, 5, and through the wire, v, with the earth, E. Both keys are furnished with contact-springs in such a way that the key-lever, immediately after the one spring has left the rest contact, is brought into connection, through the other contact-spring, with the working contact, and *vice versa*. If, now, the lever of the key, T_2, be pressed down, there will be introduced, besides B_1, the battery portion, B_2, through n, the rest contact, 7, and the axis, 8. At the other station, therefore, R_2 will answer to the increased positive current, while the tongue of R_1 will still remain in the position of rest. If, on the other hand, T_2 remain at rest, and T_1 goes into the working position, the copper pole of B_1 is connected through c, 6, 5, and v to earth, E; the zinc pole through f, h, 9, 8, d, 1, 2, x, and r, to the line L; whereupon, at the other station, both relays, R_1 and R_2, are actuated by the increased negative current, to indicate the signals given by both keys, T_1 and T_2.

Such an arrangement has a not unimportant advantage over the older ones, in that only two relays are necessary for the receiving apparatus. Along with this advantage, however, the arrangement has two drawbacks. For, at the transmitting station, there occurs, at each movement of the key, during the suspense, an interruption (though ever so small) of the line, giving reason to fear a rupture of the signals; at the receiving station, on the other hand, when the key, T_2, is held down, and the lever of T_1 moves up and down, the relay, R_2, may not liberate its armature, although the current changes its sign. Unfortunately these two defects are of such a kind as (it is to be feared) to forbid the practical employment of this arrangement, which is the more regrettable, that the advantage of the method might warrant the hope that it constituted a further step towards the successful realisation of quadruplex telegraphy. The value of such a mode of connection, however, I regard as consisting, not so much in its making possible the simultaneous sending of four telegrams on one wire, as in the fact that through it a perfect solution of the problem of duplex telegraphing and of transmitting two messages in the same direction at once is afforded; inasmuch as, to each receiving telegraphist is furnished also a key for interruption, and to every transmitting one a receiving apparatus, with which he may be cut off from the station working with him."

19

"Morse," which was less liable to get out of order, and which avoided the troublesome operation of preparing paper chemically, and which has recently been still further improved by supplanting the embossed paper with a pen, which records its character in ink.

This later form of apparatus is in very general use throughout Europe, but it is not the fittest, and it will probably not survive other forms which are developing themselves.

The speed with which an instrument works is usually registered by the *number of words* it can transmit in a *minute*, but owing to the regularity with which messages retain their average number of words, *the number of messages* transmitted *per hour* is now the usual criterion. Messages average 35 words, and words average 4·5 letters. Hence roughly, half the number of messages per hour equal the words per minute. The earlier Morse could not exceed six words per minute, but the rate at which the instrument now works on short circuits is simply the rapidity with which the operator can manipulate his key; 70 messages per hour are frequently obtained by experts, but it is difficult to maintain such a speed. The human machine tires, errors occur. His manipulation loses clearness and legibility. Bain invented the automatic apparatus to replace the human machine by a mechanical contrivance. This secured precision in the formation of the characters, accuracy in the despatch of messages, and speed in the transmission of work. There were, however, defects in Bains' apparatus, and automatic telegraphy was not a success until Sir Charles Wheatstone introduced his beautiful apparatus which is now in such extensive use, and without which it would have been impossible for the Postal Telegraph Department to meet the requirements of the press.

(To be continued.)

The electric telegraph system is still in its infancy, and although its operations are marvellous, yet it is probable that we are at present but imperfectly acquainted with the full extent of its advantages. In this country the telegraph wires are simply used for the transmission of messages, but to Armenia belongs the honour of discovering that they may be adapted as clothes-lines for laundry purposes. The practice of hanging linen to dry on the wires has lately become general in that country, and revealed the hitherto unknown fact that the Armenian peasantry are in the habit occasionally of washing their clothes. Much dismay has, however, been caused by an order that has been issued by the authorities forbidding the continuance of this arrangement. It seems that the wires have on more occasions than one been broken by awkward washerwomen, and Shefket Effendi, an Armenian Scudamore, who has just been appointed director of the telegraph at Erzeroum, has solemnly declared that no more shirts, stockings, or other garments shall be hung on the wires on any pretence whatever.

Professor Cornu, of the *Ecole Polytechnique*, Paris, has put into successful use a new instrument for measuring the velocity of light between two stations, in which an electrical registering apparatus is used, giving, it is believed, more accurate measurements than the well known toothed wheel arrangement of Fizlan. Foucault fixed the velocity of light, by his instrument, at 185,157 miles per second. Professor Cornu, by his new instrument, fixes the velocity of light at 186,660 miles per second, 1,503 miles faster per second than Foucault.

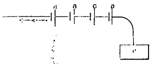
ON THE TELEGRAPHIC PROBLEMS OF DOUBLE SENDING AND QUADRUPLEX TELEGRAPHY.

By G. K. WINTER,
Telegraph Engineer to the Madras Railway.

(Continued from page 210.)

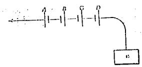
There are several ways of accomplishing this; perhaps the best is as follows:—

Let us suppose the full battery to consist of four cells (any multiple of that number would do as well). Let us represent them thus:—



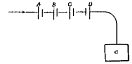
Let this be supposed to give two units of copper current to line.

Now suppose one of them, A, to be reversed by a reversing key, we shall have—



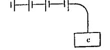
thus A and B neutralize each other, and we shall have one unit of copper current to line.

Next let us suppose A B and C to be reversed by the depression of the other key, then we shall have—



or one unit of zinc current to line.

Lastly, let us suppose both keys depressed, then A, which is reversed by the first key, will be set right again, and we shall have—



or B and C will neutralize A and D, and we shall have no current to line.

The following figure is a conventional mode of

DUPLEX ARRANGEMENT, WITH TRANSLATOR, OF M. KOCH, OF CHUR.

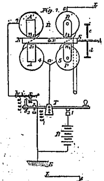
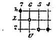
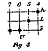


Fig. 1.



Zinc to earth. Fig. 2.



Copper to earth. Fig. 3.

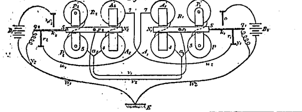


Fig. 4.

IN the first of the above figures (which we borrow from *Dingler's Polytechnisches Journal*) illustrating this system, 1, 2, and 3 represent the working contact, the axis, and the back contact, respectively, of an ordinary Morse key, on which, at its further end, an insulator e is fixed, which, on pressing down the handle, raises the lever $h\ f$ from the contact i, connected with earth E. The line-battery B is inserted between 1 and E. Of the two corresponding stations, one has the copper pole, the other the zinc pole of the battery to earth, so that the currents of both are in the same direction. The relay R contains two pairs of coils A, A', and P, P'; while A and A' form an ordinary horse-shoe electro-magnet (with unmagnetic core), the cores of the horse-shoe electro-magnet P, P', as in the Hughes type-printer, stand on the poles of a permanent horse-shoe magnet, and are so induced by it, that in P a north pole n_1, and in P' a south pole s_1 is produced. With the aid of an iron piece the magnet can be pushed one way or another so as to adapt the magnet strength to the current strength. Between the four poles of the relay is the magnetic bar N S, the continuation of which, k, plays between the set screws c and d, and on its application to the working contact c closes the local battery. The coil-end 6 is connected with the telegraph line L, the end 7 with the lever h, and the key axis 2 with the point a in which the two coil-ends 4 and 5 unite.

In order that the relay may be inserted suitably to the direction of current, each station is provided with a commutator U (figs. 2 and 3) with 3 and 4 plates. To the four vertical plates are connected the four coil-ends 4, 5, 6, and 7; to the three horizontal plates the lever h, the line L, and a or the key axis 2. The station which has zinc to earth, arranges the stops as in fig. 2, so as to connect 4 and 5 with a and 2, 7 with h, and 6 with L. The station with copper to earth arranges as in fig. 3, connecting 6 and 7 with a and 2, 5 with L, and 4 with h.

When neither key is depressed, and therefore no current passes through the line, the north pole N of the armature, if equally distant from the two cores in A and A', is attracted equally by them; but if unequally distant, it is attracted most strongly by the core nearest to it. The south pole S, on the other hand, is repelled by the south pole s_1 in P', and attracted by the north pole n_1 in P, and therefore the armature takes the position

with k on the rest-screw d.

If only one key T, is depressed, and the battery B closed at 1, at the same moment that e raises the lever $h\ f$ from i, then at the sending station the current goes from 1 to 2 and a, only through the coils P and P', and into the line L; thus in the cores of the electro-magnets P P' the magnetism is neutralised, but the armature is held by the core nearer to it in its position at d. At the receiving station, on the other hand, the current coming from L passes successively through the coils P and P', A and A', and then goes over $h\ f$ to earth E; thus not only is the magnetism of the cores in P and P' destroyed, but the cores of A and A' are magnetised, a south pole s_1 being developed in A, and a north pole n_1 in A'. Hence the north pole N of the armature is repelled from n_1 and attracted by s_1, and k is brought against the working contact-screw c.

If both keys, lastly, are pressed down at once, the strengthened current goes at both stations only through the coils P and P', and it not only destroys in their cores the magnetism present, but developes in them contrary poles; P thus becomes southly magnetic, and P' northly magnetic. The south pole accordingly moves from P to P', k becomes applied to c and closes the local battery.

If $h\ f$ is raised from i somewhat after the instant at which the battery B is closed, the current goes for a time at the sending station also through A and A'; not in the same direction as a current from the other station passes through A and A', but in the opposite; hence in this case the home-relay will not speak, if this is free from a current; if, on the other hand, it is traversed by the current of the other station, the action of this in A A' and the added action of the weak branch of the home-current going through P P' will be easily overcome by the much stronger branch of this current passing through A A', and so the arriving signal be spoiled. If, on the other hand, $h\ f$ be raised from i somewhat before the key lever closes the working contact, then during this time no way to earth would remain for the current coming by the line from the other station. In this case also, therefore, each movement of the key might spoil the coming signal, and this is as much to be guarded against as a short passage of current through A A' in the previous case. Where, however, it is a case of very small intervals of time, the circumstance that neither the action of the branch current in A A' occurs instantly, nor, on cessation of the current in P P', has the former magnetism again its original strength, may help over the difficulty.

The coils of the electro-magnets A A' should have more windings than the coils of P P', that with earth connection of the line, the action of the weaker arriving current at A A' may not also have to overcome the not quite perfect demagnetisation of the core of P P' produced by it.

In using the arrangment as translator, the continuation k of the armature lever of the duplex relay R is furnished with a further prolongation q insulated from k, and this is opposite the set-screw r as contact-screw. The zinc poles of the two batteries B_1 and B_2 (fig. 4) of the translation station are connected to earth E by the wires w_1 and w_2; their zinc poles applied to the contact screws c_2 and c. The continuations q_1 and q_2 also are connected, by thin spirally-wound wires, with the earth. From the ends 7 of the coils A'_1 and A'_2, go wires u_1 and u_2 to r_2 and r_1; from the axes x_1 and x_2 of the armature N_1 S and N_2 S_2 wires v_1 and v_2 to the points of union a_2 and a_1 of the coil ends 5 and 4. To the ends 6, lastly, come, at P'_1 the line L_1, at P'_2 the line L. The armature-lever has, for the same reasons as before, as small a space to play in as possible between the contact-screws c and r.

If now a current comes from L, it passes through P'_2 and P_2, A_2 and A'_2, goes from 7 in the wire u_2 to r_1, q_1, y_1, and in w_2 to earth E; the relay R_2 thus speaks, q_2 removes from r_2 and k_2 is applied simultaneously to c_2; accordingly the current from B_1 now goes from the zinc pole in the wire w_1 to earth E, and from the copper pole over c_2, k_2, x_2, through the wire v_2 to a_1, and from here only through P_1 and P'_1, over 6 into the line L_1, but without the relay R_1 speaking, and interrupting the passage between r_1 and q_1 for the line current coming from L.

Tel Jour Oct 15. 77.

SCHWENDLER'S duplex method is now introduced into the telegraph service of Bavaria, and has been working since the beginning of July, under very variable atmospheric conditions, with great rapidity and regularity, to the satisfaction of the Administration. The great productive power of this method must be sought in the stability of the balance, which renders correcting adjustments almost superfluous. It will apply above all to long lines, as has been proved by several years experience in the Indian service. Switzerland and Wurtemburg purpose making early trials with this method in order to study its more extended application. —*Journal Telegraphique.*

Tel Jour Dec 1, 78

SUBMARINE QUADRUPLEX.—Dr. Alexander Muirhead, together with Mr. G. Kift Winter, the inventor of the closed circuit duplex system in use in India, and Mr. J. A Briggs, have invented improvements in duplex and quadruplex telegraphy, whereby the latter system can be applied to submarine cables. The patent description was communicated from Madras, where Dr. Muirhead recently sojourned while duplexing the Madras to Penang Cable.

SUBMARINE DUPLEX.—In reply to communication to the *Times* by Mr. Herring, Sir James Anderson states the Eastern Telegraph Company are now working Muirhead's duplex system on the Marseilles-Malta section (825 miles) at the rate of 26 words per minute, whereas by simplex they only attain 15 words per minute. The increase of speed on all the sections from Malta to Bombay is at least 70 per cent. With regard to land lines, Sir James says that on the company's line between London and Porthcurnow, a distance of 320 miles, as many as 54 words per minute can be sent as against 25 by simplex.

22

which the capacity is increased to 700 must of necessity give two profits, while the capital has not been increased except by the extra cost of instruments, which in comparison with the cost of construction and maintenance of another wire, it is not necessary to take into account.

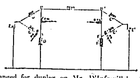
There are at present working successfully in this country five different systems of duplex: 1st and 2nd, the differential and bridge systems of Mr. Stearns; 3rd, the polarized relay system of Mr. Haskins; 4th, the system of Mr. D'Infreville; and 5th, Mr. Gerritt Smith's arrangement, lately described in the *Telegrapher*. The systems of Mr. Stearns have also been described in the *Telegrapher*. No description, however, has appeared of Messrs. Haskins or D'Infreville's inventions. The former arrangement is working very successfully on the North Western Company's lines between Milwaukee and St. Paul. I hope Mr. Haskins will soon give the fraternity a description of it through your columns. No one can do it better.

All the foregoing systems, except the D'Infreville, use condensers for counteracting the effect of the return current. In Mr. D'Infreville's system condensers are not necessary, the current of charge and discharge being rendered harmless by an arrangement of electro-magnets. Messrs. D'Infreville and Haskins also dispense with transmitters, only ordinary keys being used in their arrangements. The D'Infreville requires no instruments (with the exception of rheostats) which cannot de found in every telegraph office,

In the description of Gerritt Smith's duplex arrangement, given in the *Telegrapher* and *Journal of the Telegraph* a few weeks ago, it is stated that in this, as in all other systems of duplex, it makes no difference whether the batteries at each end are placed with similar or dissimilar poles to the line. The writer of the article cannot be acquainted with the D'Infreville system or he would not have written the foregoing. In the D'Infreville system the batteries must oppose each other, and, if I am not mistaken, I think that in Mr. Haskins' system they must *not* oppose, but be placed in same way as in an ordinary Morse circuit.

In both of Mr. Stearns' systems, and I should suppose in Mr. Haskins' also, it is possible to work other lines from the batteries used for the duplex. I understand, however, that this is not generally done. In the D'Infreville system this cannot be done with advantage, and I think the same remark will apply to Mr. Smith's arrangement.

In these days, however, of sulphate of copper batteries, this cannot be considered a very serious objection. In the diagram two stations are shown



arranged for duplex on Mr. D'Infreville's plan The line is of 7,500 ohms resistance.

A A' and B B' are ordinary relays of 200 ohms resistance.

E E' are ordinary Morse keys with the circuit closer removed.

D D' are main batteries, of equal strength, with similar poles to line. The current from each battery passes through receiving relays A A' to the line, only a very small portion of it going through the shunts formed by the rheostats and recording relays. Of course, as the batteries oppose each other, both receiving relays remain open. By depressing key E we close relay A'. The current from battery D is now short circuited through recording relay B and rheostat C, 300. The current from battery D' coming over the line also takes the same route to the ground, and relay A' at once closes. Relay A, however, remains open, owing to the current coming from battery D', meeting with a sufficient quantity of current from battery D (which leaks past the point F) to balance it. This balance is obtained by varying the resistance in the rheostat C, marked 300, so that when key E is closed (the key at the other end being open) the armature of relay A does not move. Relay A' being thus closed, let us see how relay A can be closed from the other end of the line. We close key E' battery D' being thus short circuited, the current, which before went over the line to preserve the balance at relay A is cut off, and the small portion of current which leaked past point F now goes on to point H, and thence through rheostat C, 5,000, and key E, to the ground, and relay A closes. Relay A', which had already been closed, is kept so by the leakage current, which acts the same way as at the other end. It is thus shown that no matter in what position the keys may be, the relays are always ready to respond to the writing from the other end.

The return current is neutralized by the recording relays B B' as follows:—When the line is at rest it is charged with a current of the same polarity from each battery. When the key at either end is closed the current in the line would, in discharging through the receiving relay, make a false signal; at the same instant, however, the recording relay, through which a strong current is passing, sends out an inductive current, which, running in an opposite direction to the current that produced it, meets and effectually kills the discharge current. On raising either key the line is again charged, and this current is again neutralized by the current given out by recording relay on being demagnetized. The strength of these inductive currents can easily be varied to suit any line or condition of line, by using relays of different resistances and size of core. The arrangement shown in the diagram has been working between Toronto and Montreal, on the Dominion Telegraph Company's lines, a distance of nearly 400 miles, for the last year, and is giving good satisfaction. One hundred and forty cups, of ordinary sized gravity battery, are used at each end.

THE American electric Society have lately furnished a room in the Western Union building very handsomely, which is open to any of its members. They have quite a library—some of the best books on electricity published in this country—and will soon have many others, among which will be some from societies in Europe. They are preparing their first book, which will contain some line cuts of different late inventions.

23

Institution of Civil Engineers, when the anniversary address was delivered by the President, Dr. Mann. In alluding to the establishment of a carefully planned series of observing stations by the society, the President illustrated at some length the absolute necessity of following out the inductive method of research in meteorology, and supported his argument by a reference to the history of all the leading branches of physical investigation. The President compared the meteorological doctrine of high and low pressure areas of the atmosphere, and of the movement of currents of the air under the influence of barometric gradient, to the Newtonian doctrine of gravitation in astronomical physics, to the Daltonian hypothesis of atomic proportions in chemistry, to the dynamic theory of the tides, and to Avogadro's law of the uniformity of the atomic constitution of gases under like conditions of pressure and temperature. He maintained that the perfection and practical application of this law must be worked out by organised and carefully-thought-out plans of observation, such as were now used by the society, and also under circumstances of higher opportunity and greater facility by the meteorological office of the Government. The President incidentally remarked that he believed the recent researches into the vertical circulation of the water of the ocean under the influence of the different specific gravities of its distant parts was virtually tending to the establishment of the same great influence as being the moving spring of the physical dynamics of both the ocean and the atmosphere. In allusion to the recent establishment of the permanent lightning-rod committee by the society, he gave a very interesting account of a visit he had recently made to Professor Melsens, of Brussels, and described the experiments upon which the professor is engaged in investigating the molecular changes brought about in conducting bodies by the passage through them of powerful discharges of high tension electricity. He also gave an elaborate account of the admirable system of defence against lightning which has been adopted at the Hotel de Ville of Brussels. Some curious and notable instances of the molecular effects of lightning discharge were exhibited during the delivery of the latter portion of the address. The report of the Council having been read, the proceedings concluded with the election of Mr. H. S. Eaton, M.A., as President for the ensuing year, and the appointment of the usual officers.

THE TELEGRAPH ELECTRICAL SOCIETY, MELBOURNE.

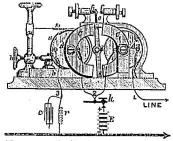
WE have been favoured with a copy of the transactions of the Telegraph Electrical Society of Melbourne for the quarter ending 31st July, 1875, along with the report for the year ending the same date. The society has just completed the first year of its existence, and now comprises 49 town members and 79 country members. Their meetings are held in the chief telegraph office at Melbourne, so that ready access may be had, when required, to large battery power and apparatus, which could not be well moved were the meetings held elsewhere. The proposal to make the society a public one, and admit strangers as members, has been negatived, and the rights of membership are restricted to the *employés* of the Postal Telegraph Service. Several valuable papers upon various subjects have been read; and the present number of the transactions includes, amongst others, a valuable note, by Mr. H. J. Aubin, upon automatic translator for closed circuits. Altogether, the society seems to be in as flourishing a condition as can well be expected.

HASKINS'S DUPLEX TELEGRAPH.

(From the *Telegrapher*.)

SINCE the first patent was taken out in this country for duplex telegraphs by Moses G. Farmer, in 1858, nearly forty other patents, including reissues have up to this time been granted in the United States for inventions of this kind, mostly within the past five years. We have from time to time published in the *Telegrapher* diagrams and descriptions of several different methods of duplex telegraphy, including most if not all of those which have been employed in actual telegraphic service in this country, with the exception of the one which forms the subject of the present article.

The apparatus we are about to describe was invented in the early part of 1874 by Mr. C. H. Haskins, General Superintendent of the lines of the North Western Telegraph Company at Milwaukee, Wis. It is one of the simplest in principle, as well as one of the most effective in operation, of the numerous inventions of the kind now before the public. The novelty of the invention may be said to consist principally in the peculiar manner in which the receiving relay is constructed and operated, and we will, therefore, give a somewhat detailed description of this part of the apparatus before attempting to explain the general principle of operation.



The accompanying illustration is an end view of the relay, the connections and other parts of the apparatus being shown on a small scale and in outline, for convenience of explanation. The relay consists of two spools or helices, A A₁, which are placed parallel to each other, and connected together at the point 2, so as to form a continuous circuit from 1 to 3, precisely in the same manner that the helices of an ordinary relay are arranged. Instead, however, of connecting the two cores

THE TELEGRAPHIC JOURNAL.

Vol. I.—No. 11.

DUPLEX TELEGRAPHY.

By W. H. PREECE, Memb. Inst. C.E. and Soc. T.E.

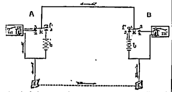
Duplex telegraphy, which has lain dormant in England for nearly seventeen years, has recently received great attention from all telegraphists, owing to its successful introduction in America by Mr. Stearns. This method of working consists in telegraphing in opposite directions upon one wire at the same time. It implies that while A is working to B, B can also work to A upon the same wire.

Before explaining how this apparently impossible operation can be performed, I will first show how A usually works to B, by means of an ordinary Morse recording-instrument.

A possesses a battery (*b*) whose number of cells depends upon the distance which separates A and B; a key (*k*) which on being depressed (as shown at B) by the pressure of the fingers at *f'* brings the points 1 and 2 in contact, causing the current to flow from the battery (*b*), and which in its normal position (as shown at A) remains with the points 3 and 4 in contact, thereby permitting any current arriving from B to flow through the Morse apparatus or receiver (*m*).

B possesses the same apparatus as A. They are connected up, as shown in the diagram (Fig. 1), the

Fig. 1.



circuit being completed by the earth. When A works to B he depresses the key (*k*), sending a current to B, which, passing through the receiver (*m*), records its mark, and for every current so sent a mark is made. Now when B works to A precisely the same thing occurs—every depression of the key at B occasions a mark to be recorded upon the receiver at A, through the passage of a current from B to A. It is evident that if the batteries at the two places be similar in every respect, and the insulation of the wire be perfect, the currents from each station will be exactly equal in strength. The currents from A to B may be in the same or in an opposite direction to those from B to A. It matters not—the effect upon the recorder is just the same. I have shown them in the diagrams to flow in the opposite direction, and therefore, for the present, we will so consider them. We will also assume, for the present, that the current received at either station is exactly equal to that going out of it.

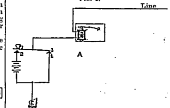
Now what happens when these two stations try and work to each other at the same time? We have a current from A flowing to B in one direction, and we have a current from B flowing to A in the opposite direction: and since these currents are equal, if they tend to flow at the same time, the effect must be *nil*; they, in fact, destroy each other; no current can be formed,—hence with such apparatus no marks can be registered at either station. But what if we can avail ourselves of this destruction of the current to register marks? That is, if we let one instrument be such that it registers when the current is *formed*, and also when the current is *destroyed*. If we can do that duplex telegraphy is possible; A can work to B while B works to A.

This problem was first solved by Dr. Gintl, an Austrian telegraph director, in 1853. Modifications of his solution have been made in Germany by Siemens, Frischen, and others; in England by the writer, and Mr. Eden of Edinburgh; and in America by Mr. Stearns. There are three methods adopted: first, that of *equation*; second, that of *difference*; third, that of *leakage*.

1. *Equation*, which was the method originally invented and applied by Dr. Gintl.

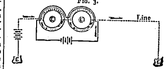
The connections are so arranged, as shown in Fig. 2, that the receiver at each station is always

Fig. 2.



in circuit, so that the currents, whether they are sent by A or received from B, pass through it; but it is so constructed that when A alone is working no effect is made on its own receiver by the outgoing current. How is this done? The electro-magnet, E', Fig. 3, which is shown here in plan, is wound

Fig. 3.



with two wires, of exactly equal dimensions and resistance, either of which operates equally upon the iron core when traversed by the same or an equal current. The character of the magnetic polarity imparted to an iron core by a current depends upon the direction of the current. If a current in one direction produces a *north* pole at at the uper end, a current in the reverse direction produces a *south* pole at the same end. If these currents acted simultaneously, the result would be no polarity at all, for the tendency to induce the one

26

On one side is advertised "Post Office, Money Order Office, Savings Bank, Postal Telegraph," and on the other "Pickles, Cattle Medicine, Perfumery." The postmaster controls and supervises all the sub-offices under his charge.

The head offices are placed in direct communication with each other, and with the chief centres, such as Manchester and Birmingham, which again in their turn are connected with the chief telegraph station in London, known as T S, so that messages are sent from place to place by the most direct routes, and every office is provided as much as possible with alternate circuits or double outlets in cases of accident or pressure.

The system before the transfer of the telegraphs to the State was mainly directed to place London in communication with the Provinces, but the Post Office has placed all towns that have business relations in direct communication with each other, and has diverted as much as possible the circulation of messages through London. It has done all in its power to prevent the unnecessary repetition of messages, and to reduce the number of transmissions to the fewest possible, for every transmission means increased cost in working and extra liability of error.

All head offices as a rule are worked by Morse circuits; some few still remain worked by needle circuits, but gradually, as the business increases, the needles are being supplanted by the Morse and the Morse by the sounder. Where several offices remain on one circuit, the needle is retained, but intermediate working induces delay, and as soon as the business admits of it, direct wires, fitted with Morse instruments, are supplied. Head offices are almost invariably worked by trained telegraphists, either in the employment of the postmaster or directly in the service of the Crown. All the large transmitting centres are worked entirely by a trained and experienced staff, under the direct control of the postmaster of the town in which it is placed.

It may be taken as a rule that, when the messages are very few, A B C instruments are used. When the number of stations on a circuit exceeds four, or when the number of messages exceeds twenty per day, then single needles are fixed. As the business increases the single needles are replaced with Morses. When the number of messages exceeds fifty per day it is time to consider the necessity of a direct wire. One such wire can transmit without delay 150 messages per day. If the messages approach 200 a day, another wire is wanted. If the distance between the stations and the amount of business warrants the expense, then Wheatstone's automatic is fixed, and this can readily transmit from 400 to 500 messages per day.

Recently duplex telegraphy, which enables messages to be sent simultaneously in opposite directions on the same wire, has been introduced. It simply duplicates the capacity of all *direct* wires, and it has placed in the hands of the Postal Department, a most valuable and useful auxiliary apparatus. Indeed without it, and with the recent stoppage of all works, it would have been difficult to have transacted all the work of the Department during the very busy autumn which has just passed, without inconvenience or delay. It is applicable to all kinds of instruments.

It may be said generally that the teaching of experience is showing that the instrument of the future for ordinary commercial work is the "sounder."

(To be continued.)

A NEW SYSTEM OF ELECTRIC TELEGRAPHY.

By PAUL LA COUR,
Sub-Director of the Meteorological Institution of Copenhagen.

(Presented to the Royal Danish Academy of Sciences at the Meeting of February 12, 1875, by Mr. Holten.)

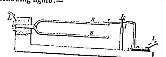
In the Electric Telegraph, up to the present time, but two simple signals have been employed, and these have been formed either by currents in opposite directions, or by the prolongation, to a greater or lesser extent, of the duration of the current. The system, which I devised on the 10th May last, enables, however, a large number of simple signals to be made with a single conducting wire.

When a vibrating body, at each of its vibrations, is made to close and open an electric circuit, the pulsations of the current will, of course, be isochronous with the vibrations of the sonorous body; and when such currents are, by means of electro-magnets, made to act upon a second sonorous body vibrating in unison with the first, the second body will vibrate, whilst another similar body giving a different sound will remain silent.

The first experiment was successfully made on the 5th June, 1874, but it was feared that the vibrations might cease to be perceptible after traversing a long distance. I therefore made an experiment upon a telegraph line, 390 kilometres in length (from Copenhagen to Fredericia and back), and even with a rather weak current, the pulsations were easily perceptible. This experiment was made during the night of the 14-15 November in the same year.

To produce the intermittent currents and receive them at the further end, the sonorous bodies employed were tuning-forks. The apparatus is constructed in the following manner:—

The key or instrument, which produces the intermittent currents in the line, is shown in the following figure:—



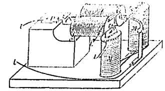
S S is a tuning-fork fixed by the shank in such a way that at each oscillation one of the prongs touches the contact *c* during a portion of the oscillation. The contact *c* can be adjusted by the screw *k*, and together with its support, is insulated from the tuning-fork by the insulating piece *J*.

When the shank of the tuning-fork is connected to one of the poles of a voltaic battery whose other pole is to earth, and when the contact piece is connected with the telegraph line and thence to earth, a blow given to one of the prongs of the fork will cause an intermittent current to be sent into the line, the pulsation of the current being in unison with those of the fork.

It follows that, by keeping the fork in vibration, the same result will be obtained, whenever the circuit is closed at any given point. It always follows that, by employing a contact upon the inside of the fork with a special battery for the same, the line can be charged with a succession of currents in opposite directions.

27

The receiving apparatus is shown in the next figure.



n p s is a tuning-fork of soft iron giving the same sound as that of the key. The prongs are inserted lengthwise in the two coils *T T*, which are surrounded by silk-covered copper wire; the prongs are so arranged as to vibrate freely within the centres of the coils. The intermittent current, on arriving at the station, passes through these two coils, and thence into the wire of an electro-magnet *M M*, which is arranged so that its poles are placed in front of the opposed poles produced in the fork. It is evident that the current, in magnetising the electro-magnet and the fork, produces an attraction which will open the prongs of the latter, but directly the current, and consequently the attraction, ceases to operate, the prongs will return to their position of equilibrium, and so on. If then the pulsations of the current are in unison with those of the fork, the vibrations of the latter will soon attain a sufficient extent for one of the prongs *n* to touch the contact piece *D*, closing the circuit *l l* of a local battery, and thereby manifesting the arrival of the current in the usual way, either directly or by means of a relay.

I cannot as yet, I admit, state the time required to produce in the fork of the receiving apparatus vibratoins of a certain extent; it is a function of various factors; but experiment shows that the time which elapses before the local circuit is closed is so small a fraction of a second as to be hardly perceptible, even when the current is very weak. In the hope that this system will play an important part in electric telegraphy, I beg to here point out its principal advantage.

The intermittent current acts upon that tuning-fork only which is in union with the fork of the key. If then any number of different keys are arranged and the same number of receivers to correspond, an equal number of simple signals can be produced, each of which requires but a single movement. If each of these signals corresponds to a letter, figure, or other sign, messages may be sent more quickly than by present methods, and the receivers can be made to act upon a printing apparatus without any difficulty.

The same peculiarity will admit of the employment of these signals where several stations are connected together by a single cable. A signal can be sent between any two of the stations without the others being aware of it. The system might also become applicable in various other circumstances, for example: to call, give warning, announce the occurrence of an accident, fire, torpedoes, &c., in a word in all cases where it is desired to transmit signals only to certain points.

Another important property of the system is that *several signals can be produced* SIMULTANEOUSLY *upon the same wire.* For when several keys are acted upon at the same time, the current thus produced, with simultaneous intermissions of different duration, will only act upon the receivers corresponding to the vibrating keys, if only the forks have been selected in such a way as to avoid simple harmonies between them. Thus, for example: by employing a system of ten tuning forks, ten simple signals can be produced, then $\frac{10 \times 9}{1 \times 2} = 45$ signals when combined two and two, without the latter requiring more time than the simple signals. The question of the limit to the number of forks which can be vibrating at the same time is one that can only be determined by experiment.

The same property makes it possible to transmit several messages to various stations, employing but one wire. For example; station A is connected by a wire with station B, whence the wire is continued to station C. Station A can use two different systems of keys, one for station B and the other for station C. The receivers at the two stations must, of course, correspond with the keys. The same property also enables the system to be employed for pantelegraphs of a more reliable and quicker form than those made by Bain, Caselli, and others. Up to the present time only one style has been used in such telegraphs, and this style has to pass over the whole surface of the telegram to produce a copy of it; in the new system, however, as many styles as may be desired can be placed side by side in the form of a comb, which will then pass over the surface of the message in one direction only. By this method also, there is the advantage that an exactly equal speed is not required in the two instruments, for the only inconvenience which would result from a difference of speed between the original and the copy would be a slight contraction or extension in width of the whole message.

Lastly, the receivers have the valuable peculiarity of *letting ordinary electric currents pass through them without any indication of their presence*, at least, unless the currents are of very considerable intensity, so that atmospheric and terrestrial currents would not, as a rule, interfere with the working of telegraphs arranged upon this new system.

The quadruplex system, by which two messages are sent simultaneously from both ends of a line was successfully worked on the Madras Railway line between Madras and Salem a few weeks ago. E.M. Oct. 75

28

ON THE TELEGRAPHIC PROBLEMS OF DOUBLE SENDING AND QUADRUPLEX TELEGRAPHY.*

By G. K. WINTER.

THE practical success which has attended the revival of duplex telegraphy has doubtless led many besides myself to inquire whether the difficulties in the way of the simultaneous transmission of two messages in the same direction, over the same line, were altogether insurmountable. A very little thought over the matter will show that the difficulties to be encountered in solving this problem are altogether of a different nature from those attending the question of duplex working, and, further, it is evident that if once these difficulties were overcome, the problem of quadruplex telegraphy would be solved by applying to our apparatus similar arrangements to those by which duplex telegraphy has already been rendered practicable.

It is obvious that, to send two messages at the same time, in the same direction, on the same wire, between two stations, two keys are required; and it is also obvious that with two keys, each having independently two positions, there are four combinations, which of course should each produce a different effect upon the receiving instruments at the distant end. Thus suppose we have two keys, which we will call A and B respectively, we shall have—

1st combination.		Both keys at rest.
2nd	"	A depressed and B at rest.
3rd	"	B depressed and A at rest.
4th	"	Both keys depressed.

* Communicated by the Author.

There are two different ways of attacking the problem, namely—

1. To devise such an arrangement of the keys that each of the four combinations shall produce a different electrical effect on the line, and then to endeavour so to arrange the receiving instruments that these different electrical effects shall be rightly interpreted by them.
2. To endeavour so to arrange the receiving instruments that, with some four variations in the electrical state of the line, four combinations, analogous to those of the keys we have noticed above, may be produced; and then to devise some arrangement of the keys by which the desired electrical states of the line may be produced by their action.

I have only seen two systems described in any of the works on electricity or telegraphy that I have read. One is given by Blavier and the other by Sabine. In each of these it would appear that the inventors had set to work according to the first method, for in each the method of joining up the keys is practically the same, and intended to produce currents as follows:—

1. Both keys at rest. No current.
2. A depressed and B at rest. One unit of current.
3. B depressed and A at rest. Two units of current.
4. Both keys depressed. Three units of current.

All the currents being in the same direction.

This is the most obvious arrangement of the keys, and it will be seen, from the following descriptions of the methods, that in each of them the inventors have been successful in rightly interpreting the different signals sent; thus, supposing the local instruments at the receiving station to be Morse instruments, we find that—

1. When no current arrives, both Morses are at rest.
2. When one unit of current arrives, Morse A is acted upon and Morse B is at rest.
3. When two units of current arrive, Morse B is acted on, Morse A is at rest.
4. When three units of current arrive, both Morses are acted on.

So that at first sight the problem would appear to have been solved in each case: on examining the matter further, however, we shall find that false signals would be made during the changes from one combination to another, which, apart from another drawback we shall notice, would suffice to render the methods useless.

The method given by Blavier is as follows:— R, R', R'' (Fig. 1) are three relays joined up one after another between the line and the earth at the receiving station.

(over)

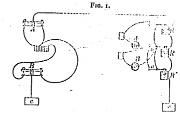
29

Of these R is the most sensitive, and will work with one unit of current.

R' is rendered less sensitive by means of an opposing spring: it will not work with one unit of current, but it will with two.

R'' is rendered still less sensitive by means of a stronger opposing spring: it will not work with less than three units of current.

FIG. 1.

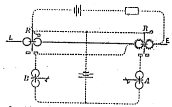


It will be seen that the Morse A is joined up in such a way that, so long as the relay R' is at rest, it will work whenever the tongue of relay R is acted upon by the current. So long, therefore, as the key A only is worked, and consequently only one unit of current sent into the line, the Morse A will indicate the signals given by the key A. When the key B is depressed it is evident that two units of current are sent into the line; consequently the current is strong enough to work both the relays R and R'. The relay R' in working completes the circuit of Morse B, and at the same time breaks the circuit of Morse A; thus, so long as only the key B is worked, the Morse B will indicate the signals given by the key B. Now suppose we depress both keys, there will be three units of current, and consequently the relay R'' will be worked as well as the others. It will be seen that when relay R'' is worked, the break in the circuit of Morse A which is caused by the working of relay R' is made good, and thus both Morses will be worked. So far all well, but now let the key B be raised; the current will be reduced to one unit, and consequently both the relays R' and R'' will be drawn back. Of course the circuit of Morse B will be broken, but so also will for an instant that of Morse A, for it is evident that the tongue of relay R'' will have broken contact with *c* before the tongue of relay R' can have made contact with *b*, and thus recompleted the circuit of Morse A. Thus at the change there will be a sudden interruption of the working of Morse A, not answering to any signal given by its key, and a confusion of signals must arise.

Added to this, however, the difficulty of keeping the three relays at proper states of sensitiveness would be almost insurmountable. The difficulty of the interruptions of the circuit in the intervals between the positions of rest and depression of the keys could be overcome by known methods.

The system given by Sabine was invented by Stark, of Vienna, in 1855. The method of connecting the keys was somewhat different from that shown above, but the result was exactly the same, so we will only concern ourselves with the receiving apparatus: this is represented in Fig. 2.

FIG. 2.



In this arrangement only two relays, of different degrees of sensitiveness, are employed. Relay R is the most sensitive, and will work with one unit of current; relay R' is less sensitive, and will work with two units of current, but not with one. When relay R' works, however, it not only completes the circuit of the Morse B, but also that of another circuit through an extra coil of the relay R, in such a direction as to oppose the action of the currents coming from the line, and thus to render it less sensitive, and only to be worked by three units of current in the line circuit.

According to this plan, whenever the key B is worked both relays will work, for it is not until the relay R' has made its contact that the sensitiveness of relay R will be reduced; consequently at every depression of the key B we shall have a momentary kick on the Morse A, not in accordance with any signal given by its key, and thus confusion of signals must result. Again, although we have only two relays to adjust as to sensitiveness, yet one of these has two states of sensitiveness, one of which, namely, that caused by the opposing action of the local current, would be even more troublesome than the adjustment of the third relay by means of a spring. Neither of these methods can therefore be said to offer any hope of practical success.

Having now examined the principles and learnt the defects of the old systems, I will endeavour to explain, as clearly as possible, the principle of the system by which I have achieved a practical success, and the line of thought which led to its discovery.

See also next page

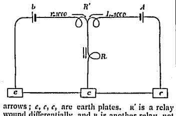
ON THE TELEGRAPHIC PROBLEMS OF DOUBLE SENDING AND QUADRUPLEX TELEGRAPHY.*

By G. K. WINTER.

(Concluded from page 210.)

In Fig. 3 let L be the line with a resistance say of 1000 units, and let *r* be an artificial resistance of the same amount. Let *b* be a local battery, and A a battery at the distant station, of equal strengths, and sending their currents in the directions indicated by the

Fig. 3.

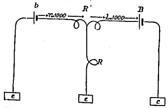


arrows; *c*, *c*, *c*, are earth plates. R' is a relay wound differentially, and R is another relay, not wound differentially, but connected between the middle point of R' and earth, as shown in the figure.

It is evident that the two currents will neutralise each other's effect on the relay R', but that they will both flow through R in the same direction. R' will evidently not work, but R will.

Again, let Fig. 4 represent the same arrangement, except that the direction of the battery B is reversed, as shown by the arrows. Then the currents will flow in the same direction through the two coils of the differential relay R', which

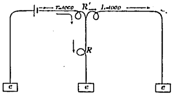
Fig. 4.



will consequently work, whereas no current will flow through R, as the potential of the circuit at the centre of the differential relay will be zero, the batteries being equal in power, and the resistance equal on each side of this point. Thus in this case the relay R' will work, but not the relay R.

Next, let us have no battery applied at the sending station, but the line joined to earth, as shown in Fig. 5.

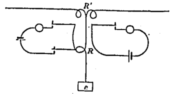
Fig. 5.



It is now evident that both relays will work, for a large portion of the current from *b* will flow through R to earth. Thus with three variations of current coming from the sending station we can produce three of our four combinations. It remains to be seen how we can produce the fourth.

Let us suppose the differential relay R' to have two tongues, and let the connections be made as shown in Fig. 6. Further, let this relay be polarised, and let both its tongues be worked by a current in the direction shown by the arrows in Fig. 5.

Fig. 6.



We must also suppose that when in a state of rest—that is, when no current is passing through the relays—the tongues will be in the positions shown in Fig. 6.

Things being thus arranged, let a current from S be sent, as show in Fig. 7.

We shall then have a current running through one coil of R' not only in a direction opposed to that from *b*, but also of double the strength, and consequently the resultant magnetic effect of the currents on this relay will be to give it a polarity which will be opposed to its working; thus not only is the tongue *t'* allowed to fall away from its contact, but is held in that position, while the tongue *t* is also forced away from its contact-point, against which it leans

* Communicated by the Author.

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que l'on retrouve toujours à l'avant-garde de toutes les tentatives propres à hâter le développement de la science électrique, nous a autorisé à témoigner de son adhésion personnelle à la réalisation d'un tel programme de l'agence internationale de l'électricité, dont nous poursuivons la très-prochaine organisation.

En inscrivant donc aujourd'hui le nom de l'académicien qui a consacré sa vie à la science électrique, en tête du comité de patronage d'une ASSOCIATION INTERNATIONALE DE L'ÉLECTRICITÉ dont notre agence sera le *siége*, le *bureau* et le *laboratoire*, notre rédaction renouvelle à tous les électriciens de France et de l'étranger l'appel que M. Hallez d'Arros leur a adressé.

Nos aspirations ne sont-elles pas dignes des destinées nouvelles qu'un tel projet ouvre devant l'électricité régénérée?

W. DE FONVIELLE.

L'ÉLECTRICITÉ A L'EXPOSITION UNIVERSELLE 1878

(10e *article*)

TÉLÉGRAPHES HARMONIQUES

POUR LES TRANSMISSIONS SIMULTANÉES

De M. Elisha GRAY

(*Suite*)

Le second système de télégraphe harmonique de M. Elisha Gray, que nous avons mentionné à la fin de notre précédent article, a pour objet d'utiliser un fil conducteur ordinaire interrompu, desservant un certain nombre de bureaux intermédiaires, de manière à en faire un fil continu susceptible de

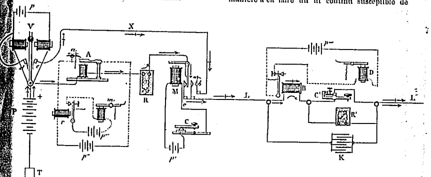

Figure théorique d'une ligne pour transmissions simultanées.

transmettre les correspondances échangées entre les stations extrêmes par deux systèmes télégraphiques différents, fonctionnant simultanément. C'est en quelque sorte un *Duplex* d'une nouvelle disposition qui a l'avantage de pouvoir être appliqué sur toutes les lignes déjà en service, et sans changer leur organisation.

Le problème était assez difficile à résoudre sur les longues lignes, et ce n'est qu'après de nombreux essais qu'il put être résolu d'une manière tout à fait satisfaisante. Sans entrer dans les détails de tous ces essais que M. Elisha Gray donne dans son mémoire, lu à la Société des ingénieurs télégraphiques de Londres dans sa séance du 12 décembre 1877, nous allons indiquer le système tel qu'il a été expérimenté en Amérique, entre Chicago et Dubuque, et tel qu'il figure à l'Exposition de 1878.

Le fil allant de Chicago à Dubuque s'étendait sur une longueur de 189 milles et desservait dix-sept bureaux intermédiaires, fonctionnant avec des appareils Morse. Or, ces bureaux ont pu correspondre entre eux comme à l'ordinaire sans troubler en quoi que ce soit le travail effectué entre Chicago et Dubuque au moyen du double système.

La disposition du système est indiquée dans la figure ci-dessus qui représente la combinaison des appareils pour un seul des postes extrêmes. L'autre poste est disposé exactement de la même manière, et rien n'est changé à la disposition des postes intermédiaires, sauf qu'on y a ajouté un rhéostat et un condensateur. L'ensemble des appareils de ces postes est exactement représenté dans la partie de la figure ci-dessus que l'on distingue à droite.

Chacune des stations extrêmes comporte donc deux séries d'appareils que nous avons disposés en deux groupes, de manière à ce que l'on puisse aisément distinguer ceux qui appartiennent aux transmissions harmoniques de ceux qui appartiennent aux transmissions Morse. Ces derniers sont à droite, les premiers à gauche. Les appareils pour les transmissions harmoniques sont les suivants : 1° une clef Morse du système Gray C, servant d'organe manipulateur; 2° un relais transmetteur M, agissant sur deux circuits issus de la pile de ligne P, l'un passant par le récepteur harmonique A et un rhéostat R, l'autre traversant le vibrateur V; ces deux circuits sont équilibrés et correspondent tous deux à la ligne L; 3° un récepteur harmonique A, dit *analyseur*, qui réagit sur un parleur ou sur un relais local *r*, et par suite sur un Morse *m*; 4° un vibrateur V analogue à celui que nous avons décrit dans notre précédent article, et qui doit être réglé pour vibrer symphoniquement avec l'analyseur; 5° un rhéostat R pour équilibrer la résistance des deux circuits dérivés en A et en V.

Les appareils pour les transmissions Morse so-

32

147,487. G. D'Infreville, New York, and W. N. Armstrong. *Duplex telegraph.* Dated April 25, 1873.—No additional local or split batteries used. Two main batteries opposed, and battery at sending station localised, for preserving equilibrium. 1. The method of duplex telegraphing, substantially as described, by localising or short circuiting the main battery at the sending station, thereby preserving the magnetic equilibrium in the signalling instrument of that station, and allowing the battery of the receiving station to exert its full force in recording or indicating signals. 2. In combination with a normally closed telegraphic line having main batteries, one at each terminal, connected to the line in opposition to each other, open circuit single contact keys, and branch circuits connected to the relay magnets at a suitable point, the closing of the said keys short-circuiting or localising the battery of the sending station through the proper proportion of the coils of the relay. 3. In combination with a relay magnet having its layers exposed for connection to key, and for approximate adjustment, as described, the shunt circuit and rheostat. 4. In combination with the normally closed line, having branch circuits and open circuit single contact keys, and opposed batteries, as described, the battery reversers and closed circuit keys. 5. The combination, at an intermediate or way station, with the main line of a duplex telegraph, of the open circuit key and branch circuit connected to the relay between the terminals, the depressing of the key closing independent circuits for both terminal batteries, giving signals to both sides of the way station in single transmission, or forming a duplex line with one terminal.

Western Union and Quadruple Transmission.

TO THE EDITOR OF THE TELEGRAPHER.

WILL you permit me, through the columns of THE TELEGRAPHER, to reply to a statement in regard to the "most erroneously" assumed advantages to accrue to the public by the use of an alleged new discovery referred to in the New York *Tribune* of the 9th instant—said new invention being called by the electricians of the Western Union Telegraph Company "The Quadruple Telegraph." By the use of which each wire now in daily use is not, and cannot, as stated, be made practically four; further, that by its use the traffic of the company cannot, as stated, be economically increased without the erection of any more wires. It being a well known fact, both here and in Europe, that specially large wires had to be erected for the "Stearns Duplex." This, taking the cost of construction or reconstruction into consideration, leaves practically the line working on the "old Morse status," at least until reconstruction is paid for.

Now, with regard to the so-called quadruple system said to be in use between New York and Boston; it is also a well known fact that it is being worked necessarily on a large line wire, for, by an apparently curious "paradoxical law," the speed of duplex, as also the speed of quadruple transmission over even a large line wire, is "reduced with mathematical precision," and this reduction of speed progresses rapidly for quintuple transmission, and so onwards until finally speed will entirely cease altogether. This fact is also well known to telegraph scientists—in a succinct way it means that if we erect, say a number six line wire for quadruple transmission, there will be (when the state of the weather admits of its being worked) practically a gain of only one wire. But, on the other hand, if it be attempted to work quadruple transmission on an old Morse line wire the gain will be practically *nil*.

This "new discovery" by the way, for some twenty-five years known to all telegraph scientists, which fact must have inadvertently been overlooked by my scientific friend, Mr. George B. Prescott—being described in the works of that eminent electrician, General Sabine, and others in 1854-5-9. Nevertheless, to Mr. Prescott is due the credit of its first introduction in this country. Now, for the sake of argument, admitting the statement referred to to be correct, let us see what would be the gain to the company according to Mr. Prescott's book, p. 149. The average rate upon Morse lines does not exceed seventeen words per minute, and this is a fair average—add seventeen words more for quadruple transmission, leaving the same still subject to all of the old Morse difficulties, such as climatic changes, liability to interpretation by feel, taste, or by sound by any Morse operator, and may be so appropriated; and, in addition, the same is subject to the inevitable fourfold complication of the Morse apparatus when adapted to quadruple transmission, and over sixteen compensations in order to meet, among other difficulties, that of ever varying climatic changes constantly taking place throughout this vast extent of continent.

What the people of this country require is a reliable, cheap system of telegraphy, whereby they may feel sure at all times of obtaining telegrams during any state of the weather, and that is to be found in the one upon which the eyes of the whole scientific world is now centred—namely, the (my) American (electro-chemical) automatic telegraphic system of the first order, which is capable of transmitting and receiving five hundred words and upwards per minute; one automatic line wire above referred to being practically equal to twenty Morse line wires. Within the past four years my rapid American (electro-chemical) automatic telegraph has repeatedly been pressed into the service of the opposition company during such seasons of stormy weather when the electro-magnetic telegraph came to a stand still. I hope you will excuse my trespass on your space when I tell you that in the year 1846, on this very important question of telegraphy, I stood before a committee in the British Parliament cheek-by-jowl with Alexander Bain.

GEORGE LITTLE, *Cons. Elec. Aut. Tel. Co.*

PASSAIC CITY, NEW JERSEY, U.S.A., *October 9, 1874.*

33

ing with the signal instruments of the present day.

(To be Continued.)

Notes.

BRYANT and May's safety matches are highly electrical, and if they be rubbed against glass or ebonite they readily ignite, especially if these electrics be dry and warm. How far their ready ignition on amorphous phosphorus is due to chemism, and how far to electricity, remains to be proved.

Nature says that a French clerical journal maintains that the tolling of the church bell is of much greater efficacy than the use of lightning-rods in warding off the effects of a thunderstorm, and advises the faithful to resort to the former means in preference to the latter.

The Anglo-American Telegraph Company have just given notice that telegrams can now be sent to Mexico, but that the lines there do not work very regularly.

Owing to delay in getting the material ready to put down, the Western Union Telegraph Company have decided not to attempt to lay the pneumatic tubes and underground wires between their general office and the branch offices on Broad and Pearl-streets until early in the spring. The work could not be conducted to advantage during the severe winter weather now soon to be expected. No part of the plans regarding the experiments contemplated, however, have been changed.

In transmitting the President's message from Washington to New York on Thursday, Dec. 7th, the Western Union Company used eighteen wires, and the time occupied was 30½ minutes. The message contained about 13,000 words, and copies were dropped at Baltimore and Philadelphia.

We learn from America that the Direct United States Cable Company state that the recent breaking of their cable in the Atlantic cannot be accounted for in any other way than that the break was caused by some vessel, but whether from accident or design is not at present known, and they decline to express an opinion on the subject. They declare, however, that the cable on examination recently was in perfect order, and that considerable force must have been used to disarrange it. The company offered a reward of £1,000 for the discovery of the vessel which broke the cable. The second break has been successfully repaired.

The first annual meeting of the American Electrical Society was held in Chicago on Wednesday, Nov. 17th, and was very largely attended, many members from various sections of the country being present. The president of the society, Gen. Anson Stager, presided.

Mr. Thomas Slater writes that the new prism electro-magnet of M. Sommati, described at p. 277 of our number of Dec. 1, 1875, was previouly invented and patented by him two years ago.

It has recently been recommended by M. Saint Edme that lightning conductors should be constructed entirely of iron, protected by a coating of electro-deposited nickel.

The Direct United States cable, broken on the 10th ult., was repaired on the 10th inst., the *Farday* having made a successful expedition.

The repairs to the first break were completed in a remarkably short time, especially if the season of the year be considered. The *Faraday* left the Thames, arrived at Newfoundland, completed the repairs, and was back again within a month.

It would seem likely that the present expedition will be equally expeditious. However, it is to be hoped that the direct cable will be left alone for the remainder of the winter, for it would be most desirable that the result of cheap American telegraphy should be known.

The Anglo-American Company's receipts for Saturday the 8th inst., at 3s. per word, amounted to £2,040, and for Sunday to £630; against an actual average in January last year, at 4s. per word, of £1,785.

During a heavy gale off Madeira the line end of the Lisbon-Madeira section of cable was broken. It was repaired in a few days, the fault evidently being easily accessible. The *Hawk* was despatched at once, and will now not be required, as the repairs were completed shortly after her departure.

The Suez-Aden section of the Eastern Company's cable is still broken down. The *Chiltern* has arrived at Aden, but the repairs are still incomplete.

D'INFREVILLE'S DUPLEX TELEGRAPH.

By HUGH NEILSON.

(*The Telegrapher.*)

THOUGH the duplex invention has lately been rather thrown in the shade by its "big brother," the quadruplex, it still remains, and, for a year or two at least, is likely to remain the most reliable means of working off business between large cities, especially when such cities are more than 250 miles apart. If an ordinary Morse circuit between two large cities can carry 350 messages a day, on which the company make a profit, an arrangement by

34

ON THE TELEGRAPHIC PROBLEMS OF DOUBLE SENDING AND QUADRUPLEX TELEGRAPHY.

By G. K. WINTER,
Telegraph Engineer to the Madras Railway.

(Continued from page 236.)

PART II.

A SECOND method of double sending which I have successfully worked, follows, almost as a matter of course, from the system previously described.

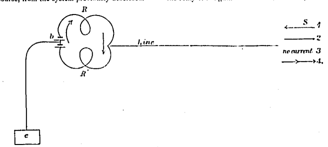

FIG. 12.

Let b be a battery, R and R^1 two relays, and let them be joined up with earth, and line in the manner shown on fig. 12. Let S be the distant station, and let the four combinations of the keys at that station produce the currents represented by the arrows, &c., opposite 1, 2, 3, 4, respectively. The current represented by the arrow opposite 1 will aid the local current through R^1, but will neutralise that in R. Again, the current represented by 2 will aid the local current in R, but will neutralise that in R^1. No current, represented by 3, will simply allow the local current to flow through both relays, and the double current represented by 4, will not only neutralise the local current in R^1, but will cause a current in it in the opposite direction to that in which the local current is flowing. Let both relays be polarised and so connected as to be worked by the local current. If now R^1 be a relay with two tongues, the position of rest of one of them being against the insulated stud, and that of the other against the central point; while the position of rest of the tongue of the relay R is against the insulated stud, and the tongues joined up as shown by fig. 13, we shall have exactly an analagous action in the relays to that described in the first part of this paper. This system possesses certain advantages over the system previously described; it is simple in theory, requires less battery power, and necessitates neither a differentially wound relay nor a bridge arrangement.

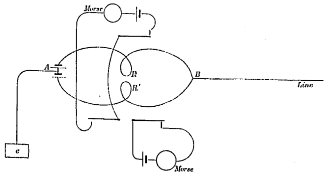

FIG. 13.

N.B.—The tongues are shown in their positions of rest.

This system works exceedingly well, and of

35

course the same arrangement of keys will suit either method. In order to duplex this system, we join the two branches of the bridge to the points A and B, and put a resistance coil between A and earth, adding condensers to this coil if necessary. Since the first part of this paper left, I have worked the quadruplex arrangements described without any difficulty.

It is very desirable that the currents should be properly balanced in the relays R and R^1, and it is also evident that the resistances of the two branches in which they are placed should be equal. In order to secure those conditions I make the following arrangements:—

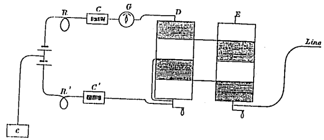

FIG. 14.

R and R^1 are the two relays as before, C and C^1 are two resistance coils for coarse adjustment, G a galvanometer, and D and E are two barrels of a rheostat by which the finer adjustments are made; the barrel D is of ebonite or other insulating material, and the barrel E is of brass or other conductor; by turning the barrels equal increments or decrements are effected in the resistances of the two branches.

We will now analyse the changes in the positions of the tongues of the relays which are caused by the action of the keys.

Fig. 15 shows the position of the tongues and the direction of the currents when both keys are at rest. It is seen that both the tongues t t^1 of relay R^1 are open, while the tongue t^{11} of relay R is closed. Both local circuits are therefore open.

Now suppose that key to be pressed which causes a current ——> in the line.

The current in R is simply reduced from three units to two units, so that tne tongus t^{11} continues

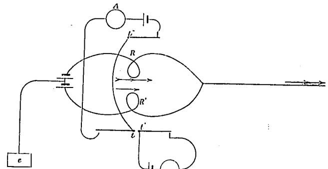

FIG. 15.

closed. The current R^1 is neutralised, so that the tongue t falls to its position of rest against the contact points, and thus completes the circuit of

if he does anything to offend me in the least. Tell him anything, so you stop him from coming. I am going to see a nice young lady in this town, and dear knows what she will do if she finds I have acquaintances like that man."

Mack told him it would be impossible to stop him, that he had gone out now to try and steal a meal somewhere. "You had better receive him kindly," he concluded, "and don't aggravate him by treating him coolly, as he might abuse you, and he don't stop at anything when he is mad." McGrew answered very weakly, "*I have the necessary courage, but I haven't the strength and muscular ability to cope with him.* I will have some of my friends here with me when he comes, to protect me.". The next night he called us up, and asked if Rasmus started for his place. Mack said, "Yes; keep a look out for him, he will be there soon." McGrew replied, "I have three men with revolvers and a shot gun in the office waiting for him. I have been to all the stores and hotels in town, and told them not to trust this man on my account, as I would not be responsible for any debts of his contracting." This was too much for Mack and the boys, they almost expired with laughter. Poor McGrew! He found out a few days afterwards when he was in town how cruelly he had been sold. He ceased to trouble us with "I am McGrew—brother of Bob's," and we were once more tranquil and happy.

[From *The Telegraphic Journal*.] Sept 1874

Duplex and Quadruple Telegraphy.

By Arthur R. Granville.

Without question, the Americans are maintaining their ground for ingenuity and enterprise in the electrical [illegible] telegraphic inventions. Although the practicability of duplex telegraphy was known as a scientific curiosity quite twenty years ago, it was far in advance of its age, and could not be put to any use by reason of certain difficulties—insuperable, according to the then known laws of electricity—so that the invention lay fallow for that period. A further reason for the invention not being followed up may be found in the fact that the traffic of those days was easily met, and telegraph engineers were not goaded on to investigate the difficulties attending the introduction of a system which, by enabling lines to perform twice their previous amount of work, has virtually doubled the efficiency of the wires in use.

To an American, Mr. Stearns, belongs every credit for dispersing those difficulties by a happy use of the condenser. Though not the inventor of the system—the honor of the invention belonging to Dr. Gintl, of Vienna, and W. H. Preece, of Southampton, Messrs. Siemens, Halske and Frischen, of Berlin—yet to him belongs the highest praise for having resuscitated an old laboratory experiment; for having nursed and trained it from infancy to maturity; and for introducing it to the practical world as a valuable system, requiring but slight additions to the instruments in use amongst telegraphers to render it ready for immediate practice. And so successful has the working of the "duplex" proved, that in a little over two years it has established itself as a great and most profitable system, and may be regarded as indisputably one of the most important turning points in the history of telegraphy and electrical science. It is reckoned equal in importance to the discovery of Steinheil, who demonstrated that return wires could be dispensed with by the use of earth plates. In resultant effects the "duplex" is strikingly similar to Steinheil's discovery, since both have doubled the resources of telegraphy—the former *directly*, by actually doubling the working capacity of wires; the latter by halving the lengths of lines, inasmuch as return wires were proved to be no longer needed.

The benefits arising from the "duplex" system bid fair to be multiplied still further by the joint labors of two Americans, Messrs. George B. Prescott and Thomas A. Edison, who announce the perfecting of what they designate "the quadruple system." This system is described as a "*new* process of multiple transmission, by which two messages can be sent simultaneously in the same direction over the same wire, and either message can be dropped at any way station on the circuit." The "duplex" system can also be applied to this "multiple" system, so that *four* messages may be despatched together over the same wire in the same direction. The recommendation in favor of the "quadruple" are that, like its predecessor, the old Morse key can be used, and the only expense attending its introduction is the purchase of additional parts of machinery; there is no sweeping away of old appliances and substitution of new ones. The Western Union Telegraph Company, of which Mr. Prescott is Electrician, is about to try this system—in fact, put it into practice on all their lines—so that we shall shortly learn with what success the system is capable of being worked. Of this we may be certain, that should fail

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Duplex, Quadruplex and Fast Telegraphy.

The following extracts from a communication of Mr. D. H. Craig, in a recent number of *The Graphic*, will be found of interest. It will be noticed that he intimates that the "Quadruplex," even if successful, is not available to the Western Union Telegraph Company:

In President Orton's recent annual address to the shareholders of the Western Union Telegraph Company much stress is laid upon the "Duplex" and high hopes placed upon the "Quadruplex" systems of telegraphing. These systems are doubtless improvements upon the Morse system in the number of words which can be transmitted over a single wire in a given time in fair weather, but the claim of the inventors and their friends that the capacity of the wires of the Western Union Company can be doubled by the "Duplex" or quadrupled by the "Quadruplex" system may answer very well to bolster up the stock of the "monster" company amongst the speculators in Broad street and the curbstone philosophers in New street; but there is not a practical operator who values truth in the employ of the company who will say that 1,500 words per hour can be averaged, one hour and one day with another, by "Duplex," nor that 2,500 words can be averaged by the "Quadruplex." If the same operators had independent wires, the first four would prefer to send 2,000 words (instead of 1,500 by "Duplex"), and the eight operators would prefer to send 4,000 words instead of 2,500 by "Quadruplex"), one hour and one day with another. A moment's consideration, therefore, will show the utter fallacy of the claim of the President and Electrician of the Western Union Company, either that the capacity of their wires can be doubled or that the business of telegraphing can be at all cheapened by the "Duplex" or quadrupled or "cheapened" by the "Quadruplex." So far are these statements from being correct that it is quite within the truth to say (and the practical telegraphers of the Western Union Company will confirm my statement) that it would cost the company at least twenty per cent. more—labor and wires included—to do their business by the "Duplex" than it would by the Morse system, and it would cost at least twenty-five to thirty per cent. more to do the business by the "Quadruplex" than it would by the "Morse." As I have a large and direct interest through the Automatic Telegraph Company (who own all the so-called inventions of Edison in the too much commended "Quadruplex" system), my judgment is not likely to err on the wrong side. I may also say that no one having authority has ever proposed to give the Western Union Company permission to use the "Quadruplex" system; and it is difficult to imagine what purpose Mr. Orton had in his extravagant allusions to it, unless it was to lend support to some of his "lame-duck" friends in Broad and New streets.

The well affected enthusiasm of the managers of the Western Union Company in favor of "Duplex" and "Quadruplex" telegraphy is by many supposed to be for the purpose of hiding their ignorance and brazon effrontery in 1869–70 in denouncing my "Automatic" or "Fast" telegraphy. At that time the President and Electrician of the Western Union Company insisted that there was no system of telegraphy equal to Morse (and this in the face of the fact that "Duplex" telegraphy was then thoroughly established upon the Franklin Boston line), and that my Automatic system was utterly valueless, because, as they said, it could not be worked at a faster speed than about sixty or seventy words per minute in a circuit of 250 miles, whilst the fact is that over 1,000 words per minute have been and can at any moment be transmitted by that identical Automatic system over 300 miles of wire. Those gentlemen are too proud, or too conceited, or both, to acknowledge their error, and they have been raising a furious dust ever since, first about one trumpery humbug or another, like "Duplex," "Wheatstone's Automatic," and now about "Quadruplex" telegraphy, and all the time, in place and out of place, through thousands of addresses, reports and "official journals," and through their legions of subservient tools all over the country, a steady stream of misrepresentation has been carried on against my system of Automatic telegraphy. The effect has been thus far, coupled with the ridiculous mismanagement of the Automatic Telegraph Company, to deter capital from taking up the "Fast" or "Automatic" system, and Mr. Orton complacently points to the fact that the Automatic Company has done nothing since 1870–71, as evidence that his original statements were true, and that the "Fast" system is of no account in comparison with his second-hand pet "Duplex."

37

THE TELEGRAPHIC JOURNAL.

Vol. I.—No. 16.

A DANGER FOR OUR IRON SHIPS.

Not long since were lost two of the best steamships ever floated, the *Atlantic* and the *City of Washington*; and not only is their loss a serious public calamity, but it places before the scientist a point requiring his unremitting attention. Of the cause of the loss of one of these vessels, it is so far certain that the navigating officer was misled by a deviation from the true line of the ship's compass needle. Placing the usual implicit trust in the magnetic needle, the captain steered his vessel not to her destination, but to destruction. The disturbing cause, affecting the truth of the compass, is said to be the load of iron, steel, and tin in the ship's hold; and how many ships put to sea, built of iron, or with cargoes of iron, that are open to the same cause of error, accident, or destruction.

But it should be known that this source of danger is not unprovided for; that, on the contrary, the greatest care is taken, in the case of an iron ship, to detect and compensate for this error. For determining the deviation due to the ferruginous material employed in their construction, iron vessels are "swung" in different directions; and the variation is noted between the indications of a standard compass placed in as nearly neutral situation as can be found—that is, at a point where the local attractions are evenly balanced—and the indications of the binnacle or ship's compass. A table is constructed upon the data afforded by these variations, and by this table is regulated the course of the ship when lunar or solar observations cannot be taken. But great as the care that may be taken in the calculation of the table—and the care taken by our naval architects and builders is exceedingly great—such care may in a moment be rendered valueless, for the vessel may acquire a new magnetic polarity very different from that with which she left the dock.

We know that magnets are of two kinds, permanent and induced. The needle of the compass is a permanent magnet. It is also known to scientists that a shell or iron bar laid in the magnetic meridian—north and south—will become temporarily a magnet; and that if struck or smartly jarred whilst in this position, that the bar will acquire a certain magnetic polarity quite sufficient to affect the ordinary compass needle. What of this? Why, an iron ship is but a big bar of iron, which, if running north and south, may be rendered permanently magnetic by the percussion of the waves against its sides, or even by the sharp strokes of the working of its own engines in a storm. Instances far too numerous are on record of the truth of this theory. The *Tiber* and the *Snowdon* both lost, or had their magnetic polarity reversed by the sharp blow of a minor collision. The *Aphrodita*, with a known deviation of her compass needle of 21° 30', ran against a pier, and the deviation was lessened by four degrees, showing that in an iron vessel the time when most is required from the compass—perhaps in the dark, when a vessel has struck—that instrument is useless. As to iron cargoes, it has been known that an iron ventilating shaft, placed near the standard compass, has quite misled the navigator. Many methods have been proposed in reference to the remedy of this defect. The latest, perhaps, is that of M. Glösener, who suggests "the placing of the standard compass out upon the bowsprit, at a distance previously determined to be without the sphere of attraction of the iron in the vessel. By this means, instead of the attracting substances being grouped around the instrument, perhaps unequally, they necessarily are all upon one side of the compass, and symmetrically placed in regard to it. The latter is, of course, so fixed, that the lubbers point and the foot of the needle pivot are in a line parallel to the longitudinal axis of the ship. To reflect a portion of the card, an inclined mirror is arranged above it, in which the indication is read from the deck by means of a glass." But some of our iron ships are constructed without bowsprits, even if the method were a reliable one, so that the subject still calls for the earnest attention of our scientific men. For the study of the subject means the saving of valuable property, nay, the saving of innumerable invaluable lives.

DUPLEX TELEGRAPHY.

By W. H. Preece, Memb. Inst. C.E. and Sec. T.E.

(Continued from page 247).

3. *Leakage.*—It now remains for me to explain the third method of duplex working, which has been adopted practically, and which is less known than any of the other methods because it has not been published before this, although it was worked experimentally, in the year 1856, between Southampton and Cowes. Our busy practical engineers have, as a rule, so much work to do, that they have no time to write and publish accounts of all the trials and experiments upon novel plans and new apparatus which they make, especially when their results are not entirely successful. Consequently

38 Tel. Jour. June 1874

It is stated that in consequence of the great success of the duplex system of telegraphing, by which messages are transmitted through a wire in opposite directions at the same time, and by which a considerable reduction has been made in the manual labour of working, the Post Office contemplates the immediate reduction of existing charges in a ratio of about 50 per cent, and are making inquiries with the view of carrying the object into effect. The difficulty of obtaining increased office space for additional instruments and additional clerical assistance, certain to be required, seems the only obstacle at present to be considered.—*Court Journal.*

203

...ll find the Queensland Government officials at the ...er place ready to receive it and connect their land ...s.

...n official memorandum, dated July 27, from the ...tern Telegraph Company (Limited) states: "This ...ompany's direct cable to Lisbon is repaired, thus restoring submarine telegraphic communication with Portugal, Gibraltar, Malta, Egypt, India and the far East."

The Eastern Telegraph Company have notified that their Vigo-Lisbon cable, which was interrupted by the steamship Chimborazo last week off the river Tagus, is now repaired, so that the whole of the company's lines are in perfect working order.

The Western and Brazilian Telegraph Company (Limited) have received intimation that the land lines connecting Rio Grande do Sul with Montevideo will be open for traffic about the 30th inst. Through telegraphic communication will be thus effected between Europe, the River Plate and the west coast of South America. The anticipated delay to through messages for Montevideo, Chili, etc., occasioned by the loss of the steamship Gomas with the Rio Grande do Sul and Chuy cable will thus be obviated.

A new cable between Shetland and Orkney has been successfully laid by the steamer Caroline.

A news report from Kingston, Jamaica, of the 10th inst., states that the submarine telegraph cable between Cayenne and Demerara will not be completed before October. The cable steamship Hooper will return to London for an additional supply of cable to duplicate the line between Demerara and Jamaica.

The Telegraph in Japan.

In a brief account of the progress of the telegraph in Japan, printed in The Telegrapher of May 30th last, it was stated that Mr. Thomas J. Larkin was the superintendent of telegraphs in that country. This was not exactly correct, as his actual position is that of assistant superintendent of telegraphs (of which class of officials there are five), with headquarters at Kobe. The position of superintendent-in-chief of Government telegraphs in Japan has been conferred upon Mr. E. Gilbert, of Glasgow, Scotland, telegraph engineer to the North British Railway Company. Mr. Gilbert, who is a practical telegrapher, is also known as the inventor of a system of electrical communication in trains, and other electrical inventions.

The Government telegraph lines of Japan extend or are being extended from Tokei to the north of the island of Niphon, and will shortly be connected by a cable with Hakodadi, in the island of Yesso.

It was also erroneously stated in the paragraph referred to that the galvanized iron wire used was made in Japan, which is not the fact, it being imported.

Before the present telegraph staff was engaged for the Japanese lines (in 1871), Mr. Gilbert, a nephew of the gentleman who has now been appointed Superintendent-in-chief, was employed by the Government, and built the first telegraph in that country connecting Yokohama with Tokei, and Kobe with Osaka.

The Duplex System on Long Submarine Telegraph Cables.

In The Telegrapher of July 18th was reprinted from *The Telegraphic Journal* the substance of a letter from Mr. C. V. De Sauty, claiming to have succeeded, after fourteen months of experiment, in solving successfully the problem of applying the duplex system to the working of long submarine telegraph cables. In the number of *The Telegraphic Journal* for August 1st, Mr. B. Smith, of the Eastern Telegraph Company, under date of Malta, July 10th, contests the impression conveyed by Mr. De Sauty's letter of priority in successfully applying the duplex to such cables. He says:

"Mr. De Sauty is to be congratulated on his success after so long a period as fourteen months of experiment. Permit me, however, to point out that Mr. De Sauty's is not the first solution of the problem of submarine 'duplex' telegraphy, as applied to long cables, as would seem to be claimed by his letter.

On my arrival at this station in June, of last year, I found Mr. De Sauty here experimenting on the matter. The instruments used at both ends were Thomson's 'recorders,' and Mr. De Sauty found, on charging and discharging the line, that a sudden jerk of the syphon took place at the home end, which he called the 'kick.' All his attempts to neutralize this having failed, on the 9th of July he returned to Gibraltar, expressing his fear that this difficulty would prove fatal to the success of the system.

After Mr. De Sauty's departure I selected one of the Company's Alexandria cables on which to experiment, as, having duplicate cables, the traffic would be less

T J. June 1874

A New Duplex Telegraph.

Mr. E. C. Cracknell, at a recent meeting of the Royal Society of New South Wales, read a paper on the "Duplex Telegraphic Instrument." His remarks were listened to with great interest. After sketching the origin and progress of duplex telegraphy, from its first trial by Dr. Gintl, the Director General of Telegraphs in Austria, on a line from Vienna to Prague, in 1853; and briefly describing the devices of Frischen, Siemens, Halske, Stearns and others, he said:

"The arrangement before you this evening is perhaps the most simple duplex working apparatus yet devised. The two instruments are the ordinary Morse recorders, with relays, in every day use on the lines in this colony. The relays are wound with one continuous wire, and the only additions are the two vertical water columns for producing the necessary artificial resistance for dividing the currents, the actual line resistance being equal to 150 miles of wire. With this plan only one battery is employed for the line circuit, which is continuous, that is, in one direction, and the adjustment requires very little attention. It must not be understood that two distinct currents of electricity pass in opposite directions through one line of wire at the same time; but the problem has been solved by increasing the amount of current on the main circuit when signals are sent simultaneously. Although duplex telegraphy may now be considered beyond a doubt as to its practicability, we are not likely to remain satisfied with its success for any lengthened period. Mr. Meyar's ingenious invention of the multiplex telegraph, exhibited in the late Vienna Exhibition, bids fair to eclipse all the telegraph instruments now in use for rapidity of signaling through one wire. This instrument has already been tried between Paris and Lyons, with four transmitters on one line, and 100 to 120 messages of average length are sent through per hour"

Award of the Great American Medal of Honour for the Invention of the Duplex Telegraph.—The *Telegrapher* says: "We recently had the pleasure of inspecting the Great Medal of Honour awarded by the American Institute to Mr. J. B. Stearns, the inventor of the Duplex Telegraph. The medal is made of gold, and is beautifully executed. On the obverse, or face of the medal, are representations of the following objects in relief: The Goddess of Liberty, holding a laurel crown in her right hand, and a staff, surmounted by a liberty cap, in her left; the United States Coat of Arms, a spinning wheel, ship under sail, sheaf of wheat, shuttle, horn of plenty, plough, and the Caduceus or Mercury's rod, the symbol of good conduct, peace, and power. The rod, representing power; the serpents, wisdom; and the two wings, diligence and activity. The reverse of the medal is surrounded by a wreath of oak and laurel leaves, enclosing the following inscription: The Great Medal of Honour, awarded to J. B. Stearns for Duplex Telegraph, 1872. The honour conferred by this award, so justly bestowed upon Mr. Stearns by the Great American Institute, which occupies so pre-eminently high a position in the metropolis of the Western World, is greatly enhanced by the fact, that only one Great Medal of Honour is awarded by the American Institute during any one year, and none unless for an invention of paramount importance." Mr. Stearns, to whom America is indebted for her duplex system, is now in Europe, where we hope his great services to telegraphy will be as fully and unequivocably recognised as they have been in his native land.

Tel Journal Oct 73

39

Scientific American, Vol. xxix., No. 13.

The Multiplex Telegraph.—On page 64 of our current volume, we called attention to an article in a contemporary, describing a French invention by which four operators can, it is asserted, each work a telegraphic communication over a single wire in one direction simultaneously; and not only this, but four others can operate at the same time in the other direction. A correspondent, J. T., writes to inform us (*The Scientific American*), that the honour of this invention belongs to the United States, and that the original and only inventor of the system by which more than two telegraphic instruments can be worked at the same time over one wire is Mr. Merritt Gally, of Rochester, N.Y., the inventor of the "Universal" printing machine. Mr. Gally's telegraph improvement has been patented in the United States and in some European countries. Our correspondent states as follows:—"By the use of Mr. Gally's invention a large number of operators at different stations along a single wire can be simultaneously employed sending different messages in either or both directions without conflict, each accomplishing as much or more work than would be possible

for him to do by the use of the Morse key. Mr. Gally has adapted his system to each and every kind of receiver or register. The operator can receive his letter in print or by sound, or both simultaneously; or by the embossing, marking, or the electro-chemical recorder; and his instruments are so simple and accurate in their manipulation that it seems impossible that a mistake could occur in their operations. No time whatever is wasted in adjusting the instruments. They are always in readiness, and the first stroke of the operator sends the first letter of his message. Each touch of the key-board represents a letter or other signal complete. The operator may be sending a message to a distant station, be receiving another from an intermediate or more distant station, and through a third part of his instrument be in active communication with every office on the line, receiving or sending calls or explanations; while on the same wire numerous other operators, all along the line, may be similarly employed. By using the electro-chemical recorder, on Mr. Gally's system, at least sixty operators may be simultaneously employed upon a single wire sending messages to any destination along the line; thus entirely doing away with the necessity of previously preparing the messages in punched slips of paper, as is done for the automatic machine." *The Scientific American* hopes soon to publish full particulars and illustrations of this last addition to and improvement in telegraphic apparatus, the capabilities of which multiply with astounding rapidity.

Lecture Experiments in Electricity.—An extract from a series of papers, entitled, "The Magic Lantern as a Means of Demonstration," by Professor H. Morton, Ph.D.—If a piece of thick platinum or tin wire is bent into a hoop circling the interior of one of the glass tanks above mentioned, and the tank itself is filled with a strong solution of bichloride of tin, then, on inserting another wire at the centre of the solution and connecting with a series of two or three Grove's elements, so as to make the centre wire the negative and the hoop the positive pole, a beautiful growth of metallic crystals will shoot out from the centre, and spread over the entire surface of the field. A similar experiment may, of course, be performed with a vertical tank, but the unsupported weight of the metallic blades then soon breaks them down. In this arrangement, however, they are supported perfectly, resting, in fact, on the bottom of the tank, as the solution should not be more than an eighth of an inch deep. If a small compass-needle be mounted on a pointed support, like an inverted tack or drawing pin, its motions are, of course, vastly amplified in the huge image projected on the screen, and may thus be utilised in a number of ways which are too evident to need mention and too numerous to admit of it. If, moreover, a piece of covered copper wire is bent into a flat rectangle and placed beside the needle, with its ends, of course, in binding screws or mercury cups, it will form a galvanometer quite delicate enough for all ordinary use. It will indeed show the induced current developed by introducing a magnet into and withdrawing it from a helix. This, of course, opens a wide field of illustration. A more complete apparatus for use as a lantern galvanometer has been described and used by Professor A. M. Mayer, of the Stevens Institute of Technology, with great success, but as it involves several modifications in the constructive detail of the instrument, we must refer the reader to the Professor's original description. (See *American Journal of Science*, 1872, vol. iii., p. 414; *Journal of the Franklin Institute*, 1872, vol. lxiii., p. 421; and "The Earth a Great Magnet," Chatfield and Co.) Another arrangement, superior to this for many purposes, and not requiring a vertical lantern, has since been devised by Professor Mayer, and will be found described in *American Journal of Science and Arts*, 1873, vol. v., p. 270.

City and Commercial Notes.

Messrs. Grant Brothers, as bankers and agents of the River Plate and Brazil Telegraph Company, are now offering for subscription £91,000 share capital of this company, in 4550 shares of £20 each, to be issued at par, being the balance of £391,000, the capital required for the completion and working of the whole of the land and submarine cables undertaken by the company. By the statutes of the company, the authorised share capital amounts to £600,000, but advantageous arrangements have been entered into by which the total requisite expenditure will be limited to the amount mentioned above, and, of this, £300,000 has already been subscribed. An exclusive privilege has been granted by the Imperial Government of Brazil for a period of forty years, by the terms of which, power is reserved to the Government to purchase the cables at any period after the expiration of ten years, upon the advantageous terms of paying for the same on the basis of the amount of the earnings of the five previous years; the cable reverting to the Government at the expiration of the terms of the concession; and a reserve fund of 10 per cent of the earnings will be created with a view of providing for the repayment of that portion of the capital represented by the cables. Messrs. Siemens Brothers have already manufactured upwards of 700 miles of the cables, leaving only about 430 miles to be completed. The specifications of the cables have been prepared by Sir William Thomson, F.R.S., and Professor Fleeming Jenkin, F.R.S. The Montevidean Government have granted a concession authorising the construction and working of a network of land lines throughout Montevideo. The construction of the land lines has been entrusted to Messrs. Lamas and Co. The calls on the £20 shares now offered will be payable as follows—viz.: £1 on application, £4 on allotment, and £5 on the 1st of December, January, and February next, interest at the rate of 6 per cent being allowed up to the 15th April next, by which time it is anticipated that the whole of the cables will be duly laid, and cable communication established from the states of the River Plate to Rio de Janeiro, Bahia, Pernambuco, and Para, and dividend will then accrue. It is calculated that the amount of British capital alone invested in River Plate and Brazilian securities and enterprises is between 50 and 100 millions sterling. It is evident that a more rapid means of communication is demanded; when the entire system of telegraph to Europe is complete, communication will be reduced from over forty days to a few hours.

The Eastern Telegraph Company's traffic receipts for the month of September, 1873, amounted to £33,162, and to £29,303 in the corresponding period of 1872.

The Eastern Extension, &c., Telegraph Company's traffic receipts for the month of September, 1873, amounted to £19,128.

The Eastern Extension, &c., Telegraph Company have declared an interim dividend for the quarter ending the 30th June, at the rate of 6 per cent per annum, or 3s. per share, free of income-tax, payable this day.

A memorandum from the Secretary of the Globe Telegraph and Trust Company, Limited, says:—"I am instructed to state that interim dividends of 1½ per cent, or 3s. per share, upon the fully paid preference and ordinary shares of this company for the quarter ending 18th October current, and on the preference and ordinary shares not fully paid, at the rate of 6 per cent per annum on the amounts paid up from the respective dates of the payments, to the same date, will be paid on the 18th inst. The transfer books will be closed from the 15th to the 19th inst."

Quadruplex telegraphy has been successfully introduced in America by Messrs. Prescott and Edison, and a large supply of apparatus is being manufactured by the Western Union Telegraph Company. Tel Journal Jan 1875

Quadruplex telegraphy has very recently been accomplished on the Madras Railway Telegraph. The system which Mr. G. K. Winter, the telegraph engineer, invented in March last proved perfectly successful on 80 miles of line, and its extension to lines of greater length is simply a question of additional condensers and battery power. The principle of sending two messages simultaneously in the same direction, on which this quadruple system depends, was successfully worked between Salem and Madras on April 16th last, but unfortunately other duties prevented Mr. Winter carrying out the duplexing of this principle until very recently. His exertions have

THE OPERATOR,

THE ORGAN OF THE AMERICAN AND CANADIAN TELEGRAPH OPERATORS AND JOURNAL OF SCIENTIFIC TELEGRAPHY.

The Publishers, in announcing the Fourth Volume of THE OPERATOR, which commences with the number for Sept. 1, 1875, de ire to return thanks for the liberal support which it has hitherto received, which it is expected and believed will be continued during the ensuing year.

All the popular and valuable features of the paper will be retained, and it will continue as heretofore to labor for the best interests of the Telegraphic Fraternity, and the advancement of Electrical Science and the Telegraphic Art.

As heretofore, no labo , time or expense, warranted by the patronage received, will be spared to improve its character and add to its interest, and to sustain its reputation as the only first-class Electrical and Telegraphic Journal upon the American Continent.

On Quadruplex Telegraphy.

As furnished by George B. Prescott, Electrician W. U. T. Co.

The simultaneous transmission of two telegrahic communications in opposite directions upon the same wire, now known the name of duplex telegraphy, dates back to the year 1853. The first to conceive of its possibility as well as the first to carry the conception into practical effect, was Dr. Wilhelm Gintl, Director of State Telegraphs in Vienna, Austria He describes his method in a paper read by him before the Vienna Academy of Sciences on the 9th of June, 1853, and in July of the same year it was put in practical operation between Prague and Vienna.

In March of the following year Carl Frischen, a telegraphic engineer of Hanover, Germany, improved upon Gintl's plan, by making u-e of a branch current from the main battery for compensating the effect of the outgoing current upon the home relay, instead of a local current employed by Gintl. This is unquestionably the most important improvement which has been made in duplex telegraphy from the time of its original invention by Gintl down to the time of the addition of the condenser by Stearns, in 1872.

Frischen used a diffe ent relay having helices composed of two equal parts and opposing wires, and an artificial or rheostat equal in resistance to the main line, substantially as they are used at this day. His first practical experiment was made between Hanver and Gotting on the 26th of May, 1855.

The labors of Frischen, and of Siemens and Halske, of Berlin, who during the same year, independently but subsequently worked out a method almost precisely similar to Frischen's, brought the system of simultaneous transmission in opposite directions to a state of perfection which answered a very good purpose upon the comparatively short lines, and at the slow rate of transmission in vogue at that day.

The success of these ingenious inventions gave an entirely new direction to the minds of the host of enterprising electricians on the continent of Europe, and during the following year, 1855, the problem of simultaneous transmission in the same direction which naturally suggested itself as the next step in the progress of invention, was solved with more or less success by the independent labors of Dr. J. B. Stark, of Vienna, Dr. Werner Siemens, Dr. August, Kramer and A. Bernstein, of Berlin, and Dr. J. Bosscha, Jr., of Leyden; each of these inventors having published a full account of his method in the latter part of 1856 and the early part of 1856. At least two of them, Stark and Bosscha, clearly saw that the successful solution of the difficult problem of simultaneous transmission in the same direction included, as a necessary consequence, the solution of the problem of quadruple transmission also; for a knowledge of the invention of Gintl, as perfected by Frischen, was all that was needed to show that it was equally applicable either to a single or double telegraph in one direction. In the first published description of his method, dated at Vienna, October 31, 1855, Stark concludes as follows:

"With the method of double transmission in the same direction we may also combine that of counter transmission (gegensprechen), and hence arises the possibility of simultaneously exchanging four messages upon one wire between two stations which will, however, hardly find any application in practice."*

This is unquestionably the earliest published suggestion of what is now known as the quadruplex system.

Dr. Bosscha, in a description of his system read before the Royal Academy of Sciences of Holland, on the 27th of October, 1804, and published in their transactions, Vol. IV, p. 101, not only makes the same suggestion, but sets forth in detail a method of accomplishing the result. Having described his method of double transmission in the same direction, he says: "Now, if we wind each of the receiving relays with two wires, and divide the current at the sending station, according to the plan of Siemens and Halske (Frischen), through the two coils of the home relay in opposite directions, then it becomes practicable for both stations to transmit at the same moment, without their own relays being affected by their own transmitted currents, and it is possible to send four signals simultaneously through one wire. This solves the problem in its largest generality."

Thus Stark and Bosscha, as early as 1855, both recognized the indisputable fact that the production of a successful method of quadruplex transmission depended solely upon the successful solution of the problem of double transmission in the same direction. If this could be accomplished, it becomes a mere matter of mechanical detail to combine with it Frischen's or any other system of counter transmission.

It has been stated that methods of double transmission in the same direction were worked out independently, but almost coincidently, by a number of inventor during the year 1855. The ingenious and active German electricians, recognizing that the accomplishment of this result was the key to simultaneous quadruplex transmission, had diligently labored at the problem. Let us now consider the result of their labors.

In any system of simultaneous double transmission in the same direction two keys are required at the sending station, and at least four different electrical conditions of the line must be provided for, one for each of the four following cases:

1. When the first key is closed and the second key open.
2. When the second key is closed and the first key open.
3. When both keys are closed.
4. When both keys are open.

The method's of Stark, Siemens and Bernstein (No. 1), though varying in detail, were arranged upon one general principle, the four electrical conditions of the line being as follows:

1. A positive current having a strength of 1.
2. A positive current having a strength of 2.
3. A positive current having a strength of 3.
4. No current.

The methods of Bernstein (No. 2), Bosscha and Kramer, and at a later date those of Schreder (1860), and Maron (1862), were arranged upon another and better principle, as follows:

1. A positive current having a strength of 1.
2. A negative current having a strength of 1.
3. A positive (or negative) current having a strength of 2.
4. No current.

There are two serious difficulties, leaving minor ones out of consideration, which are inherent in every system of simultaneous double transmission in the same direction. In the first place, when either key is passing from its front to its rear contact, it causes a momentary interruption of the signal which is at the same time being transmitted by the other key.

Neither Stark nor Siemens suggested any means of overcoming this difficulty. Bosscha and Kramer made use of a device originally invented by Gintl, viz., that of keeping the battery constantly in the main circuit, but shunted by the key, so that when the latter was depressed the short circuit was broken and the current flowed to line, but when raised the battery was again short circuited. This plan effectually disposed of the difficulty in question, but was injurious in its effect upon the batteries. Bernstein, however, hit upon the method now in use, that of providing each of his keys with a spring so arranged as to close the front contact at or before the time of interrupting the rear contact. This difficulty was, therefore, effectually removed as early as 1855. The second difficulty is a still more serious one, and arises in the following manner: In the simultaneous operation of the apparatus there must, of necessity, frequently be a change from a positive to a negative condition, or *vice versa*, of the line, and of the relays or receiving instruments, consequent upon the movement of a single key; yet it is evident that the reversal of the magnetic polarity of a receiving instrument by the action of one key must interfere with a signal which is being given upon it at the same time by the action of the other key. This difficulty is met with, in some form, in every arrangement of the receiving instruments. Stark employed three neutral relays, adjusted to varying degrees of sensitiveness, in one arrangement, and two polarized and one neutral relay in another, as did also Bosscha and Kramer. Bernstein used a single relay with three armatures, of varying adjustment. Neither Stark nor Siemens suggested any method of remedying this defect, and, judging from his published paper on the subject, the latter evidently considered it an insurmountable one. Bosscha, Bernstein and Kramer, by making use of different modifications of the same principle —that of operating the recording instrument or sounder by the opening of a shunt circuit as the first and last had already done with the main batteries, and by working from the rear instead of the front contact of the receiving relay—theoretically succeeded in surmounting this obstacle. Practically, however, the method of operating a register or sounder by closing and breaking a shunt is a very unsatisfactory one. It not only exhausts the local battery with great rapidity, but the demagnetization of the iron cores takes place with far less rapidity when the battery is cut off by a shunt, even of very small resistance, than when it is completely interrupted by breaking the circuit in the usual way, and this renders it impossible to receive and record the telegraphic signals with the rapidity that is necessary in modern telegraphy.

When these methods came to be tried on lines of a length exceeding 100 or 150 miles, the interference of the static discharges was superadded to the already existing difficulties, and for these reasons the results were, on the whole, so unsatisfactory that the subject remained in abeyance for many years. The subsequent labors of Schreder, Wartmann, Maron, Schank and Zetshe, between 1855 and 1865, though exhibiting great ingenuity and research, added little or nothing of practical value to what had already been done by the earlier inventors in the same field.

The revival of the duplex system in America, and

*Brix's Journal, II, 224.

*Brix's Journal, II, 185.

See page 42

48

Oct. 75

Electro-Harmonic System of Multiple Transmission.

During the past two weeks, Mr. Elisha Gray of Chicago, Ill., has been exhibiting his electro-harmonic apparatus in the Western Union Building, in this city. More than a year since we published an article descriptive of this curious discovery, so far as it had been developed at that time. Since then Mr. Gray has devoted the greater part of his time to the perfection of the apparatus, and has already succeeded in producing some very remarkable results. Mr. Gray's earlier experiments disclosed the fact that composite tones were as easily transmitted over a wire as single notes, and from this discovery he developed a system of multiple transmission, founded on this principle. The apparatus was tested experimentally on a wire between Boston and New York, on September 11, with very satisfactory results. Four separate communications were simultaneously transmitted from Boston, and copied from four sounders by a like number of receiving operators in New York. In the main the signals were perfectly received on all the instruments, the only apparent defect being a tendency to shorten them somewhat, a difficulty which can doubtless be overcome by a suitable modification of the transmitting apparatus.

The principle of the apparatus is a very simple one. The depression of each key sets a self-vibrating electrotome in operation, which is adjusted or tuned to vibrate at a certain rate, differing from that of any of the others, when under the influence of the electro-magnet controlled by its corresponding key. These several sets of electrical vibrations are transmitted through the circuit without interfering with each other, in the same manner that almost any number of different sets of sound waves may pass through the air without mingling. At the receiving station, each instrument is so adjusted as to respond to its own special sets of waves or vibrations without regard to others. By breaking and closing the circuit upon the transmitting electrotome, so as to form telegraphic signals, these are transmitted and taken up by the corresponding receiving apparatus.

It is not easy to fix a limit to the number of different communications that may be carried on over the same wire simultaneously, either in the same or opposite directions. The marked success which attended the operation of the principle through two hundred and forty miles of line, on September 11, seems to promise results in the future of the greatest value.—*Journal of the Telegraph.*

The Harmonic-Electric Telegraph.

The harmonic-electric telegraph invention (now commonly known as the telephone) of Mr. Elisha Gray, of Cleveland, is undoubtedly destined to prove a very useful and important one. On Friday of last week we saw four despatches transmitted simultaneously from Boston to this city, on one of the Western Union wires. It is believed, and with good reason, that at least sixteen messages can by this invention be transmitted simultaneously over a single wire. Mr. Gray has made a discovery and invention which will be likely eventually to revolutionize the present Morse telegraph system.—*The Telegrapher.*

its extensive introduction into practical use, both in this country and in Europe, resulting from the improvements of Joseph B. Stearns—notably his method of compensating the effects of the static discharge from the line by the application of the condenser, which was made known in the winter of 1871-2—once more turned the attention of electricians to the problem of simultaneous transmission in the same direction.

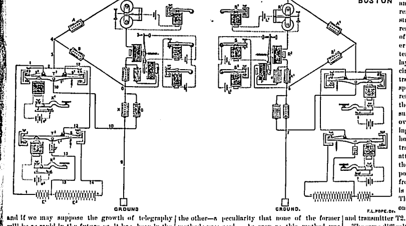
In a paper published in the *Philosophical Magazine* of June, 1873, Oliver Heaviside, of Newcastle-on-Tyne, England, pointed out, as Stark and Bosscha had done before him, that the invention of a system of simultaneous transmission in the same direction furnished at the same time the solution of the problem of quadruple transmission. He says: "It is theoretically possible to send any number of messages whatever simultaneously and in the same direction upon a single wire. Now, by combination with a null duplex system it becomes obviously possible to send any number of messages in the other direction while the opposite correspondences are going on, and without interference Thus the working capacities of telegraphic circuits may be increased indefinitely by suitable arrangements. * * * From experiments I have made I find it is not at all a difficult matter to carry on four correspondences at the same time—namely, two in each direction, and if we may suppose the growth of telegraphy will be as rapid in the future as it has been in the past, it seems not improbable that multi telegraphy will become an established fact."

During the summer of 1874, T. A Edison, of Newark, N.J., while engaged in conjunction with George B. Prescott, electrician of the Western Union Telegraph Company at New York, in experimenting upon Stearns's duplex apparatus, with a view of introducing certain modifications and improvements therein, devised a system of simultaneous transmission in the same direction which differed materially in principle from any of its predecessors, and which was destined to furnish the basis of the first practical solution of the curious and interesting problem of quadruplex telegraphy.

The distinguishing principle of this method consists in combining together two distinct and unlike methods of single transmission in such a manner that they may be carried on independently upon the same wire, and at the same time, without interfering with each other. One of these methods of single transmission is used principally in England, where it is known as the double current system, and the other is the single current or open circuit system, used on the continent of Europe. In the double current system the battery remains constantly in connection with the line at the sending station, its polarity being completely reversed at the beginning and at the end of every signal without breaking the circuit. The receiving relay is provided with a polarized or permanently magnetic armature, but has no adjusting spring, and its action depends solely upon the reversals of polarity upon the line, without reference to the strength of the current. In the single current system, on the other hand, the transmission is effected by closing and breaking, or increasing and decreasing the current, while the relay has a neutral or soft iron armature, provided with a retracting spring. In this system the action depends solely upon the strength of the current, its polarity being altogether a matter of indifference.

It will therefore be apparent that, by making use of these two distinct qualities of the current, viz., polarity and strength, two sets of instruments may be operated at same time on the same wire. This method possesses, moreover, the important practical advantage that the action of each of the two receiving relays is perfectly independent. Each receiving operator controls his own relay, and can adjust it to suit himself without interferring with the other—a peculiarity that none of the former methods possessed. As soon as this method was practically worked out, it became at once obvious that any of the different methods of simultaneous transmission in opposite directions already in use might be applied to it, as Stark, Bosscha, and others had long ago pointed out, the result of which would be a practical system of quadruplex transmission. This was shortly afterwards done upon the lines of the Western Union Telegraph Company between New York and Boston, a distance of 240 miles, and both the bridge and the differential system of duplex working were tried in combination with it with excellent results. When, however, the apparatus was experimentally tested on a circuit of about 450 miles, the effects of static induction became very strongly marked, and it was found that these could be more conveniently compensated in the bridge than in the differential system. The former was, therefore, decided upon as being better suited to the usually existing conditions than the latter.

The diagram shows the quadruplex apparatus as arranged upon the bridge plan.



T1 is a double current transmitter or pole-changer, operated by an electro-magnet, local battery e1, and finger key K1, in a manner well understood. The office of the transmitter T1, is simply to interchange the poles of the main battery E1 with respect to the line and ground wires, whenever the key K1 is depressed; or, in other words, to reverse the polarity of the current upon the line by reversing the poles of battery E1. By the use of properly arranged spring contacts, s1 s2, this is done without at any time interrupting the circuit. Thus the movement of the transmitter T1 cannot alter the strength of the current sent out to the line, but only its polarity or direction. The second transmitter T2 is operated by a local circuit, and the key K2 in the same manner. It is connected with the battery wire 12 of the transmitter T1 in such a way that when the key K2 is depressed the battery E1 is enlarged by the addition of a second battery E2, of two or three times the number of cells, by means of which it is enabled to send a current to the line of three or four times the original stength, but the polarity of the current with respect to the line of course still remains as before under control of the first transmitter T1.

At the other end of the line are the two receiving instruments R1 and R2. R1 is a polarized relay with a permanently magnetic armature, which is deflected in one direction by positive and in the other by negative currents, without reference to their strength. This relay consequently responds solely to the movements of key K1, and operates the sounder S1 by a local circuit from battery L1 in the usual manner. Relay R2 is placed in the same main circuit, and is provided with a neutral or soft iron armature, and responds with equal readiness to currents of either polarity, provided they are strong enough to induce sufficient magnetism in its cores to overcome the tension of the opposing armature spring. The latter, however, is so adjusted that its retractile force exceeds the magnetic attraction induced by the current of the battery E1, but is easily overpowered by that of the current from E1 and E2 combined, which is three or four times as great. Therefore the relay R2 responds only to the movements of key K2 and transmitter T2.

The same difficulty which had baffled former inventors arises, however, in this connection. When the polarity of the current upon the line is reversed, during the time in which the armature of R2 is attracted to its poles, the armature will fall off for an instant, owing to the cessation of all attractive force at the instant when the change of polarity is actually taking place, and this would confuse the signals by false breaks if the sounder were connected in the ordinary way. By the arrangement shown in the figure, the armature of the relay R2 makes contact on its back stop, and a second local battery, L2, operates the receiving sounder S2. Thus it will be understood that when relay R2 attracts its armature, the local circuit of sounder S2 will be closed by the back contact of local relay S; but if the armature of R2 falls off it must reach its back contact and remain there long enough to comlete the circuit through the local relay S, and operate it before the sounder S2 will be affected. But the interval of no magnetism in the relay R2, at the change of polarity, is too brief to permit its armature to remain on

The Quadruplex Controversy.

WASHINGTON, April 18, 1875.

The Edison quadruplex telegraph controversy has assumed a new phase. Mr. Edison originally assigned an interest in his invention to George B. Prescott, and a joint application was made for a patent. Mr. Prescott agreed to assign to the Western Union Telegraph Company his interest in the patent, but the Automatic Telegraph Company claimed the whole benefit of the invention through a contract with Mr. Edison. An application was made to the Secretary of the Interior to induce him to overrule the decision of the Commissioner of Patents, and to make Mr. Edison the sole patentee. The appeal was made by George Harrington, who also claims to be Mr. Edison's assignee. His counsel, W. E. Chandler and J. H. B. Latrobe, contended on Friday that the Secretary had jurisdiction in this case. Gen. Butler, counsel for Mr. Edison, insisted that the patent should issue to his client alone on the ground that, whatever may have been his arrangement with Mr. Prescott, it was in the nature of a partnership, which had been dissolved by the withdrawal of Edison without having received a dollar from Mr. Prescott for any interest in it. The patent should not be granted to Messrs Edison and Prescott conjointly, as the Commissioner of Patents recently ordered, but that it should be issued to Edison, leaving any equities which might be claimed to exist by virtue of assignments to be adjudicated by the courts. Senator Conkling replied at once, raising the question of the Secretary of the Interior's jurisdiction over the matter. He contended that the decisions of the Commissioner of Patents are absolutely final as to all purely executive questions. He denied that the Secretary of the Interior had any jurisdiction whatever over any question relating to patents.

Gen. Butler and Leonard Meyers replied by citing decisions of the Supreme Court and the usage of the Patent Office respecting the natere of assignments. Secretary Delano in postponing his decision, said: "I recognize the fact that to the Commission is intrusted in the first instance, the duty of examining and deciding upon all questions that arise before him in his office, and are presented to him; but I am unable to bring my mind to the conclusion that it would be my duty to sign a patent, because in his best judgment he had directed it to be issued, if *I*, on the evidence in the case as presented to me, should be of the opinion that his conclusions were clearly and distinctly erroneous." In conclusion, Secretary Delano informed the counsel that he would allow fifteen days for the preparation of printed arguments on the merits of the case on the record, after which ten days further time would be allowed for counsel to file replies to briefs.—*N. Y. Tribune.*

from page 41.

its back contact long enough to affect the local relay S, and through the agency of this ingenious device the signals from K2 are properly responded to by the movements of sounder S2.

By placing the two receiving instruments R and R1 in the bridge wire of a "Wheatstone balance," according to Stearn's patent of Nov. 12, 1872, and duplicating the entire apparatus at each end of the line, the currents transmitted from either station do not affect the receiving instruments at that station. Thus in figure 1 the keys K1 and K2 are supposed to be at New York, and their movements are responded to only by the receiving relays R1 and R2 at Boston. The duplicate parts which are not lettered operate in precisely the same manner, but in the opposite direction with respect to the line.

In applying this system of quadruplex transmission upon lines of considerable length, it was found that the interval of no magnetism in the receiving relay R2 (which, as above stated, takes place at every reversal in the polarity of the line current), was greatly lengthened by the action of the static discharge from the line, so that the contrivance of the local relay S was not sufficient to overcome the difficulties arising therefrom. A rheostat or resistance, X1, was therefore placed in the bridge wire with the receiving instruments, R1 and R2, and shunted with a condenser *c*, of considerable capacity. Between the lower plate of the condenser and the junction of the bridge and earth-wire an additional electro magnet, *r*, was placed, acting upon the armature lever of the relay R2, and in the same sense. The effect of this arrangement is, that when the current of one polarity ceases the condenser c immediately discharges through the magnet *r*, which acts upon the armature lever of relay R2, and retains it in position for a brief time before the current of the opposite polarity arrives, and thus serves to bridge over the interval of no magnetism between the currents of opposite polarity.

It will be seen that the combination of transmitted currents in this method differs materially from any of those used in previous inventions. They are as follows:

1. When the first key is closed and the second open.......................... −1
2. When the second key is closed and the first open.................. +3 or +4
3. When both keys are closed.... −3 or −4
4. When both keys are open.............. +1

Here we discover another very important practical advantage in the system under consideration, which is due to the fact that the difference or working margin between the strength of current required to produce signals upon the polarized relay and upon the neutral relay respectively may be increased to any extent which circumstances render desirable. Within certain limits, the greater this difference the better the practical results, for the reason that the range of adjustment of the neutral relay increases directly in proportion to the margin. The ratio of the respective currents has been gradually increased from 1 to 2 to as high as 1 to 4, with a corresponding improvement in the practical operation of the apparatus.

over

From what has been said, therefore, it will be seen that before it became possible to produce a quadruplex apparatus capable of being worked at a commercial rate of speed upon long lines, it was essential that its component parts should have arrived at a certain stage of development. When in the early part of 1872 simultaneous transmission in opposite directions was for the first time rendered practicable upon long lines by the combination therewith of the condenser, the first step was accomplished. It now only remained to invent an equally successful method of simultaneous transmission in the same direction, which, as we have seen, was done in 1874.

administer to the wants of the public. The whole operating department can be seen on entering the Broadway door. The ladies department is at the Broadway end of the room and the switch is at the extreme west. Mr. S. H. Edwards presides at this handsome piece of mechanism. It contains 60 wires and is capable of hold two or three hundred loops. It was designed by President Eckert and manufactured by L. G. Tillotson & Co., of this city, who completed it in six days from the date of the order. The office contains fourteen quartette tables, eleven perforating instruments and eight automatic transmitters which are used only to the prominent points. There are about seventy employees in this department, sixteen of whom are ladies. All of the male employees are required to wear single breasted blue coats while on duty. Those of the managers and chiefs are double breasted that their rank may be readily distinguished. The neatness of the men is in keeping with the fitting of the room, and together they present a very pleasant appearance. The room is well ventilated making it a fine healthy office. On the whole the office is what has long [illegible]

QUADRUPLEX TELEGRAPHY.

"We are not aware," says the editor of the London *Telegraphic Journal*, "that a quadruplex circuit exists in England at present, although we are assured that since 1874 quadruplex telegraphy has been an established fact in America, and that its employment there has been eminently successful. Statistics are nevertheless wanting to establish its practical value."

* * "We seem to be still as much in the dark as ever to the real advantages of quadruplex telegraphy. Without entering at all minutely into the system, it is sufficient to state that the difficulties inherent to the adoption of quadruplex telegraphy are greater than at first sight would be imagined."

* * "Working a quadruplex system—that is, four circuits upon one wire—to meet the requirements of busy centers of commerce, looks very much like intrusting too many of the eggs to one basket, and in the event of interruptions could not fail to be attended with the most serious inconvenience."

June 16/77

For the information of our valued British cotemporary, we would state, by way of statistics, that the Western Union Telegraph Company is now regularly operating, daily, by the quadruplex system, about twenty thousand miles of its wires. The lines between New York and all the large cities, as Boston, Philadelphia, Pittsburgh, Chicago, St. Louis, Washington, New Orleans, are worked by the quadruplex plan.

For the illumination of our cotemporary, we would state that the real advantage of quadruplex telegraphy is that it permits the sending of four messages over one wire during the time heretofore required for sending one message by the old method. In other words, as much business may be done over one wire, by the quadruplex, as can be done over four wires by the common plan.

There are no inherent difficulties about the adoption of the new system in England. All that is needed is to send over to New York a postal money order and pay for as many instruments as are wanted, and then set them to work. They will work just as well in London as here.

To stand in the gallery of the great operating room of the Western Union Company, in this city, and gaze upon the multitude of operators there daily at work with the quadruplex instruments, does indeed seem like looking upon a good many eggs in one basket; but we hear of no inconvenience or interruptions therefrom resulting. On the contrary, so great is the regularity and necessity for the new system that the business of the Western Union could not now be transacted except for the quadruplex, the use of which is being rapidly extended. Finally, we suggest to our cotemporary that he make a summer excursion over here and learn something about modern telegraphy. The absence of the quadruplex in England shows conclusively that his countrymen are several telegraphic generations behind the age.

44

DUPLEX TRANSMISSION WITH TWO RELAYS.

July 15 1880 — Telegraphic Journal

By M. KOVACEVIC, Secretary of the Telegraphic Administration at Agram.

The employment of two relays for duplex transmission has for its object the avoidance of the necessity of establishing equilibrium, an indispensable condition with a single relay, and to give the means of obtaining duplex or diplex transmission without other means than those which are required for ordinary simple working.

It is possible to obtain this object in different ways, and the arrangement depends upon the disposition of the batteries, that is to say, whether like or unlike poles are put to earth at the two stations.

I.

Arrangement of Terminal Stations.

Fig. 1 shows the arrangement to effect duplex working in the first of these two cases, that is to say, when the batteries at the two stations have similar poles to earth, and when, consequently, the poles act against one another. The transmitting keys are of the ordinary kind, having their axes connected to the two relays of each station, and the working contacts to the batteries, of equal power, B, and B,, and to earth.

R, and R,, are neutral relays, which can, however, be also polarised relays. The relays, P, and P,,, on the contrary, must necessarily be polarised so that they may be acted upon only by the current coming in through the line, W, and not by a current going out to the same.

The figure shows clearly how communication is established with the local batteries, L, and the Morse writers, M, and M,,, by means of the relays, P, and R,, on the one hand, and the relays, P,, and R,,, on the other. The closing of the local batteries and, consequently, the production of signals on the Morse writers can only take place when the armatures of the polarised relays remain in contact with the screws, u,, and when, on the contrary, the levers of the neutral relays are in communication with the lower screws, v,.

The condition indicated in the figure is the state of repose, during which the batteries, of equal power, B, and B,,, which communicate with earth by their negative poles, send their positive currents out to the line, W, or produce a neutral effect.

The levers of the neutral relays remain free, and rest in contact with the lower screws, v,, whilst the armatures of the polarised relays establish communication with the screws, u,.

In this case, neither of the Morse writers produce signals, the circuit of the local batteries, L, not being closed.

If the station, I, depresses his key, the positive current of the battery, B,, passes through the relay, R,, and returns by the point, a, to the negative pole, by the axis and the working contact of the lever of the depressed key.

The resistance of this latter path of departure by the point, a, which can be formed of short and thick iron wires, being *nil*, it does not produce any bifurcation, and, consequently, it does not allow any of the current of the battery, B,, to pass out to the line, W.

The relay, R,, at the station, I, which sends signals, works when its lever is moved away from the screw, v, and goes over to the screw, v,. The Morse printer, M,, produces then its proper signal, if the armature of the polarised relay, P, remains in contact with the screw, u,, but such is not the case, as will be seen.

By the fact of the introduction of the battery, B,, in the closed local circuit, the battery, B,, of the station, II, is the only one which works to line. Its positive current passes through the two relays, R,, and P,, of the station, II, by the line, W, the polarised relay, P,, of the station, I, from whence it arrives at the point, a, by the lever of the key at the station, I, which has been depressed, and by this means goes to earth. The relay, R,,, comes into action when its lever leaves the screw, v, and makes contact with the screw, v,. On the other hand, the polarised relay, P,,, does not work, for the northern magnetism being increased in the lower coil and increased in the upper coil, the contact of the armature of the relay with the lower screw, u,, is only made stronger.

The local battery, L, has its circuit closed through the medium of the levers of the two relays, P,, and R,,, and thus the Morse writer, M,,, reproduces the signal sent out by the station, I.

The positive current of the battery, B,,, which goes through the polarised relay, P, of the station, I, increases the northern magnetism in the upper coil, whilst it decreases it in the lower coil. The armature of this relay leaves then its contact with the screw, u,, and that before contact is established with the screw, v,, of the relay, R,, when the key is depressed.

The circuit of the local battery, L, of the station, I, remains open, and consequently, the Morse writer, M,, does not reproduce the signals.

The same thing occurs when station II depresses his key whilst the key of station I remains in its normal position. As, in this case, the current of the battery, B,,, is the only one which goes out to line, the relay, R,, comes into action while P, remains inactive. The local battery, L, of the station, I, is then closed, and the Morse writer, M,, reproduces the signal sent out by station II.

When the positive current of the battery, B,, which goes out to line, has broken the contact of the armature of the polarised relay, P,,, with the screw, u,, the circuit of the local battery, L, of the station II becomes open, although the relay, R,,, of that station works by its own current, which finds a closed local circuit from the point, b, through the depressed key.

If the two stations depress their keys, the relays R, and R,, are worked by their own currents introduced in the local closed circuit.

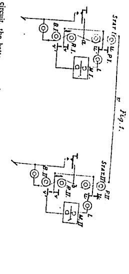
The polarised relays, P, and P,,, not being, at this moment, acted upon by any current, their armatures continue resting against their contact screws, u; and in consequence, the circuits of the local batteries are closed and the Morse writers respond.

If the station, I, allows his key to return to its normal position, his Morse writer continues to work, the levers of the relays, R, and P,, remaining in contact with the screws, v, and u,. On the other hand, the signals sent out by the station, I, cease to be reproduced by the Morse writer, M,,, for the contact of the tongue of the relay, P, with the screw, u, becomes then interrupted by the current of the battery, B,, coming to line, and the circuit of the local battery, L, becomes opened.

If the station, II, also allows his key to come back to its normal position, the effects of the currents from the batteries, B, and B,,, neutralise one another and produce again the state of rest which has been previously referred to, and therefore the station, I, ceases also to reproduce the signals emitted by the corresponding station.

If leakages or changes of resistance occur on the line, the effects of the currents are only to produce partial compensation, and each section of the line

Fig. 1.



The Operator.

The Telegraph Operators' Journal.

Vol. II. | OCTOBER 1, 1874. | No. 3.

DUPLEX—No. II.

There is an extra phenomenon in the electrical duplex which does not occur in the water device. This is electrostatic induction, the effect of which is to destroy the balance of currents in the coils of the differential relay.

In sending a dash, for instance, through the relay to the distant station, the static inductive current is added to that of the battery current, thereby increasing the strength of the first portion of the signal within the main line helice, while the artificial line, being free from these currents, is not thereby increased. Hence the cores of the differential relay will become magnetic by this excess of current, and the lever will be attracted for an instant only, or "kick," as the operators say.

On disconnecting the battery a static current flows from the line in a contrary direction to the first current, and this again produces a movement of the relay lever.

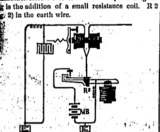
Now, it follows that if we could by any means create a static induction current upon the artificial line, equal to that of the main line, at the moment the battery is connected and disconnected from both circuits, that the two currents would balance each other in the differential relay.

Mr. Stearns was the first to bring about this necessary result, and without which previously devised apparatus were impracticable on lines of ordinary length. Mr. Stearns effected it by adding a condenser to the artificial line.

A condenser consists of a number of sheets of tin foil or other metallic surfaces, connected to the artificial line, and facing an equal number of plates connected to the earth. These plates are separated from each other by sheets of insulating material, usually paper dipped in boiling paraffin.

If the main line is very short, as between New York and Philadelphia, the strength of the static induction currents are insufficient to produce a movement of the relay lever and the condenser is unnecessary; but when the line is long, as between New York and Buffalo, the static induction is sufficient to prevent all signalling until the condenser is added to the artificial line, and then it is requisite that a large number of sheets are used, otherwise it will not set up currents of sufficient strength to maintain the balance.

Another essential device to obtain perfect signalling is the addition of a small resistance coil. R 2 (fig. 2) in the earth wire.



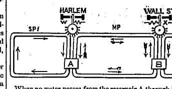
This coil has a resistance equal to that of the battery, so that if either be made to form part of the main line the resistance will be constant. It also serves to reduce the spark which occurs when the battery is for an instant "short-circuited" by the signaling point and spring. Were no coil inserted in the earth wire the resistance of the main line would be increased when the battery was inserted, and decreased when put to earth. This variation in the resistance of the line would vary the strength of the received signals. If the battery was inserted the distant signals would be "light," and when disconnected they would be heavy; and when the received current was exceptionally weak it would prevent signaling altogether, if the battery resistance was considerable.

The spark, if a grove battery is used, would quickly destroy the contact points on the sounder lever. This device is also due to Mr. Stearns.

With these exceptions the electrical and water duplex are alike.

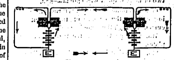
One peculiarity of the duplex is, that it may be operated when the signaling batteries are connected to the line in such a manner that they oppose each other, *i. e.*, when the positive pole of each battery is connected to line. When this takes place, no current passes over, but the current circulating within the artificial lines keeps the relays closed.

The water duplex diagram, slightly changed, will show this action clearly:



When no water passes from the reservoir A through the main or secondary pipes, the water from B passing through M P, throws the lever of W to the left, and the local circuit is closed, so to speak; but, as explained before, the wheel X remains unaffected. If, now, the water is made to pass from A into the main and secondary pipes, in the direction indicated by the unfeathered arrows, it will act, or we will suppose it to act, against the other stream passing in a contrary direction, in such a manner that the water will become still or cease to flow. The effect of this would be to allow the lever of W to be drawn to the right by the spring, were it not for the fact that now instead of the lever being held by the water from B the water in the secondary pipe, SP 1, performs this operation. If the water ceases from A, the balance between the two streams in the main pipe is destroyed; the water ceases in SP I, but the lever will still be held against the point on the left by the water from B. It will be seen that when the two streams oppose each other, the wheels and levers are held to their forward points by the water in the equating pipes, while if only one stream is passing they are held by the water in the main pipe.

If the direction of the water in the main pipe is the same, then all the signalling is done by these currents only and independent of the equating circuits. The arrows shown in figure 3 will show this action



in the electrical duplex. When both stations connect the battery to line they oppose each other, and no current passes over it but the relays close, nevertheless; for the current in the coils on the artificial lines, not being balanced by an equal amount flowing through the main line coil, closes the relay; when the batteries have their dissimilar poles connected to line, a current flows and the relay is closed only by the main line current.

It has been found in practice, that if a relay be inserted in a wire worked duplex, the balance is destroyed.

The reason for this is, that the passage of the signalling current through the coils of the relay sets up secondary magnetic inductive currents (these currents are distinct from static induction currents), the effect of which is to weaken the main current on closing and sending a current in the same direction after the battery is disconnected.

This effect, which is absent from the artificial line, destroys the equation. If a relay of the same character be inserted there the balance is preserved.

In fact, if all the evil effect which take place on the main line could be produced upon the artificial, the equation would be maintained and perfect signaling would always be obtained.

There are many effects produced on the main circuit which are not produced upon the artifical, among which may be mentioned.

1st. Static Induction.
2d. Magnetic Induction, as from relays.
3d. The induction from other wires.
4th. The phenomenon of secondary battery action.
5th. Leakage.
6th. A permanent current from the other wires.
7th. Variability of leakage, caused by opening other wires which acts as earth connections.
8th. Variability of the electrostatic capacity by opening and closing wires in close proximity.
9th. Momentary currents from other wires by leakage across the arms.
10th. The variability of leakage by increasing and decreasing the strength of the signalling currents.
11th. Lightning.
12th. Auroral currents.
13th. The difference between the electrostatic capacity of the wire at noon and midnight.

There are other causes which prevent perfect signalling to be found in the various instruments, among which may be mentioned the following:

46

Decision of the Secretary of the Interior Against the Professor of Duplicity and Quadruplicity and Mr. Harrington.—Sharp Practice of ex-Secretary Delano.

IN THE TELEGRAPHER of April 24, 1875, we gave an account of an appeal to the Secretary of the Interior by Mr. GEO. HARRINGTON, from the decision of the then Commisioner of Patents on the *prima facie* title to the quadruplex patents, so called (which T. A. EDISON had applied to have issued to himself and Mr. GEO. B. PRESCOTT as assignees, but which application he subsequently attempted to withdraw, and asked that they should be issued to himself and HARRINGTON), that they should be issued, as first requested, to EDISON and PRESCOTT, leaving HARRINGTON to establish his claims to them, if he had any, in a Court of Equity. Patents, when issued, are required to be signed by the Commissioner of Patents, and countersigned by the Secretary of the Interior. What HARRINGTON asked, and what the professor of dup[licity] and quadruplicity tried to aid him in obtaining, was [that] the Secretary should refuse to sign the patents when ready to be issued to EDISON and PRESCOTT. A hearing was had on the appeal, and the Secretary declined to give a decision on the main question of the title to the patents until they were presented to him for signature. In the meantime he directed the Commissioner to send up to him all the papers in these cases, and *held them until he went out of office*, unbeknown to Mr. PRESCOTT, thus making any action on the applications impossible.

When the present Secretary, Hon. Z. CHANDLER, came into office, and as soon as he could get time to look into the matter, he returned the papers to the Commissioner of Patents for further action, with the following decision on the appeal of HARRINGTON, which effectually checkmates one of the little games of the professor of duplicity and quadruplicity and his associates.

It should be known, however, that while these applications were, by what certainly appears to be very sharp practice on the part of Mr. DELANO, withheld from possibility of action, Chief Examiner WILBER, of the Electrical Division of the Patent Office, allowed EDISON to amend an old application known as Case H, and incorporate in it a vital part of the invention in one of the suspended applications, which the Commissioner had desided should issue to EDISON and PRESCOTT, and on the last day of the late Commissioner's official connection with the office had the amended patent issued to EDISON, who subsequently assigned it to HARRINGTON. This was so evidently a fraud upon Mr. PRESCOTT's rights, and in such direct opposition to the previous order of the Commissioner, that Mr. PRESCOTT is now prosecuting the Examiner before Mr. DUELL, the present Commissioner of Patents therefor.

After reciting the history of the case and the points contended for, and on which a decision was asked by the respective parties, the Secretary says:

I have considered the very able and exhaustive arguments of the learned counsel for the respective parties with great care, and have reached the conclusion that the action of the late Secretary in arresting the proceedings before the Commissioner was premature, in any view of the case, and not consonant with good practice and the orderly conduct of business in your office.

I might stop at this point and return the papers without considering the principal question, as to the power of the Secretary of the Interior to revise the decisions of the Commissioner of Patents; but in view of its importance, and the very full arguments thereon by counsel for the respective parties, I deem it proper to express my opinion upon this question also.

No appellate jurisdiction in cases like this is conferred upon my office by any express statute. The grant of power from which it is sought to be inferred is found in secs. 441, 481 and 4883, R. S. Sec. 441 is as follows:

"The Secretary of the Interior is charged with the supervision of public business relating to the following subjects: * * Fifth, patents for inventions."

Section 481 provides that "the Commissioner of Patents, under the direction of the Secretary of the Interior, shall superintend or perform all duties respecting the granting or issuing of patents directed by law."

Sec. 4883 provides "that all patents shall be issued in the name of the United States of America, under the seal of the Patent Office, and shall be signed by the Secretary of the Interior, and countersigned by the Commissioner of Patents."

That a grant of supervisory power has not been intended by Congress to include an appellate power I think is evident.

In defining the power of the Secretary of the Interior with respect to the census, it provides that he "shall exercise supervising and appellate powers in relation to all acts of marshals," &c., R. S., sec. 443. So, in sec. 441, above cited, the same supervision is given of public lands as of patents; yet the right of appeal to the Secretary is expressly granted by sec. 2273, R. S., in cases of contest for the right of preëmption.

And in the act of March 3, 1849, for the establishment of this Department, it is provided "that the Secretary of the Interior shall exercise and perform all the acts of supervision and appeal in regard to the office of Commissioner of Patents now exercised by the Secretary of State."

Nor does the statute which provides that the Commissioner of Patents shall superintend or perform all duties respecting the granting and issuing of patents under the direction of the Secretary of the Interior confer upon the latter office any appellate power. The power to supervise includes the power to direct.

Supervision is the act of overseeing, of superintendence—is concurrent with, and accompanies the official action which is its subject, and is applicable to executive duties.

To appeal is to move from a lower to a higher jurisdiction for review of judicial action, and necessarily *follows* such action.

The provision of the act of 1849, above cited, was repealed by the act of July 8, 1870; but I am unable to learn that any appellate jurisdiction has ever been exercised or claimed by any Secretary of State or of the Interior Department over the judicial action of the Commissioner of Patents since the creation of the office by act of July 4, 1836.

An ample remedy against the consequences of an erroneous decision of the Commissioner is provided by appeal to the Supreme Court of this District, or by bill in equity, as the case may be.

For the reasons above suggested, I am of the opinion that no power is vested in me to review the decisions honestly made by the Commissioner of Patents in cases within his jurisdiction, and I return herewith all the papers relating to the applications above mentioned, in order that due legal proceedings may be had thereon in your office.

Very respectfully, your obt. servt.,
Z. CHANDLER, *Secretary*.

To the Commissioner of Patents.

In the November *Scribner* [Dec 1879] is an article—with portrait of Edison—on the latter's system of quick telegraphy, which was put in practice eight years ago, transmitting over a single wire several thousand words per minute for the twenty-five usually sent by the Morse machine.

The Plumber and Sanitary Engineer

47

[Q.] J. E. H. asks: How is it that telegrams [ar]e sent two ways over one wire at the same [time]? A. The instruments are so arranged that [the c]urrent sent does not affect the receiving in[strum]ent of the station sending. This is effected [in v]arious ways. One of these consists in winding [the] magnets with double coils, the convolutions [of w]hich are put on oppositely; or the connections [ar]e made that the result amounts to the same [thin]g. One end of one coil is connected to the [line] wire: one end of the opposite coil, to the [gro]und, through a resistance equivalent to that of [the] line; and the other ends of the coils are joined [tog]ether. The junction is then connected to the [tra]nsmitting apparatus. When a current is sent [ou]t it divides where the two coils meet, half pass[in]g through one coil to the line, the other half, [th]rough the opposite coil and resistance, to [gro]und. As the half currents are oppositely di[re]cted in the two coils, the action of one neutral[ize]s that of the other, and the iron cores remain [un]polarized. The half current which goes to line [pa]sses on to the receiving instrument at the dis[ta]nt station, and, if the key at that point is open, [go]es through one coil of the instrument, thus pro[duc]ing a signal. There may also be a time, in si[mu]ltaneous transmission, when the received half [cu]rrent passes through both coils of the home in[str]ument. It will be observed, however, that, for [suc]h a case, the convolutions of the coils supple[me]nt each other; but at the same time, the cur[ren]t must pass through the extra resistance, so that [wh]ile the number of convolutions is doubled, the [cu]rrent is reduced one half by this added resist[an]ce, and thus the effect remains as before.

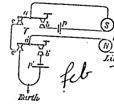
FEBRUARY 16, 1878. SCIEN[TIFIC AMERICAN]

SIMULTANEOUS TRANSMISSION IN OPPOSITE DIRECTIONS.

By M. GIOVANNI MARINI, of the Italian Telegraphic Administration.

THE system of double transmission that I am about to describe is based upon the following principles: A relay with two bobbins is fixed to a permanent magnet in such a way that the armature acts by repulsion, and not by attraction. The wire of one of the bobbins is distinct from the wire of the other bobbin, and the two wires thus form two distinct circuits—the one a local circuit, the other a line circuit. The soft iron cores of these two bobbins of the relay are fixed, the one to the north pole and the other to the south pole of a permanent magnet. The transmitting key is of the ordinary Morse form, very slightly modified; to the front part of it two contacts insulated from one another are added, which serve for the two circuits above mentioned. These contacts should be so adjusted that by the movement of the key they should make or break contact exactly at the same moment.

The figure represents the arrangement of this system of double transmission. R represents the relay, N the bobbin with the north pole, S the bobbin with the south pole, T the double key, a and a' the two levers of the key, formed of little flat springs, to which springs the two outer ends of the wires of the bobbins are connected; c and c' are two metallic contacts fixed at the extremities of the levers and in connection with the earth. In the normal position of this double key the levers rest on these contacts, and are thus in



feb 78

connection with the earth; b and b are two little metallic plates connected to the positive poles of two batteries—the local battery p and the line battery p'. The connections being thus arranged, the following results are obtained:

It is first of all necessary that the strength of the local battery, which sends a current through the south pole bobbin, be so regulated that it may transmit a current exactly equal in power to the one sent out by the line battery through the wire of the other bobbin and out to line to the corresponding instrument at the further station. This equality can be arrived at by observing the deviations given by a good galvanometer, which can be switched either into the line or the local circuit—the battery of the latter being varied, so that the deflections in both cases are the same. When the batteries are in good condition this equilibrium may be maintained for several days unless accidental circumstances interfere.

For a line of a given resistance the relation between the local and line batteries is in the proportion of about 1 to 8. If, now, the key at one station be depressed, the levers a a' are put simultaneously in communication with the contacts b b' and at the same instant the communication of the levers c c' with the earth is interrupted. The current of the local battery p traverses the south pole bobbins to get to earth, and produces in the soft iron core a contrary magnetism to that which is given it by the permanent magnet; that is to say, the current tends to diminish the attractive force of the core for the armature; but, at the same time, the current of the line battery p' traverses the north pole bobbin and out to line, and increases the attractive power of the core of that bobbin; for at the transmitting station this current produces in the soft iron core a magnetism equal to that which the local battery takes away, consequently the armature remains attracted against the poles.

At the other station, the arrival current entering by the outer extremity of the wire of the north pole bobbin goes to earth through the lever a' and the contact c', and produces in the soft iron core a magnetism contrary to that which is given it by the permanent magnet; the attractive force on the armature being thus diminished, the armature rises off the poles under the influence of an antagonistic spring. Immediately on the cessation of the current the core regains its magnetism, and the armature is again attracted.

Finally, if the keys at both stations are simultaneously depressed, the currents going out to line being equal and contrary, annul one another, and thus the north pole bobbins of the two relays are not influenced by the currents. The south pole cores, then, being both under the influence of the local batteries, have their magnetic powers diminished, and the armatures at both stations consequently rise.

If in this last position one station allows his key to rise, the current from that station ceases to be emitted by him; but the connection of the line wire to earth is not interrupted, and the armature, though no longer under the influence of the local current, but under the influence of the current from the other station, which current is no longer nullified, continues to remain detached from the poles of the magnet. But at the moment when there are no longer simultaneous currents on the line, the battery of the station which continues to keep his key depressed itself ceases to influence its own electro-magnet, and the armature at that station consequently rises.

Thus, then, the armature acts when the current arrives on the relay, or when the local battery is in action; but in these two cases, in order to detach the armature of the electro-magnet, it is sufficient simply to adjust it so that the strength of the arrival current is sufficient to diminish a little the magnetism imparted by the permanent magnet, and the armature then detaches itself from the cores by the influence of the antagonistic spring, and never by the action of the arrival or the local current.

When, on the contrary, the armature is attracted, this attraction always takes place in virtue of the same constant force of the magnet, which at the moment when the arrival current ceases on the relay, or on the line, restores magnetic power to the cores as much when the key of the station by which they are acted on is in its normal condition as when it is depressed. Under this condition the armature is always attracted by a permanent magnetic force of equal strength without undergoing in its movements any kind of change

OVER

48

which could prevent the correct reception of the signals. In the laboratory experiments this result can be obtained by the same form of key and with the same connections with an ordinary relay, or Morse ink-writer of sufficient resistance, provided the two bobbins are separate, so that the connections can be made in the manner which has been indicated.

But such is not the case on a line where, the armature of an ordinary relay being attracted irrespectively by the arrival and the local current, which are never equal (that of arrival being from the leakage on the line always less than the local current, which, as we have before said, is equal in strength to the departure current), would thus be affected either by the greater or by the less force, being thus able to remain continuously attracted if the spring is adjusted for the smaller current, or not being attracted at all if adjusted for the greater current.

In all these cases the movements of the armature would be very irregular, whence would result confused, broken, or weak signals.

It is for this reason that I have proposed for this system of transmission a relay with a polarized electro-magnet.—*Journal Telegraphique.*

July 78

The "duplex" method of telegraphy has been successfully applied to the Wheatstone automatic instruments, and on a recent occasion as many as 358 messages were sent in an hour by its means—219 in one direction, and 139 in the other. More than 139 could have been sent, but they were not received.

Dec 78

DUPLEX TELEGRAPHY.—Mr. Muirhead has recently successfully applied his duplex system of working telegraph lines to the cable from Madras to Penang, a length of 1300 miles. This extension of the system makes a total of about 10,000 miles of cable worked upon Mr. Muirhead's system, and we understand that, so far, it is the only successful method whereby long submarine cables are practically worked on the duplex principle. The Eastern Telegraph Company have for several years employed this system for working the traffic on all their trunk lines, and the latest extension, above referred to, carries the working as far east as Penang. Duplex telegraphy consists in a method of sending two messages on the same wire at the same time in opposite directions, and Mr. Muirhead's system was fully described in *The Times* about a year since.

Edison in Trouble.

NEW YORK July 23.—A Washington special despatch to the Graphic says: "Edison has a claimant for his quadruplex. H. C. Nicholson, a Kentuckian, professes that the machine involves principles which he originated. The case is being considered at the Patent Office, and if it is found that there appears to be any equity in the new claim, a hearing will be given to the matter. This machine is now one of the most elaborate and valuable in use in the telegraphing, and should Mr. Nicholson's claim be demonstrated, Mr. Edison's perquisites will suffer materially." Newark Advertiser July 23 78

AN ACCOUNT OF DUPLEX TELEGRAPHY

THE introduction of the duplex system of working not only upon land-lines, but on sub-marine cables, is without doubt the most important advance recently made in electric telegraphy.

Duplex telegraphy may be defined as the art of telegraphing in opposite directions simultaneously along one line wire.

It is claimed by M. Zantedeschi in papers read before the Academy of Sciences, Paris, in 1855, that as early as 1829 he had suggested and demonstrated the possibility of working "duplex;" but until the year 1853 there do not appear to have been any noteworthy attempts made to effect it practically. In that year, Dr. Gintl, a director of Austrian telegraphs, described a system of duplex telegraphy to the Academy of Sciences, Vienna, and practically tested it on the land-lines between Vienna and Prague.

The principle underlying this and all other systems, is that the outgoing currents at a station shall not sensibly affect the receiving instrument there, while, at the same time, the latter is free to be affected by the incoming currents, so to speak, from the other station. That is to say, no signals are made at a station by its own sending currents, unless when these are interfered with by the sending currents of the other station.

Gintl's plan was as shown in Fig. 1. The receiving instrument, R I, was wound by two separate wires, one long and thin, the other short and thick. The long wire, shown by a full line, was connected at one end to the line L, and the short wire, shown by a dotted line, was connected at one end to a local, or, as it was called, a "com-

pensating" circuit. Both of these wires were connected at their other ends to a signalling key or sending instrument, K, having duplicate points. Two batteries, B and B', one large and the other small, were also connected to this key in such a manner that on making contact the current from the larger battery B passed through the long coil of the instrument into the line, while at the same instant the current from the smaller battery B', passed through the short coil and compensating circuit. These two currents were so adjusted as to balance each other in their effects on the indicator of the receiving instrument, and no signal was therefore made by the outgoing or signalling current from the battery B. Such was Gintl's arrangement at both stations, S and S'. Confining our attention to any one of these stations, say S, we see that as long as only S is sending, the receiving instrument at that station is unaffected, but when S' is also sending at the same time, the currents in the line from S' must interfere with the currents in the line from S, either aiding or opposing these according to the poles of the battery which are applied, and thereby disturbing the balance of currents on the receiving instrument at S, causing it to make signals. And we see also that these signals are entirely under the control of S'—that when S' applies his battery to the line, S's instrument will make a signal, and that when S applies his battery to the line, S''s instrument will make a signal, or that when either put "earth" to the line, that corresponding "spaces" will be recorded. The currents do not cross each other in the line, as was sometime thought, but they interfere with each other in such a way as to disturb the electric balance which independently exists at either end.

One objection, however, to this plan of Gintl's was that the lever of the key during sending interrupted the line circuit when it was between the earth and battery contacts; and another more serious objection lay in maintaining the equivalence of the two currents, as the smaller battery working through the shorter circuit lost power more rapidly than the signalling battery.

Gintl, however, in the following year (1854) obtained better success with a Bain's chemical printing instrument. Here he made the two currents oppose each other upon the chemically prepared paper and no stain was produced by the outgoing current. The sending current from the other station neutralised to a certain extent the outgoing current and the *local* current then overmastering it stained the paper and produced signals.

Early in 1854, while Gintl was still engaged in experimenting with the Bain's instrument, a great improvement was effected on his plan by Herr Carl Frischen, a telegraph engineer of Hanover. Frischen dispensed with the second battery B' and split up the signalling current itself, causing one part to pass round one coil of the receiving instrument into the line and the other part to pass round the other coil of the instrument into the local or compensating circuit. Instead of making the two wires of the instrument dissimilar, like Gintl, he made them both alike, so that the instrument was practically wound by equal wires in opposite directions and thereby rendered *differential*. He inserted into the compensating circuit a rheostat or set of resistance coils whose resistance could be adjusted to equal the electric resistance of the line. His arrangement at either station is shown in Fig. 2. Here R I is the differentially wound receiving instrument, B is the battery, and R is the rheostat or artificial line as it was called, because of its being intended to imitate the actual line. K and E are as before, the sending key and earth plates respectively. In the act of sending a message, on making contact between the key and battery at *a* the current flowing into the apparatus divides itself at the point *b*, and part passes through the right coil of the instrument into the line, while part passes through the left coil into the local circuit. But the resistance of the local circuit being made equal to that of the line and the two coils of the instrument being electrically equal one *half* of the current will flow through one coil and the other *half* through the other coil. The coils being oppositely wound these currents will neutralise each other in their effect on the indicator or needle of the instrument and no signal will be produced as long as they flow freely. We have seen, however, that the sending at the remote station may either oppose or assist that part of the current entering the line. Thus the balance is disturbed and signals will be made on the receiving instrument of one *kind* or another according as the line current or the local current overbalance each other.

In sending by this method of Frischen's the line circuit is never completely interrupted, but it will be observed that according to the position of the key the line is either applied "to earth" direct or through the battery, or through the resistance R, and this leads to a troublesome variation in the signals.

Frischen's method was re-invented a few months subsequently by Messrs. Siemens and Halske of Berlin, who patented it in England, where, however, they were forestalled by a week by Mr. Stirling Newall, of Gateshead, whose patent bears date October 30, 1854. Newall describes substantially the method of Frischen–Siemens, and in 1855–56, successful experiments were made under his patent on the Manchester and Altringham line; but when he came to make trials upon the longer line between Birmingham and London, the *static* charge and discharge of the line was found to make false signals. Condensers or accumulators of electricity were applied to correct this disturbance with promising results, but the expense of constructing large condensers was objected to and their use was prematurely abandoned.

At this time there was a great deal of activity in the direction of duplex working displayed both at home and abroad. Besides the names mentioned, Messrs. W. H. Preece, Highton, De Sauty, and others in this country, Edlund, Bosscha, Kramer, in Germany, and Farmer, in America, were all more or less engaged in the work. In 1856 a good many lines were worked on the duplex principle in Prussia, but the time was not yet ripe for its successful introduction, and it gradually fell into disuse again. Some desultory activity was still shown here and there, however, showing that the idea had not been lost sight of. In 1862 Mr. William Hinckling Burnett patented a method of working two or even three distinct systems of telegraphy by the use of currents of different degrees of force, and in 1863 M. Maron, of Berlin, appears to have first placed the receiving instrument in the diagonal of a Wheatstone's balance. This has been called the Wheatstone bridge method in the recent revival of duplex, and it may be shown as follows, Fig. 3.

Here r and r' are two of the branch resistances of a Wheatstone's balance; the line and artificial line, or rheostat, R, forming the other two branches. The receiving instrument, R I, is inserted in the "bridge" wire. In sending, the current from the battery B splits at b, and part passes by r into the actual line, while part passes by r' into the artificial line. If r be equal to r', and the actual line be equal to the artificial line, the current will divide itself equally, and the potentials, or, as it may be called, the electric levels, at c and d, will be equal, and there will be no tendency for a current to flow through the cross channel or "bridge wire," and the receiving instrument will not, therefore, be affected. When, however, the line currents are interfered with by the sending currents of the distant station, this balance will be disturbed, currents will flow through the "bridge wire," cd, and the receiving instrument will signalise. The resistance, w, may with some slight advantage be made equal to the battery resistance. It will be seen that in the balance method, as in the differential method, the principle consists in dividing the signalling current between two circuits whose electrical properties are practically the same,

Théorie générale de la transmission simultanée (Duplex telegraphy),

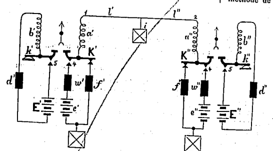
par M. Schwendler [1]).

(Traduit de l'anglais d'après une communication de l'auteur).

4e Partie.

III. Méthode de compensation [2]).

C'est la plus ancienne des méthodes. La figure suivante en donne le diagramme général.



Explication du diagramme.

e force électro-motrice de la pile de ligne.

β sa résistance intérieure.

E force électro-motrice de la pile de compensation.

α sa résistance intérieure.

K manipulateur de résistance constante. Le Dr. Gintl se servait d'un manipulateur ordinaire qui, la chose est claire, devait forcément échouer.

k manipulateur ordinaire; les deux manipulateurs d'une même station se meuvent simultanément, c'est-à-dire les contacts 4 et 5 sont établis et interrompus en même temps.

d, f et w différentes résistances.

a une des bobines de l'appareil différentiel, celle qui est combinée avec la ligne.

b l'autre bobine intercalée dans le circuit de compensation. Par a et b sont aussi désignées les résistances respectives de ces deux bobines.

Les bobines a et b, avec leurs piles e et E, sont disposées de façon à produire des effets magnétiques opposés par rapport au même pôle-magnétique. Dans chaque station, les deux circuits (le circuit de ligne et le circuit de compensation) sont isolés l'un de l'autre. Toutes les autres lettres, comme L, L', L'', etc., ont la même signification que dans les articles antérieurs.

La méthode de compensation a deux défauts principaux que ne présentent pas les deux méthodes précédentes.

Primo: Le succès de la télégraphie Duplex par la méthode de compensation dépend de la possibilité de fermer et d'interrompre simultanément deux contacts différents (4 et 5). Le Dr. Werner Siemens a démontré la difficulté mécanique que présente une solution satisfaisante de ce problème et c'est, en fait, une des raisons qui l'ont amené à proposer la méthode différentielle.

Secondo: La balance dans chaque station peut être troublée *directement* par des variations de la condition électrique (résistance intérieure et force électro-motrice) des deux piles E et c.

Dans les deux méthodes précédentes, la variation de la résistance intérieure de la pile de ligne ne peut être ressentie qu'*indirectement* par l'altération de la balance à l'autre station et la variation de la force électromotrice n'a pas d'effet du tout. De là résulte qu'une variation donnée se produisant dans l'une ou dans les deux piles doit troubler plus profondément la balance avec la *méthode de compensation* qu'avec les deux méthodes précédentes. L'on sait que même dans les piles dites constantes, en fonction, les conditions électriques varient très-sensiblement, surtout en ce qui concerne la résistance intérieure; ce défaut tranche donc la question au détriment de la méthode de compensation. Sous tous les autres rapports, cette méthode présente les mêmes défauts que la méthode différentielle et elle en a, en outre, quelques autres que vont faire ressortir les procédés d'investigation.

Expressions générales pour les deux fonctions « D » *et* « S ».

Pour obtenir les fonctions D et S, nous avons à développer les expressions générales pour les forces p, P et Q, soit pour la station I.

$$p' = A' m' - B' n'$$

expression dans laquelle A' et B' représentent les courants qui passent par les deux bobines a' et b', quand

[1]) Voir pour le commencement de cette étude le Journal télégraphique, vol. II, pages 580 et 595 et vol. III, pages 9, 26, 37, 160 et 188.

[2]) Le Dr. Wilhelm Gintl, Directeur général des télégraphes autrichiens, est l'inventeur de cette méthode qui est la plus ancienne. C'est en 1853 qu'il fit les premières expériences sur une ligne entre Vienne et Prague (386 kilomètres).

DUPLEX TELEGRAPHY.

WE have lately had occasion to record, in an incidental ay, that a system of duplex telegraphy has been successlly introduced upon some of the lines between this country

and India, and the success is of sufficient importance to require a somewhat more extended notice. In the original methods of telegraphy the signal is produced by a battery current, which is passed through the sending station, along the connecting wire, to the receiving station, and then through the earth, back to the battery from whence it came, so as to make a complete circuit. In the course of this circuit the current passes through the recording instrument at the sending station, as well as through that at the receiving station, so that the operator produces his signal upon his own instrument as well as upon that with which he wishes to communicate. It follows that the instrument at the sending station, being thus disturbed by the current which is passing through it, cannot, at the same time, be receiving a message from the other extremity of the line; and electricians have long been engaged in researches with a view to alter this condition of things, and to leave the instrument at the sending station unaffected, so that it may be able to receive messages and to record them.

The difficulties in the way of accomplishing this object were found to be much greater on long than on short lines, and very much greater on submarine cables than upon land lines of whatever length. The latter differ from the former by being more completely insulated; the submarine cables being surrounded by water which is in contact with the earth, and which brings them into direct relation with it. One effect of this relation is that the passage of the battery current along the wire produces an induced current around it, which delays the speed of the battery current, so that this, instead of traveling rapidly, as it does upon land, travels very slowly, and flows out of the wire in a way which has often been compared to the escape of a viscid liquid. For this and other reasons, the submarine lines require to be furnished with recording instruments of much greater delicacy than those which are used for land lines, and the former are, therefore, more liable to be disturbed. The principle on which efforts at the attainment of duplex telegraphy have been made is that if the original battery current is split into two equal parts, these may be conducted around the recording instruments by two different wires proceeding in opposite directions, and may then be conveyed along two different circuits; one half-current serving to excite the recording instrument at the distant station, the other half, after fulfilling its function of "balancing" the needle at the sending station, being simply wasted. The power of the second half-current to balance the recording instrument at the sending station—that is, exactly to counteract the signalling half-current—depends upon the two being precisely of the same strength; and this only happens when the two circuits which they respectively travel are precisely of the same resistance. If the circuit, say to the left, is of less resistance than that to the right, more electricity will flow to the left than to the right; the original battery current will thus be unequally divided, and the recording instrument will no longer be balanced—that is, it will no longer remain at rest while the divided current is passing. On land lines, formed by wires suspended in the air, the resistance of the signalling wire to the current is easily ascertained, and is easily imitated on the second or artificial circuit; but in submarine lines, on account of the induction already mentioned, there is not only the resistance to be taken into account, but also the retarding capacity of the cable. In any given cable, each knot of length presents a certain resistance, and has also a certain retarding capacity; but these two qualities do not bear the same proportion to each other in any two cables, and have to be separately tested in each. The second circuit, which for the land line need only be equal to the signalling wire in resistance, must for the cable be equal to it both in resistance and in capacity; and it has been found very difficult to fulfill both these requirements. It is not enough that the whole of the second circuit should be equal to the whole of the cable, but the resistance and the capacity must be distributed equally in both, and any portion of the second circuit must be equal to any corresponding portion of the cable.

Attempts have been made by Mr. Varley, Mr. Stearn, and others to overcome the difficulty by various combinations of condensers with resistance coils; the former to imitate the capacity, the latter the resistance, of the submarine cable itself. All these combinations seem to have failed from not being sufficiently uniform in their qualities; but Mr. J. Muirhead, Jr., has lately succeeded in obtaining the uniformity which was desired. He has formed his second circuit by sheets of paper prepared with paraffin, and having upon one side a strip of tinfoil, wound to and fro, to represent resistance, and through which the second current is conducted, and on the other side a sheet of tinfoil, to represent the gutta percha or other covering of the wire and to afford the capacity. Each sheet of paper may thus be made to represent precisely a given length of cable, having enough tinfoil on one side to furnish the resistance, and enough on the other to furnish the capacity. It follows that a sufficient number of such sheets would exactly represent the cable in every part of its length, and that the non-signalling half of the current would be precisely equal to and would be discharged under precisely the same conditions with the signalling half. For utilizing this invention two methods may be employed; the two halves of the current being either carried around the recording instrument in different directions, as already mentioned, or the two circuits being connected near their point of divergence by a Wheatstone bridge, on which the recording instrument is placed. Then, as long as the divided current flows evenly, one-half along the signalling wire to the recording instrument at the distant station, the other half along the artificial circuit, the equilibrium of the bridge between the two is not disturbed, and the instrument placed upon it is not affected. But as soon as the operator at the distant station, who has a precisely similar arrangement, sends a battery current into the signalling wire from his end of the line, this meets and opposes the half-current which is coming toward him. The flow through the signalling wire is thus interrupted, and, in consequence, the resistance of the two circuits being no longer equal, the balance of the first recording instrument is disturbed, and is disturbed in a degree which is regulated by the admission of the current from the other end. The result of this is that a single wire will convey signals simultaneously in two opposite directions, and that one wire will do the work for which two have previously been required.

On all marine lines this invention of Mr. Muirhead's is of the greatest possible importance, on account of the enormous expense of laying additional cables to meet increasing traffic; and also because, while it theoretically doubles the carrying capacity of each cable, it does still more than this in practice, by doing away with much loss of time in arranging about the precedence of outward and homeward messages, and about the repetition of those which were not perfectly intelligible at first. The new plan was first tried, on a working scale, on the line between Marseilles and Bona; but it has since been brought into operation from Marseilles to Malta, from Suez to Aden, and, lastly, from Aden to Bombay. On a very recent occasion, when there was a breakdown upon the Indo-European line, the duplex system rendered essential service, and maintained telegraphic communication which would otherwise have been most seriously interfered with. Mr. Muirhead's invention cannot fail to be highly profitable to the proprietors of submarine cables, and it will, we hope, before long, bring about a material reduction in the cost of messages from places beyond the seas.—*London Times.*

Good Work on the Duplex.

78

NEW YORK, *March* 30.

To the Editor of the Journal of the Telegraph:

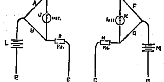
On the 29th inst. there was transmitted from the Board of Trade Office in this city to Chicago on the duplex, between 10.35 A. M. and 2.10 P. M., 257 messages, being an average of about 72 messages per hour. There were received on the same wire during the same time 182 messages; making a total of 441 messages in 3 hours, 35 minutes. Very good work for a branch office.

W. A. V. O.

STUDENTS' COLUMN.

ANSWERS TO QUERIES.

3. *Duplex Working.—Wheatstone's Bridge Method.*—Perhaps a rough sketch of a Wheatstone bridge duplex will be of more assistance than a whole page of explanatory remarks.



Arms A and B equal say 100 ohms each; C and D equal 2000 ohms each. If L is sending to M no current will pass through Inst. I. Should Station M wish to send at the same time, the equilibrium of the current is disturbed, and signals recorded at I. Reverse the order, and signals will be recorded at M. Further and fuller particulars will be found in Culley's 6th edition, and Preece and Sivewright's text book.

4. *Joint Resistance.*—The rule for finding the joint resistance of two wires is to divide their product by their sum, thus—

$$\frac{75 \times 125}{75 + 125} = 41{\cdot}875 \text{ joint resistance.}$$

The two wires having a resistance of 75 and 125 are in proportion of 3 and 5. If, therefore, the 25 farads be divided into 8 parts, 5 parts, or 15·625, will go by the wire containing 75 ohms, and 3 parts, or 9·375 farads, by that with 125 ohms.

WM. DENNETT, Dover P.O.

Nov 78

MR. J. B. STEARNS has just succeeded in duplexing the Anglo-American Cable by his ordinary condenser system. The balance he has obtained, we understand, is absolutely complete, and the working of the siphon recorder (the instrument employed) is just as perfect as it was when single working was employed. Considering the marvellous sensitiveness of the siphon instrument this result is in the very highest degree satisfactory, and we congratulate Mr. Stearns on the success he has attained.

DUPLEX AND QUADRUPLEX TELEGRAPHY IN THE STATES.—The progress of American land lines certainly compares favourably with that of England. We can boast of one quadruplex circuit. America has fifty-nine such circuits, comprising 16,157 miles of line; while it has also fifty-two duplex circuits, containing 14,580 miles of line, giving a grand total of 30,737 miles working duplex or quadruplex. July 78

SIEUR'S DUPLEX TELEGRAPH.—The duplex system of M Sieur, the apparatus for which is exhibited in the Telegraphic Annexe of the French Exhibition, is shortly to be adopted on the line between Paris and Rouen. It is distinct in principle from all other practical duplex systems, being based upon the use of a "distributor," or automatic current reverser, which divides the time of sending into a series of small and equal intervals, during which a succession of currents, alternately in opposite directions, are sent into the line. These currents are received separately on two polarised relays, corresponding respectively to the direction of the currents. This system equally admits of sending two messages simultaneously in the same direction, or in opposite directions. M. Sieur is said to have invented, also, a system of double and quadruple transmission, based, like the American systems, on the employment of currents of different intensity. Sept 78

[From *The Telegraphic Journal*.]

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The quadruplex system of Messrs. Edison and Prescott was introduced into this country in September, 1877. It has, therefore, been on trial here for a year.

Fears were from the first entertained that our variable climate would greatly interfere with the working of the system and, at the outset a battery of 100 Fuller's Mercury-Bichromate Cells was used at each end of the wire; the supervisors being Mr. Gerritt Smith, the Assistant Electrician of the Western Union Company in London, and Mr. Hamilton, also of the electrical department of that company at the Liverpool end. When once fairly started, and in spite of variable and stormy autumnal weather, the operation proved eminently successful. Four distinct circuits were worked steadily on that wire for six or seven consecutive hours daily, and the number of ordinary messages per hour transmitted on the quadruplex was at that time surprising. As many as 213 ordinary despatches were sent and received within the sixty minutes—a total said to exceed the highest number ever heretofore attained by American telegraphists in the native land of the system. This result appeared to astonish Messrs. G. Smith and Hamilton, who, not unnaturally, had believed the famed manipulation of their telegraphic compatriots to be entirely unapproachable.

The quadruplex continued to behave satisfactorily after the return of the American electricians to the States, and may be said to have since then exceeded even the most sanguine expectations of its capabilities.

After having been in operation for some months to Liverpool, the apparatus was removed to Leeds, where a number of experiments have been made, and some improvements introduced that will materially enhance its value. The carrying power of the instrument, great as it is, can be increased about twenty-five per cent. by the Wheatstone automatic duplex system being used on the "double current" side of the apparatus. This has been effected between London and Leeds at a speed of fifty to sixty words per minute in each direction, without at all interfering with the ordinary duplex working on the "single current" side. Thus we may employ two independent and different systems, both duplexed, and transmitting between them a grand total of, say, 260 messages per hour, upon one wire two or three hundred miles long. By the introduction of this important English improvement, the capacity of the quadruplex, as we have said, has been augmented, and, besides, it has demonstrated the economy in wires that will result from the extension of the system. For instance, if "one side" be used as a duplex Wheatstone automatic circuit from London to a large centre, such as Manchester, the other section may be worked independently as an ordinary duplex circuit to, say, Carlisle, if a local line wire between Manchester and Carlisle be connected to the quadruplex apparatus, which would act as a translator or repeater on the "single current" side. A London-Manchester length would thus be economized.

We believe that the Post Office have decided to extend the quadruplex system immediately to several important telegraphic towns; in fact, the additional apparatus required for six or seven new sets are now nearly completed. Birmingham, Bristol, Southampton, Plymouth, and Jersey are spoken of as likely to receive the early benefit of these additional instruments.

MUIRHEAD AND WINTER'S QUADRUPLEX.—This novel system of quadruplex is working very successfully on the trans-Indian line, between Madras and Bombay. It is a split battery system, and promises to be superior to Edison and Prescott's. We are obliged to reserve a full account of it until the patents are secured, but will do so then. The advantages claimed for it are (1) that considerable change in the resistance of the line do not disturb the balance; (2) that the receiving instruments do not require to be differentially wound, and (3) that there is no loss of current-power from the use of a Wheatstone Bridge. Feb 79

AN OCTOPLEX PRINTING TELEGRAPH.—Prof. Klinkerfues, the director of the Gottingen Observatory, has, it is said, taken out a patent for a new invention in telegraphy. The professor has discovered a method by which up to eight different messages may be sent simultaneously by the same wire, an apparatus at the receiving end printing the messages separately and all at the same time.

Mining & Sci Press Nov 22 1879

Engineering, Dec 21, 1883.

KERITE TELEGRAPH CABLE.

Kerite is the invention of an American manufacturer, Mr. A. G. Day, who was impelled by the increasing cost of india-rubber to seek a substitute for it as an insulating material for electric wires. The invention is patent, and the substances of which kerite is composed are not made public; but it is known that it is composed of various bodies. It may be combined with india-rubber, sulphur, and oxides of metals in the usual manner; renders the india-rubber more durable, while reducing the cost, and is applicable to the whole class of goods into the manufacture of which caoutchouc enters. At Mr. Day's factory at Seymour, Conn., the whole process of the manufacture of cable is carried on, except that of making the wire. The ingredients of the kerite are thoroughly mixed, put into boilers, and allowed to stand until ready for use. When hot the composition is of about the consistency of thick treacle; it is run into cakes, which, when cool, are kept separated by a thin layer of soapstone, in order to facilitate handling. Pure Para gum, cleansed by a process of Mr. Day's invention, is then thoroughly mixed with the kerite by the usual grinding operation, and the whole carefully strained. It is afterwards cut into strips about an inch square, and fed into a machine, which covers it on to the wire as the latter passes through. The wire is then coiled in layers in large pans, fine soapstone dust being used to prevent adhesion, and is vulcanised. The coils are afterwards rewound upon "testing reels," and submerged in water for forty-eight hours. The wire is most carefully tested while in the bath, and the process is then complete. Wire for single lines is wound and despatched at this point, while that for cables is wound up for the cable-making machines. Submarine cables have a coating of prepared tape over each strand, they are then surrounded with an envelope of jute fibre, and, lastly, enclosed in an armour of the best "B. B." galvanised iron wire.

[TEL]EGRAPHIC APPARATUS FOR DUPLEX TRANSMISSION.

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[Polar]isation of the Poles of a Magnet.—If a permanent magnet [in t]he form of a horse shoe, has its arms prolonged by pieces [of soft] iron, the magnetic poles of the primitive magnet will be transferred to the extremity of the soft iron, that is to say, the south pole to *a*, and the north pole to *b* (fig. 1). Now direct a current around the soft iron bars B, by means of coils. The current will act upon the bars of soft iron fixed to the permanent magnet. If, at the moment when the current is passing through, we place a magnetic needle near the extremity *b* of the magnet A, prolonged by the soft iron bars B, we shall see this bar deviate considerably from its original position, indicated by fig. 2. And, if the current be of sufficient intensity, the needle will be reversed, its pole *b′* will turn towards *b*, thus indicating to us that at the extremity of the soft iron extension of the magnet A, and at *b′*, we have produced a southern pole, that is to say, at this extreme point, a complete reversal of the magnetism of the primitive magnet A. In other words, the two arms become by the passage of the current two electro-magnets, the communication of which, with the permanent magnet A, nevertheless, does not modify the poles of the magnet A. The same thing takes place in an opposite direction with the extension of the other pole, since we have taken for granted the simultaneous passage of the current in the two coils.

A magnetized Armature of Steel or Soft Iron is repelled from the Poles of a Magnet.—Let us place beneath the arms, and at a very short distance from them, an armature of soft iron, or of magnetized steel (fig. 2). At the moment of the passage of the current this armature is repelled. In fact, if the armature is of magnetized steel, and such that its north pole lies under the south pole, and its south pole under the north pole of the permanent magnet A, this armature, at the moment of the passage of the current, will be repelled by the prolonged poles of the magnet A, which, as we have shown, become of the same kind as those of the extremities of the armature of magnetized steel. If, on the contrary, this armature is of soft iron, it becomes, in fact, magnetized by the induction of the permanent magnet A, and its poles are similar to those in the case of a magnetized armature; thus, on the passage of the current, the same phenomenon of repulsion will be observed.

Application to the Construction of Telegraphic Receivers.—Let us remove the call-spring of a telegraphic receiver, and replace it by a permanent magnet prolonged by arms of soft iron surrounded by coils, as indicated in figure 2. We have fixed these coils in such a manner as that the circulating current shall polarise the prolonged poles of the permanent magnet A, whilst at the same time determining, in an electro-magnet placed below the armature, a magnetism of the same kind as that of the permanent magnet A. It is clear that we shall have obtained an attraction of the armature by the lower electro-magnet thus formed, at the same time having determined a downward repulsion of this armature, a repulsion due to the formation of the upper electro-magnets. This phenomenon will continue till the moment when, the interruption of the current withdrawing all magnetic action from the various electro-magnets, the permanent magnet A alone becomes active, and, being extended then to the extremity of the arms which prolong it, brings back the armature to its original position. There is here a differential action, and the equilibrium being well established by the adjustment of an instrument thus constructed, will allow us to work it with a very much reduced electro-motive force; since, whatever this force may be, there will always be attraction on the one hand and repulsion on the other.

Special Application of the Receivers.—It is in accordance with these observations and these data that we have constructed an instrument which can be adapted to ordinary telegraphic receivers. Here, for instance, is a description of this instrument applied to the Morse system. In the ordinary Morse instrument the point, by means of which the whole of the signals are reproduced on the paper which is unwound by the clockwork, is supported by a lever, which at its other end supports the armature of an electric magnet. This armature is kept at a distance from the electro-magnet by means of a small spring. When a current from the line passes into the coils of the electro-magnet the armature is attracted. On the other hand, it follows from our first explanation that if, instead of keeping the armature at a distance from the poles of the electro-magnet by means of a spring, we keep it at a distance by the permanent magnet A, we shall have a magnetic spring in place of a mechanical spring. But at the moment of the passage of the current this spring will be repellent, whilst below we shall have excited by the lower electro-magnet an [attr]active force. The armature will thus be doubly attracted, and will lower itself, and rise again only on the interrup[tion of the] current.

Explanation of Fig. 3, showing the whole of a Morse Receiver furnished with the Apparatus.—Fig. 3 shows in principle the construction of our apparatus applied to a Morse receiver. A is the permanent magnet; R the regulator, of soft iron, working by means of a rack, in order to allow the force of the permanent magnet A to be increased or diminished at will. There is a screw which by means of a brass cross-piece is joined on to the permanent magnet A. The end of this screw presses against a support, and the magnet being fixed *à charnières*, we can, by means of this screw, at will cause the prolonged poles of the permanent magnet to approach the armature or retire from it. This screw, again, is furnished with a counter stop-screw, so that the working of the apparatus may not gradually cause the upper coils to slip down.

We dwell upon these details because the adjustment of the apparatus depends on this regulator and this screw. G is a copper cross-piece fixed on to the body of the Morse, and supporting the magnet and the two upper coils. T is a bar of soft iron joining the cores of the electro-magnet. P is the soft iron, or magnetised armature.

a. The extended southern pole of the permanent magnet A. *b*. Extended northern pole of the permanent magnet A. *a′*. Southern pole of the lower electro-magnet. *b′*. Northern pole of the lower electro-magnet. M. Case of the Morse.

Before going any further we will mention some experiments made with our apparatus:—

Correct Transmission through 30.000 *Ohms.*—We have succeeded in obtaining signals absolutely correct, through a resistance of 20,000 ohms, by making use of a rheostat belonging to Messrs. Latimer-Clark, Muirhead, and Co., of London. The number of cells employed was twenty-five Leclanchés, of seven centimètres in height. Sensitizing the apparatus by a careful adjustment, we succeeded in getting correct signals through 30,000 ohms. Another experiment was to make the apparatus work through a resistance of 1,000 ohms, with one small Leclanché cell. These experiments were made with the object of proving the sensitiveness of the apparatus.

Transmission through a Non-Insulated Wire.—A rather curious experiment was made at the Brussels Zoological Gardens, before fully competent persons. A bare copper wire of one-and-a-quarter millimètres in diameter had been unwound upon the ground, in the grass, the shrubs, &c., for the distance of a kilomètre. The earth-plates were of copper, laid horizontally, and measuring forty-nine square décimètres. The battery used was a small Leclanché of ten cells. The signals were transmitted very regularly, and we think that no more conclusive proof can be given of the sensitiveness of the apparatus and the small electro-motive force which it requires. It should be observed that, the day before this experiment was made, and the whole time it was going on, a fine rain was falling, such as is always detrimental to electric telegraphy. From the series of facts which we have just enumerated we gather clearly that the apparatus works at much greater distances than the various receivers with springs at present in use, and that it has the advantage of needing a much smaller electro-motive force than any of them.

Duplex working without Condensers.—But the advantages we have just mentioned are secondary. The apparatus possesses others far more important, which we will proceed to analyse, and the demonstration of which will form a sequel to the description of our apparatus. The first of these advantages is that it allows not only simple transmission with reduced electro-motive force, but also duplex working without condensers. Of course, we are not speaking here of submarine lines, or of aerial lines of too great length. Our experiments seem to impose upon us a limit of from 400 to 500 kilomètres, according to the lines.

Automatic Control of Messages.—Another no less important advantage is the power of automatically controlling messages. For a commutator added at the two stations enables us to transform the lever of the receiver into a manipulator, so that the sender can follow with absolute certainty the reception of the message by his correspondent, which is undoubtedly the most complete control to be possibly obtained.

Rheostat.—The apparatus is furnished with a rheostat, but this rheostat, placed in a pigeon-hole drawer under the wooden pedestal of the Morse, is composed of only three coils of very fine wire. Each of these coils is of a different resisting power; they are marked respectively—*very dry weather*, *ordinary weather*, and *thaw or bad weather*. This set of coils, or rather this rheostat thus composed, is arranged according to a proportion which we shall speak of shortly, and this proportion is fixed in accordance with a law based on the resistance, or part of the resistance, of the coils of the electro-magnets and of the line. By this method of construction of the rheostat, and by the differential adjustment of the apparatus, we have succeeded in

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Mining & Sci Press Nov 22 1879

Engineering, Dec 21, 183.

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BY S. W. DE SUSSEX.

[Polar]isation of the Poles of a Magnet.—If a permanent magnet [in t]he form of a horse shoe, has its arms prolonged by pieces [of soft] iron, the magnetic poles of the primitive magnet will be transferred to the extremity of the soft iron, that is to say, the south pole to *a*, and the north pole to *b* (fig. 1). Now direct a current around the soft iron bars B, by means of coils. The current will act upon the bars of soft iron fixed to the permanent magnet. If, at the moment when the current is passing through, we place a magnetic needle near the extremity *b* of the magnet A, prolonged by the soft iron bars B, we shall see this bar deviate considerably from its original position, indicated by fig. 2. And, if the current be of sufficient intensity, the needle will be reversed, its pole *b'* will turn towards *b*, thus indicating to us that at the extremity of the soft iron extension of the magnet A, and at *b'*, we have produced a southern pole, that is to say, at this extreme point, a complete reversal of the magnetism of the primitive magnet A. In other words, the two arms become by the passage of the current two electro-magnets, the communication of which, with the permanent magnet A, nevertheless, does not modify the poles of the magnet A. The same thing takes place in an opposite direction with the extension of the other pole, since we have taken for granted the simultaneous passage of the current in the two coils.

A magnetized Armature of Steel or Soft Iron is repelled from the Poles of a Magnet.—Let us place beneath the arms, and at a very short distance from them, an armature of soft iron, or of magnetized steel (fig. 2). At the moment of the passage of the current this armature is repelled. In fact, if the armature is of magnetized steel, and such that its north pole lies under the south pole, and its south pole under the north pole of the permanent magnet A, this armature, at the moment of the passage of the current, will be repelled by the prolonged poles of the magnet A, which, as we have shown, become of the same kind as those of the extremities of the armature of magnetized steel. If, on the contrary, this armature is of soft iron, it becomes, in fact, magnetized by the induction of the permanent magnet A, and its poles are similar to those in the case of a magnetized armature; thus, on the passage of the current, the same phenomenon of repulsion will be observed.

Application to the Construction of Telegraphic Receivers.—Let us remove the call-spring of a telegraphic receiver, and replace it by a permanent magnet prolonged by arms of soft iron surrounded by coils, as indicated in figure 2. We have fixed these coils in such a manner as that the circulating current shall polarise the prolonged poles of the permanent magnet A, whilst at the same time determining, in an electro-magnet placed below the armature, a magnetism of the same kind as that of the permanent magnet A. It is clear that we shall have obtained an attraction of the armature by the lower electro-magnet thus formed, at the same time having determined a downward repulsion of this armature, a repulsion due to the formation of the upper electro-magnets. This phenomenon will continue till the moment when, the interruption of the current withdrawing all magnetic action from the various electro-magnets, the permanent magnet A alone becomes active, and, being extended then to the extremity of the arms which prolong it, brings back the armature to its original position. There is here a differential action, and the equilibrium being well established by the adjustment of an instrument thus constructed, will allow us to work it with a very much reduced electro-motive force; since, whatever this force may be, there will always be attraction on the one hand and repulsion on the other.

Special Application of the Receivers.—It is in accordance with these observations and these data that we have constructed an instrument which can be adapted to ordinary telegraphic receivers. Here, for instance, is a description of this instrument applied to the Morse system. In the ordinary Morse instrument the point, by means of which the whole of the signals are reproduced on the paper which is unwound by the clockwork, is supported by a lever, which at its other end supports the armature of an electric magnet. This armature is kept at a distance from the electro-magnet by means of a small spring. When a current from the line passes into the coils of the electro-magnet the armature is attracted. On the other hand, it follows from our first explanation that if, instead of keeping the armature at a distance from the poles of the electro-magnet by means of a spring, we keep it at a distance by the permanent magnet A, we shall have a magnetic spring in place of a mechanical spring. But at the moment of the passage of the current this spring will be repellent, whilst below we shall have excited by the lower electro-magnet an attractive force. The armature will thus be doubly attracted, and will lower itself, and rise again only on the interruption of the current.

Explanation of Fig. 3, showing the whole of a[n instrument] furnished with the Apparatus.—Fig. 3 shows in principle the construction of our apparatus applied to a Morse receiver. A is the permanent magnet; R the regulator, of soft iron, working by means of a rack, in order to allow the force of the permanent magnet A to be increased or diminished at will. There is a screw which by means of a brass cross-piece is joined on to the permanent magnet A. The end of this screw presses against a support, and the magnet being fixed *à charnières*, we can, by means of this screw, at will cause the prolonged poles of the permanent magnet to approach the armature or retire from it. This screw, again, is furnished with a counter stop-screw, so that the working of the apparatus may not gradually cause the upper coils to slip down.

We dwell upon these details because the adjustment of the apparatus depends on this regulator and this screw. G is a copper cross-piece fixed on to the body of the Morse, and supporting the magnet and the two upper coils. T is a bar of soft iron joining the cores of the electro-magnet. P is the soft iron, or magnetised armature.

a. The extended southern pole of the permanent magnet A. *b.* Extended northern pole of the permanent magnet A. *a'.* Southern pole of the lower electro-magnet. *b'.* Northern pole of the lower electro-magnet. M. Case of the Morse.

Before going any further we will mention some experiments made with our apparatus:—

Correct Transmission through 30,000 Ohms.—We have succeeded in obtaining signals absolutely correct, through a resistance of 20,000 ohms, by making use of a rheostat belonging to Messrs. Latimer-Clark, Muirhead, and Co., of London. The number of cells employed was twenty-five Leclanchés, of seven centimètres in height. Sensitizing the apparatus by a careful adjustment, we succeeded in getting correct signals through 30,000 ohms. Another experiment was to make the apparatus work through a resistance of 1,000 ohms, with one small Leclanché cell. These experiments were made with the object of proving the sensitiveness of the apparatus.

Transmission through a Non-Insulated Wire.—A rather curious experiment was made at the Brussels Zoological Gardens, before fully competent persons. A bare copper wire of one-and-a-quarter millimètres in diameter had been unwound upon the ground, in the grass, the shrubs, &c., for the distance of a kilomètre. The earth-plates were of copper, laid horizontally, and measuring forty-nine square décimètres. The battery used was a small Leclanché of ten cells. The signals were transmitted very regularly, and we think that no more conclusive proof can be given of the sensitiveness of the apparatus and the small electro-motive force which it requires. It should be observed that, the day before this experiment was made, and the whole time it was going on, a fine rain was falling, such as is always detrimental to electric telegraphy. From the series of facts which we have just enumerated we gather clearly that the apparatus works at much greater distances than the various receivers with springs at present in use, and that it has the advantage of needing a much smaller electro-motive force than any of them.

Duplex working without Condensers.—But the advantages we have just mentioned are secondary. The apparatus possesses others far more important, which we will proceed to analyse, and the demonstration of which will form a sequel to the description of our apparatus. The first of these advantages is that it allows not only simple transmission with reduced electro-motive force, but also duplex working without condensers. Of course, we are not speaking here of submarine lines, or of aerial lines of too great length. Our experiments seem to impose upon us a limit of from 400 to 500 kilomètres, according to the lines.

Automatic Control of Messages.—Another no less important advantage is the power of automatically controlling messages. For a commutator added at the two stations enables us to transform the lever of the receiver into a manipulator, so that the sender can follow with absolute certainty the reception of the message by his correspondent, which is undoubtedly the most complete control to be possibly obtained.

Rheostat.—The apparatus is furnished with a rheostat, but this rheostat, placed in a pigeon-hole drawer under the wooden pedestal of the Morse, is composed of only three coils of very fine wire. Each of these coils is of a different resisting power; they are marked respectively—*very dry weather*, *ordinary weather*, and *thaw or bad weather*. This set of coils, or rather this rheostat thus composed, is arranged according to a proportion which we shall speak of shortly, and this proportion is fixed in accordance with a law based on the resistance, or part of the resistance, of the coils of the electro-magnets and of the line. By this method of construction of the rheostat, and by the differential adjustment of the apparatus, we have succeeded in.

Engineering, July 14, 1882.

New Method of Working Long Telegraphs.

In working long telegraph circuits where an automatic translator or repeater cannot be employed between two sections for the purpose of forwarding a message from one section to the other, it is customary to employ a clerk or operator to receive and write down the message arriving on one section and then pass it to another clerk who transmits it over the next section. In this process a great deal of valuable time is wasted by the writing of the message at the intermediate station, and a new system of personal translation has been introduced by Sir James Anderson and Mr. Benjamin Smith, of the Eastern Telegraph Company, to avoid this delay and facilitate the despatch of traffic by transmitting it direct while it is being received. Briefly described, it consists in causing the clerk who receives the message from one section to send it at the same time over the next section; so that while he is reading the message from the receiver as it comes he is also re-transmitting it further on its way, thus playing the part of a human relay or repeater as distinguished from an automatic relay. The new system, which has been already adopted on the submarine lines of the Eastern, Eastern Extension, and South African Telegraph Companies, has many advantages over the old system of working. These are in point of despatch of traffic, accuracy of transmission, and economy of labour and apparatus. First, with regard to despatch of business, the time at present lost in writing down the message received by one clerk, say from station A, and passing it to another clerk to be transmitted over the next section to station C, is entirely saved, for the clerk who receives it from station A is all the while transmitting it to station C himself, and thus the message gets to station C in the same time that by the ordinary system it takes to reach station B, thus traversing two sections of the line in the same time as is ordinarily occupied in traversing one. Greater accuracy of sending is insured by the fact of there being no intermediate copying of the message; and the clerk can give his whole attention to the reading and re-transmitting of the message. Further, by means of this direct personal translation, one clerk suffices to do the work of two in working lines by the simplex method; for instead of having one clerk to receive and another to transmit, the same clerk both receives and transmits simultaneously. Thus the translating station can be manned by half the usual number of operators. Where the duplex method of working is employed there is a still greater saving of labour, for ordinarily six clerks are necessary to work two duplex circuits, namely, three to each section, one to receive, one to transmit, and a third to look up errors for correction, so that the others may continue at their proper duties uninterruptedly. By the new system of Messrs. Anderson and Smith these six men are replaced by two, each receiving from one section and transmitting to the next without delay. A very much smaller staff is therefore necessary at intermediate stations, and a saving is effected in the expenses of the *personnel*, as well as in stationery and apparatus.

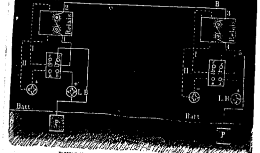
Transmitting Telegrams Simultaneously in Opposite Directions over a Single Wire.

The transmission of telegraphic signals simultaneously over the same wire in opposite directions was for a long time supposed to be utterly impossible. According to the old theory of electricity it was considered as a subtle imponderable fluid or force, and the conclusion was unavoidable that if two such fluids or forces of equal intensity meet in opposite directions they neutralize or annul one another. Some advanced minds, however, began to see a similarity in the mode of the propagation of sound, light, and electricity, and therefore suspected that the so-called electric current passing through a wire was nothing but a wave motion transmitted from atom to atom, with a velocity intermediate between that of sound and light, and that it would be subject to the same laws. It is known that sonorous waves are transmitted in long tubes in contrary directions without the least interference, that the different rays of light or luminous waves coming from the stars, and in fact from every luminous or illuminated object, intercross in an infinite number of ways and never interfere, and finally that the electric currents of thousands of telegraph batteries come back to the station from which they are sent, through the earth as their common conductor, without ever manifesting any trace of being influenced one by the other.

Besides the question of the possibility of conducting simultaneously several currents in the same or opposite directions over one single wire, there is in practical telegraphy still another difficulty to be overcome. As well in the Morse system as the printing and chemical telegraphs, an arrangement has been adopted by which every time a dispatch is transmitted, the recording instrument of the transmitting office is disconnected from the line, and only the instrument of the receiving office is kept in the circuit. If we wish to transmit and receive telegrams over the same line, at the same time, this arrangement must be abandoned, and the receiving instruments of both stations must continually be kept in the line, so that each may be ready at any moment to receive a dispatch from the other station. If this were done without further precautions, the current of the transmitting station would affect also its own receiving instrument, and it would record its own dispatches at the same time with those received from the other station, which would of course result in the most fatal confusion.

The problem to be solved is therefore this: The receiving instruments or relays must at both stations be in permanent connection with the line, without being affected by the current of their own battery when messages are sent out.

This problem was first solved by the director of the Austrian telegraphs, Dr. Gintl. His arrangement is represented in the annexed figure. Each relay of the apparatus A and B is provided with two mutually independent coils, of which the interior one as usual is connected with the line and its battery; the exterior coil however, consisting of thicker wire, is connected with a compensating battery, in such a way however that the batteries, when the current is closed, throws a current around the electro-magnet in opposite directions, and so equal that they neutralize one another in their magnetic influence and do not affect the iron core at all.



DUPLEX SYSTEM OF TELEGRAPHING.

In order to accomplish this simultaneous closing and opening of the circuit for both batteries, a double key, over $a\ a'$, has been introduced, consisting of two single levers mutually isolated one from the other, but in its fore part connected by an isolated cross-piece. The double key has one single knob, by which both levers are simultaneously depressed and brought in contact at the same instant with the points $a\ a'$ underneath. In the state of rest these levers, which have their turning point or axis and connection in $b\ b'$, (just above $a\ a'$,) are in contact with the points $c\ c'$. The key at the right side, as is customary in the Morse system, is connected with the line battery L B, the relay, and the wire, as well as with the earth. The key at the left, on the contrary, is connected with the compensating battery and the exterior relay coil.

Now if at the station A the double key is depressed, the line battery L B and compensation battery are closed at the same time, the current of the first goes from + along a' b' and 1, through the inside coil of the relay through 2, over the line to station B, and here by 3 through the relay over 4, b', c', 5, ground connection P, subterranean conduction to P of station A, and to the — pole of its line battery L B. At the same time the current of the compensation battery at the left goes from the + pole over a, b, 1, through the exterior coil of the electro-magnet and II to the — pole of the battery. The relay A is therefore influenced by two currents in opposite directions, while the relay B is only affected by the current of the line battery of station A.

It is easy to arrange the strength of the batteries and the length of coils in such a way that the effect of the two opposite currents on the relay will be perfectly neutral. Notwithstanding the relay of both stations is in the circuit, that of the transmitting station A is not affected, while the compensation battery here neutralizes the action of the line battery. The latter sends its current undisturbed to the receiving station B, when it magnetizes the relay, and so sets the writing apparatus in operation.

If now at station B the double key is depressed at the same time as at station A, then the current of the line battery goes here also (the same as in A) through the inner relay coil and the line wire to A, at the same time however the current of the compensating battery goes through the outer coil of the relay, and these two currents neutralize one another in the relay of station B; wherefore this is only affected by the current of the line battery coming from A, in the same way as the current from the line battery at B acts on the relay at A, therefore in both stations the instruments are recording the messages of the opposite station at the same time, and not their own.

It must be remarked however that when in A and B the key is depressed at the same instant, the current of the line battery in A takes another course in B than is the case when the key in B is not depressed. In the latter case the line current coming from A passes through 3, the inner relay coil, 4, b', c', 5, P, earth; in the former case (when the key in B is depressed) this current goes from 3 through the inner relay coil, 4, b', a', and through the line battery to the earth. It is the same in station A in regard to the currents coming from the line battery in B.

The practical tests with this arrangement have shown that the neutralization of the relays at the transmitting offices was the only condition to be satisfied, and that the opposite currents in the line of telegraph wire itself did not interfere or destroy each other, but crossed one another like two waves of sound, which is a strong argument against the old doctrine of electric fluid, and in favor of the modern theory that it is a mode of motion in ponderable matter, of a different nature however as in the case with heat, of which the mechanical nature may now be considered as one of the best established principles in the field of physics.

Duplexing the Atlantic Cable.

The simultaneous transmission of two telegraphic messages in opposite directions upon one wire, now known by the name of duplex telegraphy, dates back from the year 1853. In that year Dr. Gintl, the director of state telegraphs in Austria, described a method by which this feat could be accomplished, and in July of the same year the method suggested by Gintl was tried between Prague and Vienna. An improvement on this method was suggested by a German electrician, Frischen, by Messrs. Siemens and Halske, of Berlin, and other workers at this subject. Nevertheless, owing to practical difficulties, the experiments were little more than interesting additions to our knowledge. So little hope, indeed, was there of the practical realization of this important matter that, in a standard work on telegraphy, published in 1867, after describing the early methods of duplex telegraphy, the author remarks: "Systems of telegraphing in opposite directions, and of telegraphing in the same direction more than one message at a time, must be looked upon as little more than feats in 'intellectual gymnastics,' very beautiful in their way, but quite useless in a practical point of view." Such assertions should teach all scientific writers the lesson of "hoping all things not impossible, believing all things not improbable," an attitude of mind which, Sir John Herschel remarks, should always characterize the natural philosopher, and which, in the present day, is certainly the safest one. Within six years of the publication of the foregoing statement duplex telegraphy was not only largely employed in actual telegraphy, but its use on certain busy lines became absolutely indispensable. The change from theoretical to practical success is due to an American, Mr. J. B. Stearns, who, in 1872, succeeded in overcoming the main obstacle in duplex telegraphy, namely, what is known as the static discharge from the line. This Stearns accomplished by using a "condenser;" and further, he developed a system of "duplexing" the line similar to the principle of the Wheatstone bridge.

More or less successful attempts were afterwards made to duplex submarine cables, and in the early part of 1877 Mr. J. Muirhead succeeded in duplexing the cables of the Eastern Telegraph Company by his artificial condensers. But we believe that his success was only partial. Subsequently Mr. Muirhead has been at work duplexing the Direct United States Cable, with some prospect of success, and lately Stearns, who may be called the father of duplex telegraphy, has actually achieved the great feat of perfectly duplexing

[DECEMBER 21, 1878.

the Anglo-American cable. In a message received by Mr. W. H. Preece, Mr. Stearns says, "I managed to get some specimens for you this morning, though we had no time to make the balance especially perfect for the purpose."

All the messages now sent across the Atlantic are automatically registered by means of Sir W. Thomson's delicate and beautiful siphon recorder, which spirts out little jets of ink in a fine stream on a moving ribbon of paper. When no current passes the ink marks form a straight line, but a current causes this line to deviate to the right or left, according to the direction of current. Hence the ordinary right and left strokes of a needle instrument, or the long and short dashes of a Morse, are indicated by marks above and below the middle line.

The essence of duplex telegraphy is to obtain an electrical balance round on the line, such that the sending instrument is not affected by currents circulating round it coming from the sending end, but only by currents received from the opposite end, and *vice versa*. Hence, if the balance be once obtained, double transmission is possible. This balance Stearns has succeeded in obtaining by the use of his system as applied to land lines, and without the aid of the additional arrangements of artificial condensers used by Dr. Muirhead.
—*Nature.*

59

Duplex Telegraphy.—Mr. Muirhead has recently successfully applied his duplex system of working telegraph lines to the cable from Madras to Penang, a length of about 1,300 miles. This extension of the system makes a total of about 10,000 miles of cable worked upon Mr. Muirhead's system, and we understand that, so far, it is the only successful method whereby long submarine cables are practically worked on the duplex principle. The Eastern Telegraph Company have for several years employed this system for working the traffic on all their trunk lines, and the latest extension, above referred to, carries the working as far east as Penang. Duplex telegraphy consists in a method of sending two messages on the same wire at the same time in opposite directions, and Mr. Muirhead's system was fully described in the *Times* about a year since.

Jan 79

MR. EDISON. — This inventor filed his bill in the Supreme Court of the District of Columbia, some days ago, against the Western Union Telegraph Company for an injunction to restrain infringement of patent for improvement in duplex telegraph, to establish title, &c. This is another remedy for an injury which has been complained of by Edison in other suits. It will be heard early next summer. Dec/79

The Canadian Elec. News. Jan 1/81

A SINGLE POLE QUADRUPLEX.

We have the pleasure to place before our readers a description of a Single Pole Quadruplex, which has just been invented by Superintendent B. B. Toye, of the Great North Western Telegraph Company's service at Toronto. We understand the patents have been applied for, as we are confident from the serviceable appearance of the innovation, that this new Canadian invention will be adopted everywhere in America and Europe.

We think the arrangement of Arm X a very pretty one, where it cuts out a magnet, when it is required to be cut out, and cuts it in again, when it is necessary to be in, and both by *a stroke in the same direction.*

The apparatus works remarkably well on a short line; and will, no doubt, do all that is anticipated, when introduced on a main business circuit.

We understand Mr. Toye has given this invention most of his spare time during the past six months, overcoming one difficulty after another, and in many cases "overcoming a difficulty" means introducing another, in another place. Thus it seems the main parts of this new invention are nearly as simple as a Repeater. We are pleased that a Canadian gentleman should be the first to invent this improvement, and we wish him all the success he merits.

60

STEARNS' SUBMARINE CABLE DUPLEX SYSTEM.

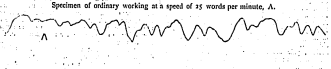
THERE can now be no doubt that submarine duplex telegraphy has fairly passed the experimental stage and is a practical success even as regards long cables. The difficulties which stood in the way of duplexing the long ocean cables seemed almost unsurmountable, and the feat was judged by many to be impossible. The success which has attended the labours of Messrs. Muirhead and Stearns, has practically set the matter at rest, and it is practically demonstrated that the longest cable ever likely to be laid can be duplexed. Very little is at present known of the details of the methods employed for effecting the end in view, in consequence of the question of the patent rights involved not having been settled; but we hope soon to make them clear.

As is well known, Mr. Stearns has lately turned his attention to the subject of duplexing the Atlantic cables, and has had complete success. We are able, through the kindness of Mr. Stearns, to reproduce some specimens of the records very recently obtained on the 1873 Atlantic cable duplexed by his system. The difficulty of preserving a balance with such a sensitive instrument as the Siphon Recorder must be evident, and the fact that the cable has now been working for more than two months, speaks well for the system.

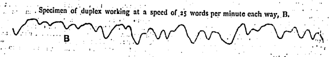
The speed which has been obtained experimentally is as high as 50 words per minute, that is 25 words each way. This latter is as great a speed as can be obtained when working in the ordinary way.

The following fac-simile copies of the Recorder slip will shew that the signals are as perfect as can be wished :—

Specimen of ordinary working at a speed of 25 words per minute, A.



Specimen of duplex working at a speed of 25 words per minute each way, B.



MULTIPLE TELEGRAPHY.

THE following is an abstract of a lecture at the Royal Institution recently delivered by Mr. W. H. Preece. In commencing his lecture Mr. Preece said:—Many of you, in your rural rambles, may, during a moment of reflection or thoughtlessness, while standing on the parapet of a rustic bridge, have dropped a stone into the river flowing below, and have noticed the rings of waves projecting outwards. If at the same moment a hungry fish, in his desire to satisfy a natural craving, should dart or snatch at a fly on the surface of the water, a second series of rings of waves would be produced, and in such a case a careful observer would notice that where crest of wave meets crest of wave, there is a higher crest formed, and where hollow meets hollow a deeper hollow is formed. This super-position of wave on wave is called interference, and the interference of undulations plays a most important part in the phenomena of sound, of light, and of electricity. In electricity, wave upon wave can be super-imposed, either in waves flowing in the same direction or in waves flowing in opposite directions. The usual indication of the presence of electric waves is either by the attraction of a magnet or by the deflection of a needle. Here is a needle that is subject to the action of the passage of such waves of electricity. I send a current of positive electricity through the wire surrounding the magnet to which this needle is attached, and you see I get a certain deflection; I increase the strength of that wave by super-imposing another wave, and you see I increase the strength of the deflection. In the same way, if I reverse the direction of the current and send a negative current, I get a wave of certain strength, and if I double the strength of the current I get a stronger deflection. But if, instead of super-imposing one wave on the other in the same direction, I send one wave in one direction and another wave in the opposite direction, we get neutrality. This neutrality is a phenomenon corresponding very much to silence in sound or to darkness in light. Advantage is taken of this neutrality in duplex and quadruplex telegraphy in a way in which I will show you. It is usually imagined by those who think of duplex telegraphy that something crosses or passes in the same way that railway trains pass or cross each other. It is not at all necessary to conceive that anything whatever passes. For instance, here I have some glass balls placed in a row between two parallel wooden rods. If I take the ball at one end, say No. 1, a short distance from its normal position, and drive it along the rods back again, you will notice that a something, a form of force, passes through the other balls, and the one at the far end is by this developed motion forced a distance away from its neighbours. The same thing occurs if I take No. 12, No. 1 is displaced by the concussion. This resultant motion represents, and may be called, a telegraphic signal. If I am skilful enough to take No. 1 and No. 12, and let them return together, we shall see that they are both driven back simultaneously, the intervening balls remain undisturbed, and two such signals will be made. It is this latter phenomenon that I wish you to bear in mind as being analogous to the principle used in duplex telegraphy.

The next fact that I wish to impress upon you is that if a current of electricity have made paths open to it, it will always separate or spread itself among those paths in inverse proportion to the resistance which each opposes to its progress. The greater the resistance the smaller the current; the less the resistance the greater the current. If we have two paths or lines open to a current, and these two lines

61

be of exactly equal resistance, the current will divide itself between them in exactly equal proportions. The next point, almost as self-evident as the previous one, but which time will not allow me to illustrate by experiment, is that the magnitude of the magnetism produced in the electro-magnet is simply proportional to the strength of the current passed through the magnet. The next and last elementary fact I have to bring before you is that the polarity or direction of the magnetism simply depends upon the direction of the current. On the wall I have two electro-magnets corresponding to each other. Around each are coiled two wires of exactly equal length and equal resistance. If I send a current through one of the wires I produce a deflection in one direction; if I send a current through the other wire I get a deflection in the opposite direction. You can imagine that one of these magnets is in Brighton and the other in London, with the connecting line wire between them. I want to arrange matters so that when I make a signal at Brighton I shall not in any way affect my own instrument, and to do so I divide my current in halves; one half goes through one wire of the magnet, and tends to deflect the needle in one direction, and the other half goes through the other wire of the magnet, with a tendency to throw the needle in the opposite direction. If by an arrangement, an artificial line or otherwise, I make these two halves exactly equal, no deflection of my needle takes place; but at the same time I do influence Brighton's needle. This gives us the first principle of duplex telegraphy. Of course, with a similar arrangement at Brighton, on the key at that end being depressed and a current divided in half sent through the electro-magnet, the needle there remains unaffected, while at the same time the needle at this end is deflected. Under these conditions, when currents are sent from both instruments signals or deflections are noticed at each station. It is by using resistance that we are able to make an artificial line attached to the second wire of the electro-magnet exactly equal to the line wire attached to the other wire of the electro-magnet. I have in a box here resistance equal to three or four hundred miles of line. Resistance is measured in ohms, an ohm being a unit used by electricians, and which represents about a yard of fine platinum wire, or about one-tenth of a mile of ordinary iron wire. The resistance contained in this box is divided into quantities ranging from one to two thousand ohms, any portion of which can be brought into use by simply taking out pegs representing the amount required. With this ready means at hand you will easily comprehend the facility with which a balance can be adjusted, and the opposition to the two halves of the current passing through the electro-magnet made equal. Whatever the distance of the line, whether between here and the Central Telegraph Station, or between here and Calcutta, or any distant place to which you choose to exert your imagination, the effect is just the same. To show you this system in actual working I have here instruments joined to a wire which passes through the streets to the Cental Telegraph Station in the city. It is just as easy for us to connect a wire up in actual operation as to have assistants secreted in the adjoining room, which is sometimes supposed to be the case. I must first of all explain to you how telegraphic signals are interpreted into ordinary language. It is by meant of what is known as the Morse alphabet, which consists of combinations of dots and dashes used to represent the ordinary letters. A dot and a dash, for instance, represent *a*, a dash and three dots represent *b*, dash dot, dash dot *c*, and so on throughout the alphabet. A dot itself is represented on the instrument before us by a short sound or beat, and a dash by a longer one. The sounds caused by the signals appeal to the consciousness through the ear, and are translated into the proper language. (The central station was called up, and a message was sent to him at the same time that one was being received from him, in illustration of duplex working.) The operation which you have just seen going on exactly corresponds with that which I described. The division of the current is arranged at each end by the use of a resistance box or "rheostat," and signals are sent without any interruption the one with the other. The duplex system of telegraphy is employed to a very large extent in this country, no less than 320 circuits being so fitted. The system is applicable to long and short lines, and even long cables in Red Sea, Indian Ocean, and across the Atlantic (in one case 2,400 miles long), have been successfully so fitted. Its application enables really more than double the amount of work to be done. This happens from the fact that no interruption arises from repetitions being required or questions asked, but the messages pass in a continuous stream in opposite directions almost without let or hindrance.

I would just mention another thing in answer to any who are surprised at errors taking place in the transmission of messages. The signals representing certain letters are very similar, and it is very easy for a faint dot to be missed or a short dash to be misinterpreted for a dot, and as the difference between the letter *t* (represented by a dash) and *r* (represented by a dot, dash, dot) is simply two dots, you will not be surprised at a message, informing some friends of the arrival of a party of ladies, "all right," was delivered as "all tight." And, again, a friend of mine in Manchester, whose wife wished to inform him that the "rush was all gone," was astonished to receive an intimation that the "cash was all gone." Many of these errors are simply due to the failure of a dot or the shortness or breaking of a dash, and the wonder is that with the more than one hundred million messages which are despatched every year in this country the percentage of errors is not greater than the small amount it is. I hope that, after the practical illustration you have just had of the extreme care and exactitude which is attendant on the accurate receipt of signals, you will deal lightly with errors of conversion of words such as "rush" into "cash," "right" into "tight," &c.

We have now to deal with another class, and that is called diplex telegraphy. Duplex telegraphy means sending two messages in opposite directions at the same time; diplex means sending two messages at the same time in the same direction. I have here two little instruments which give out their signals in musical tones, and I have also two keys attached to a battery in connection with them. There is only one wire between them. If I press down, say, key No. 1 I call up the sounder which emits a deep tone; if I press down key No. 2, I obtain a response from the sounder with a tone an octave higher. If I press both keys down at the same time both sounders answer, and whichever key is depressed it is always answered by its proper sounder. This power of sending two signals or messages at the same time in the same direction is called diplex telegraphy. It is difficult to explain how this is performed without the aid of a diagram, and it really requires some amount of courage to attempt the feat. Currents of electricity are developed in two ways; they differ in the direction in which they flow and also in their strength. The key on my right hand simply reverses the direction in which the currents flow every time it is depressed; the other key simply increases the strength of the current flowing, whatever may be its direction. A relay is also employed, which responds to a reversal of the current whatever its strength may be; and another relay responds to the increased strength of the current whatever its direction may be; so that on depressing the key to which the deep-toned sounder responds I send, say, a positive current; and if I touch the light sounder key I simply make that sounder speak by increasing the strength of that current. The same effect would be produced if I first sent a negative, and caused one sounder to respond, and then by increasing the strength of that negative current the other sounder would respond. The one relay is affected only by a strong current, while the other relay is affected by a strong or weak current, and is, therefore, influenced by either strong or weak reversals. (Mr. Preece here very minutely traced the different currents from the battery, through key and relay to sounder, so as to produce sounds by currents, varying in either direction or strength, and acting upon one or both sounders at the same time, or separately at will.) The increase of current was brought into action by means of the one key having attached to it a greater proportion of cells of the battery. That is diplex telegraphy.

How is this diplex used for quadruplex working? I showed you in diplex working that we simply split the current in two paths made exactly equal to each other. It matters not whether we have one or any number of relays in. Theoretically, it is possible to insert a great number relays, but practically only two are used; and in quadruplex working we simply duplex what I have called the diplex arrangement. On one end of the table before you we have two sides of the quadruplex, or one diplex; and on the other end of the table we have the other side of the quadruplex which also works diplex, and by this apparatus we are able to send four messages at the same time on the single wire, which you see goes from the table to the wall, and so proceeds to the Central Telegraph Station. The system, although difficult in description, is really wonderfully and beautifully simple, and if it were only requisite to follow out what I have just said, quadruplex working would be a very easy matter indeed. But there is such a thing in England as a climate, and there also is unfortunately such a thing as rain, and rain interferes considerably with the action of our duplex and quadruplex working. In a word, the effect of rain is precisely the same as reducing the length of our line. Supposing we have a wire between Liverpool and London, about 200 miles long, then when we have rain it covers the insulators with moisture, and the moistened insulators allow the current to escape to earth, and the result is just the same as though the line itself were reduced in length; and to compensate for this it is necessary to take out resistance equal to the loss. But by means of the rheostat it is not a very difficult matter to adjust a balance, and by carefully noting and watching storms of rain, snow, sleet, or fogs and mist, which are so troublesome to the working, a clerk has simply to vary his rheostat, and can so maintain working on wires of ordinary length. When we come to very long lengths of wire the weather disturbance becomes serious. There is another disturbance besides that produced by rain or weather, which is due to the existence in a telegraphic line of what is called electrostatic induction. This is a very hard word, but it really means something similar to the effect of friction in pipes on the flow of water or gas. When gas or water is forced through pipes, a quantity of it adheres to the sides, and produces a diminution of pressure due to friction. So, when we try to force electricity through a wire, a quantity of it adheres, as it were, to the sides of the wire, remains there as a charge, and diminishes the action of the current, and produces what is called retardation in signals. Retardation means really reducing the rate at which we work. If it is possible, say, between London and Aberdeen to work as fast as ever we like, when we attempt to work over a long submarine cable the speed diminishes very greatly indeed. Between London and Cork, and between London and Aberdeen we are at the present moment working practically as fast as the instruments will run, at the rate of about 160 words a minute, while through the Atlantic cable, with all their skill, they cannot work at more than 25 words a minute, and this is due to the disturbing element of electrostatic induction. To compensate for this it is necessary to make your artificial line exactly similar in all respects to your real line, and, with duplex circuits, this is done by inserting, in addition to the rheostat, a condenser. A condenser is simply a series of leaves of tinfoil separated by paraffined paper. A series of alternate paraffined papers and tinfoil readily comprise a Leyden jar, and such a Leyden jar would have the capacity of retaining a charge similar to that retained by the line; and it is only necessary to increase the size of the condenser until the same electrostatic capacity in it is obtained as is experienced in the line itself. Here is a condenser which has not the appearance of being a very formidable instrument, but it has sufficient electrostatic capacity to compensate for a line about 200 miles long.

We have in England at the present moment six circuits worked upon the quadruplex system. In America the system is carried out to a much larger extent, and sixty-three wires are fitted with it, and over these sixty-three circuits no less than eight million messages are transmitted annually. The question may arise in your minds as to why the quadruplex apparatus is not used as extensively in this country as in America, and the answer would be that in this country we have not the necessity for it. We have apparatus in use superior to the quadruplex. I mean the Wheatstone automatic, an instrument which was in its early stage brought before an audience of this institution. It enables us to transmit messages and news with enormous rapidity, and makes us quite independent of any of those supposed advanced inventions.

THE DUPLEX SYSTEM ON CABLES.

Sir,—I have read in your and other journals accounts of the lecture (which I had also the pleasure of hearing) recently delivered by Mr. Preece on the subject of Duplex Telegraphy before the Society of Arts. As it appears to me that an incorrect impression is likely to arise from certain statements of the lecturer, I beg to forward you for publication a copy of a letter I have sent to Mr. Preece,

And remain, Sir, yours faithfully,
J. MUIRHEAD, Junr.

29, Regency Street, Westminster, S.W. *May* 28, 1879.

"Dear Sir,—I was much surprised to hear you say in your lecture on Monday evening before the Society of Arts that, although I 'had duplexed some of the cables of the Eastern Telegraph Company in the Mediterranean and Red Sea on Mr. Stearns' principle, Mr. Stearns had only recently succeeded in duplexing one of the Anglo-American Company's Atlantic Cables.'

"The inferences naturally drawn from this statement are, first, that in duplexing the Mediterranean and Red Sea cables I had either infringed Mr. Stearns' patents or used them with his consent. Secondly, that I had not duplexed any one of the Atlantic cables, or any of the long cables east of the Red Sea.

"Now it is within your knowledge that I absolutely deny using any of Mr. Stearns' patents, and that for years past I have challenged that gentleman to take legal steps to decide and enforce his claims, but he has not thought fit to accept the challenge, or take any action in the matter.

"It is, I think, also known to you that besides duplexing several cables of the Eastern Telegraph Company in the Mediterranean and in the Red Sea, I have successfully duplexed the following long submarine cables:—

"Suez to Aden	1,500 miles	in 1876.
"Aden to Bombay ...	1,800 "	" 1877.
"The Direct United States Cable, being the longest cable in existence	2,400 "	" 1878.
"Madras to Penang ...	1,300 "	" 1878.
"&c.		

"Altogether my system has been applied and was in use upon upwards of 10,000 miles of cable before Mr. Stearns had succeeded in his long protracted efforts to establish duplex on an Atlantic or other long line.

"The method I adopt is distinctly described in my patents and has frequently been fully explained in the scientific and other journals, whereas, we are not yet informed of the means Mr. Stearns has recently employed to duplex one of the Atlantic cables; and it will be obvious to any disinterested electrician, who compares my specifications with those of Mr. Stearns, that I use no part of his inventions, as specified in his patents, but an apparatus, the novelty of which is not, and cannot be, disputed.

"You stated also in your lecture that Mr. Stearns had succeeded in obtaining twenty-five words per minute on the Anglo-American cable (1,800 miles). If you will be good enough to refer to the Telegraphic Journal of May 15th, 1878, you will find it recorded that upon the Direct United States Cable (six hundred miles longer than the Anglo-American) I obtained a speed of twenty-five words per minute. Now our sending twenty-five words per minute on a cable 2,400 miles long is practically the same thing as sending about forty words per minute on the shorter cable 1,800 miles long.

"I do not ask you to accept my unsupported statement as to the essential difference between mine and Mr. Stearns' system. Sir William Thomson, Mr. Varley, Professor Jenkin, Mr. Latimer Clark, Professor Ayrton and others of the highest authority in the telegraphic world, have given their opinion that my method is quite distinct from what Mr. Stearns claims by his patents.

"Having regard to these well-known facts, I think I have some ground of complaint (as well on my own account as on that of my friends associated with me in the matter) in that you should have omitted to mention in your lecture upon the subject of duplex telegraphy the important work we had accomplished long before Mr. Stearns was able to duplex the only long cable he has ever been successful with, viz., the Anglo-American, and that you should have, in face of the high authorities I have cited to the contrary, stated as a fact that I had used Mr. Stearns' inventions.

"I trust you will do me the justice to read this communication at your next lecture, in order that some of the misapprehensions created on the last occasion may be removed.

"I also request the favour of this letter being published with your lecture in the proceedings of the Society.

"I am, dear Sir, yours faithfully,
"J. MUIRHEAD, Junr.

"W. H. Preece, Esq.,
"General Post Office, E.C.
"*16 May*, 1879."

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FIG.4.

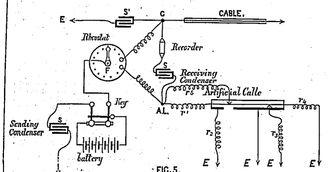

FIG.5.

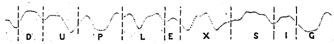

Fig. 6.

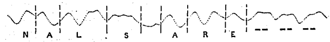

Fig. 6A.

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NEW YORK, JUNE 1, 1879.

DUPLEXING OCEAN TELEGRAPH CABLES.

ONE of the most important of recent advances in practical telegraphic operation is the duplexing of long ocean telegraph cables. The obstacles encountered and the difficulties to be overcome to accomplish this were numerous, and of such a character as at times to be discouraging. The problem of duplexing submarine cables was a much more difficult one to solve than even that of quadruplexing land lines. It was believed by even able electricians that so great were the obstacles encountered and to be overcome, that success was practically impossible. But scientific skill, experiments and persevering labor have been successful in solving even this most difficult problem, and there have been duplexed already nearly 15,000 miles of submarine telegraph cable. Among these are some of the longest cables operated, including the Direct and one of the Anglo-American Atlantic cables. After this practical solution of the problems involved, and with the experience already acquired, there will hereafter be no serious difficulty in duplexing any ocean telegraph cable whenever it shall become necessary.

Mr. Joseph B. Stearns has been engaged for some time in this work, and is to be congratulated upon the success which has finally crowned his labors. Dr. A. Muirhead, an English electrician and engineer of ability and reputation, has also devoted much time and study to the subject. To Stearns and Muirhead is the world mainly indebted for the successful application of the duplex system to submarine telegraphy. Many others have also been engaged in the work, and by the information derived even from their failures, final success has been facilitated.

In all, Dr. Muirhead claims that, assisted by Mr. Herbert A. Taylor, C. E., he has successfully duplexed some 10,000 miles of cable, which includes the Direct United States, and all the long cables of the Eastern Telegraph Company between England and Bombay. The first cable duplexed by the Muirhead system was the Marseilles to Bona section, in 1875; the latest was the Madras to Penang section of the Eastern Extension Telegraph Company, in the latter part of last year. Mr. Stearns has already successfully duplexed one of the longest cables of the Anglo-American Company, and it is understood will soon apply his system to the other cables of that company. At the last annual meeting of the company the chairman stated that the result had been to practically double the capacity of the duplexed cable for business.

It is claimed by Mr. Stearns that the Muirhead system is an infringement upon his patents, and it is understood that proceedings have been commenced by him to determine and establish his legal rights in the premises. The public, however, have but little interest in these legal complications, it is the success of the system that mostly concerns it.

The importance of this improvement will be appreciated in view of the great cost of making and laying cables, and of the fact that it nearly doubles the actual working capacity of cables already laid. The increased amount of business which can thus be transmitted within a given time, and the reduced demand for the investment of capital, will eventually reduce the expense to the public of ocean telegraph service. An increase of business is thus provided for without the necessity of duplicating cables at a large investment of additional capital. With the existing Atlantic cables duplexed and maintained in good working condition any probable increase of business for years to come can be met without the necessity of laying additional cables.

The details of Mr. Stearns' cable duplex system have not yet been made public, but we hope before long to be able to publish a description of it. The following extract from a description of the Muirhead system, prepared by Dr. Muirhead, and now being published in *The Telegraphic Journal*, will give the reader briefly an idea of the means by which the desired result is effected by him. He says:

"The system includes both a novel artificial line or model cable, and various adjustments for bringing the first part of the artificial line into close equivalence with the first few knots of the cable, and for perfecting the balance generally. Like a real cable, the artificial line is a continuous conductor of uniform capacity throughout its length, and is best named an induction resistance. It is formed by taking two strips of tinfoil and laying one over the other, but separated from it by a film of insulating material such as paraffined paper. One strip forms the conducting circuits of the artificial line; the other forms the outer or induction coating, and is connected to earth. The current is passed through the conducting strip or sheet in the same way that the current in the conductor of a cable is subjected to induction on the earth."

Engineer July 1879

4600. DUPLEX AND QUADRUPLEX TELEGRAPHY, *J. Muirhead, jun.—Dated 12th November, 1878.—(A communication.)* 8d.

The improvements in duplex telegraphy consist in placing the battery between the true and artificial lines, and connecting the receiving apparatus between the middle of the battery and earth. In order to give a signal the battery is reversed. Thus, supposing copper to be connected to the true and zinc to the artificial line, while the key is at rest, the depression of the key will join zinc to the true and copper to the artificial line.

Engineer & Mining Journal Sep 7 1878

NEW MODE OF DUPLEX TRANSMISSION.*

Engineering & ~~By O. Morel.~~ Journal Sep 7 1878

Duplex transmission, based upon the differential system, presents the following inconvenience: if the resistance of one of the differential circuits alters, the current augments in the one and diminishes in the other. Now these two effects combine, and consequently this kind of transmission is more affected than the ordinary transmission by the variations of the resistance of the circuit. The author states that he has sought to remedy the defect in the following manner:

Two relays, the one with a polarized armature, have their coils in circuit with one pole of a local battery and with the line, the polarized relay being next the line. An operating key is connected to the circuit between the two relays. The armature contacts of the relays are connected through a local battery, the poles of which battery are also connected through the coils of the receiving instrument. The contact levers of the two armatures are connected to earth.

From the description it is easy to see that so long as the levers of the two armatures are in connection with their contacts no current will pass through the receiving instrument, and if either of these levers quits this position, the circuit of the local battery will be closed in the receiving instrument. The lever of the operating key, when at rest, communicates with earth; when it is depressed or raised, neither of the relays acts; but in both cases the circuit of the line battery is closed from traversing the bobbin of the unpolarized relay, the armature of which remains always attracted. For the other part, the polarized relay is previously arranged in such a manner that the passage of the current from the line battery does not cause the displacement of its armature.

A station will then be able to transmit without reproducing its signals on its own receiver, and this receiver will nevertheless receive the signals of the station corresponding.

The batteries at the two stations presenting to line poles of the same name, if the operating key at one end is at rest, the current from the opposing station will produce an effect upon the polarized relay inversely to that of the battery at its own end of the line, and its armature is displaced by, and the receiver will reproduce the signals made by, the station corresponding.

If the two stations work simultaneously, the currents emitted annul themselves, and the armature of the unpolarized relay ceasing to be attracted, the receiving instrument will still reproduce the signals sent by the opposing station. The experiments that the author has made with the Morse have been successful, and show that the return current does not produce important perturbations; and, in fact, the polarization of the relay nearest to the line having been over-excited by the passage of the current of the line of battery, the return current has no other effect than re-establishing the magnetism to its normal state. This system does not absolutely necessitate the use of a condenser. Though the different actions of the relays are made in a satisfactory manner with the Morse, they are not produced with sufficient strength to allow of their application to the Hughes receiver. There are, at certain times, delays that can be avoided only by making the relays more sensitive, and in this case the equilibrium is very unstable. The author has also tried the following arrangement: The receiving instrument has a double coil, the one in circuit from the transmitter (mechanically stamped paper) to line, the other in circuit from the transmitter to one pole of a battery, the same pole of which is also connected to the transmitter through a rheostat; the other pole of the battery is connected to earth. The lever of the transmitter, when in repose, is in connection with an earth contact, and the circuit of the battery is closed locally. One part of the current passes by the helix between the battery and the transmitter, the other part by the rheostat, or shunt, also placed between the battery and transmitter. This shunt permits the augmentation or diminution, at will, of the force which keeps the armature attracted. When the lever of the transmitter is raised, the current goes to line by traversing the helix in circuit between the transmitter and line in such a manner that the armature remains attracted. It results, that one is able to transmit without receiving his own transmission. When the two stations transmit simultaneously, currents are annulled and the armature raises itself. When the opposing station alone transmits, its current traverses the helix in circuit between the transmitter and line in an inverse manner to that of the battery at its own end, and the armature is still raised. They will receive, in the two cases, the transmission from the station corresponding; but the return current also releases the armature. P. H.

* Abstract of a paper in *Annales télégraphiques*, 1877, pp. 401-405. From the Proceedings of the Institution of Civil Engineers, edited by James Forrest, Secretary.

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~~Journal of Tel~~
Telegraphic Journal July 15 1879

MUIRHEAD AND WINTER'S QUADRUPLEX SYSTEM (FOR LAND-LINES).

As is well known, the solution of the problem of quadruplex telegraphy depends upon a successful system of "diplex" telegraphy; that is, a method of sending two messages in the *same* direction at the same time; this system being obtained, the duplexing of it is an easy matter. Messrs. Muirhead and Winter in their system of quadruplex telegraphy have employed a somewhat novel method of "duplexing" their "diplex" system, which is worthy of publication.

FIG. 1.

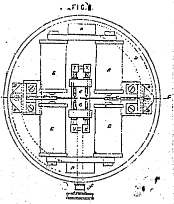


FIG. 2.
Section thro C. D.

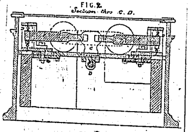
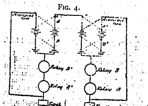


FIG. 3.

FIG. 4.



In the diplex arrangement at the transmitting station the two keys are so arranged in connection with batteries that in the several positions of the keys the battery strengths flowing out to the line are as follows :—

Both keys at rest,	+ 3
Key B depressed, A at rest,	+ 1
Both keys depressed,	— 1
Key A depressed, B at rest,	— 3

The arrangement of the keys and connections by which this is effected will be described further on.

At the receiving station there is a polarised relay adjusted to break the local circuit when the current is plus, and to complete it whenever the current becomes minus; a local sounder or other receiver connected with this relay records the depressions of key A.

There is also in the main current at the receiving station a double tongued relay, which is used for completing the circuit of the sounder or receiver intended to respond to the movements of the key B.

This double relay, which forms an important feature of the system, is so arranged that in order that the local circuit should be completed, it is necessary for both tongues to be against their respective contact points. To accomplish this either the tongues are insulated and the contact between tongue and tongue caused to be completed through the contact points, which in this case are connected electrically with each other, or the contact points are insulated and the contact between point and point is completed through the tongues, which in this latter case are of course connected together.

The polarity and adjustment of the tongues is so arranged that the contact between one tongue and its point is only broken when the current is + 3, and that between the other tongue and its point is only broken when the current is — 3. With the intermediate strengths of + 1 and — 1 both tongues are in contact with their points, and the circuit of the relay is complete. Thus the local circuit is broken when the current is either + 3 or — 3, but it is closed when the current is either + 1 or — 1.

Both the contact points are fixed to the same carrier, and the arrangement is such that when once the contact points have been individually adjusted, their further adjustment for ordinary changes in strength of the currents is made simultaneously by one and the same motion of the carrier.

Figs. 1 and 2 represent respectively a plan and section of one form of the double tongue relay. In this form the tongues C C are polarised with like polarity by the permanent magnets D D. The tongues are insulated from the framework of the relay and from each other, and contact between them is established when both tongues are against their respective contact points, which are fixed to a single carrier and on one side of it; the screws on the other side of the carrier have insulated points.

The electro-magnets E, E, E, E, are polarised by the ends of the permanent magnets D D, the other ends of which polarise the tongues, so that all four poles of the electro-magnets have the same polarity.

The result of this arrangement is that, when the relay is acted upon by the currents + 3, + 1, and — 3 respectively, the tongues take up the respective positions shown by fig. 3.

After the first adjustment of the tongues, their further adjustment is made by moving the whole carrier *e e*, by means of the slow motion screw *f*, which works in a nut underneath the carrier.

It is evident that the action of any current passing through the coils of the electro-magnets, which are wound in the usual manner, is to cause the electro-magnets to act oppositely on the two tongues in consequence of the opposite polarity; thus, if a plus current tends to cause the one tongue to move in the direction of its insulated point, a minus current will have the same effect on the other one. The adjustment of the tongues is such that it requires a strength of + 3 to act thus upon the one tongue, and — 3 to act in the same way on the other tongue. If the current has either of the intermediate strengths of + 1 or — 1, the strength is insufficient to move either of them against the bias given them against their contact points, and consequently both tongues are in contact with their respective contact points, and the local circuit of the relay is complete. When the current changes rapidly from + 3 to — 3, the one tongue leaves its contact point before the other tongue has time to make contact. It is only when this change is retarded that any difficulty is experienced in working the local instrument B direct with this relay. If the instrument is a recorder the signals are perfect, as the effect of retardation is only to cause a slight trembling of the armature against its upper limiting stop, and is insufficient to affect the record. With sounders this is an inconvenience which can be remedied by using an extra local relay to complete the circuit of the sounder, the local circuit through the coils of which extra relay being completed by the double relay described.

In duplexing the "diplex" system a method of "double substitution" is employed. This system consists in placing the battery between the true and artificial lines, and connecting the receiving apparatus between the middle of the battery and earth. In order to give a signal the battery is reversed. Thus supposing copper to be connected to the true, and zinc to the artificial line, while the key is at rest, the depression of the key will join zinc to the true and copper to the artificial line.

In this arrangement perfect balance is obtained when the true and artificial lines are equal, and balance is perfectly independent of any changes in the resistance and electro-motive forces of the two halves of the battery, any inequality in which will merely cause a current to flow through the receiving instrument, but which current will remain the same whether a signal is being sent or not, that is, whether the battery is direct or reversed. The arrangement will be understood from fig. 4.

In this arrangement the keys B and B' separate the batteries into two portions, one of which contains $2n$ cells, and the other n cells. When these keys are at rest the connections are along the continuous lines, and the two portions of the batteries are acting in the same direction, so that the current is $2n + n = 3n$. When these keys are depressed they reverse n cells of the battery, so that there are only $2n - n = n$ cells acting. The keys A and A', when depressed, simply reverse the current, whether it is $3n$ or only n as before.

It will be seen that as far as the receiving instrument and batteries are concerned it is really the true and artificial lines which are affected by the reversing key. They mutually replace one another in two portions of the circuit external to the instrument and batteries. There has, therefore, been given the name of "double substitution" to this form of duplex working, which, although similar in appearance to the split battery system, differs from it essentially in principle, for whereas in the split battery system balance depends on the maintenance of a strict proportion between the electro-motive forces of the two halves of the battery and the resistance of the true and artificial lines, the balance in the method of double substitution depends only on the equality of the true and artificial lines, which, however, experience shows may differ widely without affecting the received signals injuriously.

The principal merits claimed for this plan are,—

1. Its very wide working range. The artificial line may be altered within wide limits without affecting the signals.

2. The fact that the plan requires no special winding of the coils as in the differential system.

3. That the sensitiveness of the relay is not reduced, and magnetic retardation increased by the shunting action of bridge wires, as in the bridge span.

4. The balance, as stated above, is not disturbed by variations in the electro-motive forces or resistances of the two halves of the battery, as is the case in the ordinary split battery system. In addition to this, the action of the signalling on the distant instrument is of course doubled.

All that is necessary to neutralise any current which may be passing through the receiving instrument in consequence of inequality in the two halves of the battery is to join the receiving instrument slightly out of the centre of the battery. In order to do this effectually two or more of the middle cells of the battery may be shunted by a slide resistance equal to about three or four times the resistance of the cells so shunted, the receiving instrument being joined between the contact point of the slide and earth.

It will be noticed that the peculiarity in this quadruplex system consists in the duplexing portion and also in the form of double tongue relay. The arrangement of currents for the different positions of the keys is identical with that employed by Mr. Gerrit Smith, in America, but the latter gentleman employs his most ingenious, yet simple, compound relay, in the place of the double-tongued relay, and with great advantage.

67

[37293.]—**Electrical Duplex Working.**—The querist is mistaken in his anticipations. The battery B' would not merely neutralise B as to its influence on the galvanometer G'. This second battery has two circuits, the one considered in the question, and the other through the two galvanometers *viâ* their joint connection to B and the joint connection to E. If we conceive the two galvanometers as alike and oppositely connected as shown, in the first case they would be equally but oppositely deflected. On battery B' being connected the deflection in G' would be not neutralised but reversed, while that in G would be increased, the two batteries acting as one in multiple arc through it. The effects would depend altogether on the relative resistances.—SIGMA.

[37293.]—**Electrical Duplex Working.**—I cannot see how "J. B." arrives at the conclusion that he does regarding this query. My opinion is that by inserting the second battery (assuming it to be of equal E.M.F.) the deflection on G' should be *nil*, as in the circuit where it is placed the tensions are opposed to each other, and, being equal, are therefore neutralised. The deflection on G, I would say, would be nearly doubled. I have not tried the experiment, but will do so, and report result in our next issue if different to above.—OHM.

Eng Mechanic July 25 1879

Journal of Tel. Aug 1 1879

217,781.—SEXTUPLEX TELEGRAPHS. Thomas A. Edison, Menlo Park, N. J., assignor to Western Union Telegraph Company, New York, N. Y. Filed May 14, 1877.

The combination, in a telegraphic circuit, of a key to reverse the polarity of the current, a key to vary the strength of the current on the line, a vibrating reed acting to pulsate the current on the line, a key to shunt the main line and prevent the action therein of the pulsator, and three receiving instruments in the bridge, one operated by reversal of the current, the other by changes in the strength of the current, and the third by the pulsations of the current, substantially as set forth.

217,782.—DUPLEX TELEGRAPHS. Thomas A. Edison, Menlo Park, N. J., assignor to Western Union Telegraph Company, New York, N. Y. Filed Nov. 14, 1878.

1. The method herein specified of producing an electric condition in the closed circuit of a telegraph line that will give a signal in a telephone by reversing the position in that line of an electro-magnet, secondary battery, or similar device, substantially as specified.

2. The combination, in a closed circuit, of a receiving magnet, a telephone, an electro-magnet, or its equivalent, and an apparatus for reversing the connections of the same in the circuit, a rheostat or resistance, a shunt to the same, and a key, substantially as set forth.

Edison's telegraphic quadruplex, says the Paris *Journal des Debats* of July 17, is about to be tried on the line from Paris to Brussels. This will be the first experiment with it on the continent of Europe. The system, as is known, is the only one that admits of the sending on the same line and at the same moment of four different dispatches. Engineering News Aug 2 1879

68 Telegraphic Journal
~~Journal of the Tel~~
July 15 1879

THEILER'S PATENT MECHANICAL DUPLEX (FOR LAND-LINES).

DUPLEX working either on the "differential" or on the "bridge" principle, is now universally known and understood, and if the essential features of those systems are referred to in the present article, it is only in order to show clearly in what respects this new duplex system differs from all others.

In both the differential and the bridge method, the current is split between an actual and an artificial line; and it is absolutely necessary that a certain ratio of current be kept up between the two circuits so as to produce a "balance." But, considering that the resistance and the electrostatic capacity of a line, from a multiplicity of causes, varies constantly and considerably (in bad weather the resistance may vary as much as 50 per cent. in one day), and that variation in the resistance and static capacity of the line means alteration in the adjustments of the apparatus, it must be conceded that duplex working, either on the differential or bridge principle, looks simpler on paper than it is found to be in practice.

In Theiler's mechanical duplex, the current is not split between two circuits, and as no equality of currents has to be maintained, variation in the resistance of the line, be it even as much as 100 per cent., does not affect the apparatus. There are no condensers, no rheostats, and the only adjustment required is that of the relay, just as in ordinary single working.

An explanation of the diagrams fig. 1 and fig. 2, which represent the *theoretical* construction of the apparatus, will show how signals, electrically neutralised by simultaneous sending from opposite stations, are recorded mechanically.

The key lever *e*, whose motion is limited by the stops *a*, *b*, carries a spring *f*, which is insulated at the point where it is fixed to the lever of the key which touches this lever at the extremity *h* of the latter. This spring impinges on the tongue *l* of the polarised relay *m*, *m'* when the key is depressed, but does not touch *l* when the key is at rest. The (polarised) relay may be of any form, but is preferably a "Theiler's,"* as that construction allows of a convenient and nice adjustment of the electro-magnet. The armature (which is induced at the centre *c*, so that both ends have similar polarity) is adjusted that the tongue *l* has a bias towards stop 2, stop 1 being in connection with the receiving instrument, Morse or Sounder.

Now when one of the keys (connected to earth) is depressed upon the front stop *b*, as shown in fig. 2, the end of the spring *f* touches the tongue *l*, and meeting an obstacle bends, and thereby breaks contact with the lever at *h*, consequently a current flows from the copper pole of the line battery through the tongue *l*, the spring *f*, the electro-magnet *m*, *m'*, to line, and entering the relay of station II. returns through the spring *f* and the lever *e* to earth.

The effect of this current upon the relay at station II., is an *increased* pressure of the tongue *l* against stop 2, which resists all tendency of the spring *f* to move the said tongue against stop 1,

FIG. 1.

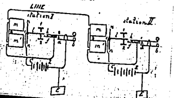


FIG. 2.

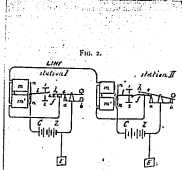
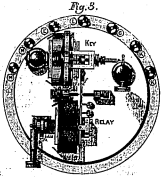


Fig. 3.



while the effect of the current upon the relay of the receiving station is exactly reversed, the current entering *m*, *m'*, from an opposite direction and causing the tongue *l* to move against the marking stop 1. Thus the outgoing current does not move the relay tongue of the sending but only of the receiving station. As both stations are connected exactly alike, the same thing will happen if station I. sends and station II. receives, both being in position to receive when at rest. It will be seen that every depression of the key tends to move the relay tongue mechanically towards stop 1, and is only prevented from doing so by the magnetisation of *m*, *m'*, which takes place the instant *f* touches *l*, and whereby the tongue is forced against stop 2.

If no current were to flow through the magnet of the sending station relay, then the key would produce its signals at its own station. Such is actually the case when both stations send simultaneously. Then the copper pole of station I. opposes the same pole of station II., and contact with earth being broken, no current goes to line; nothing now counteracts the tendency of spring *f* to push the relay tongue against the marking stop 1, and thus, in the absence of any current, the signal sent by station I. is recorded by the mechanical actuation of the relay tongue at station II. by the key of the latter station; and *vice versâ*.

But the instant the key, say at station I. falls back while that at station II. remains depressed, the relay tongue of station II. also falls back, because the returning magnetization of that station's relay will overpower the pressure of the spring *f* and force *l* against stop 2, while the relay tongue at station I. will remain against stop 1 without any assistance from the spring *f*, because the direction of the current tends to keep the tongue on that side.

The actual construction of the apparatus differs somewhat from that illustrated by figs. 1 and 2. In order to render the motion of the lever *e* exact, decided, and as small as possible, it is preferable to effect it by means of an electro-magnet, and to use an ordinary key merely to make and break connection with that electro-magnet and a local battery. In practice, the point of contact of the spring *f*, with the lever *e*, and the point of contact of the said spring with the relay tongue *l* are made equidistant from the axis of the lever *e*, in order to make the momentary short circuiting of the line battery of as short a duration as possible. Fig. 3 represents the actual form of the apparatus, three-quarters of the real size. The adjustments of the key, once set correctly, are never touched, while the distance of the relay magnet from its armature and the bias of the relay tongue against the next stop can be easily regulated; the tension of the line spring *f* can also easily be altered; both these adjustments, however, need but very seldom be touched. A loop circuit of 200, and afterwards of 400 miles were, for instance, worked without altering the relay adjustment.

As the static charge from the line does not affect this system more than it does ordinary single working condensers are entirely dispensed with, and thus duplex working on this system with no rheostat, no condensers, and only the relay to adjust, is rendered as simple as ordinary single working.

In countries like England where duplex working has been extensively established for some time, and a change in the present system would necessitate change in a large stock of duplex apparatus, it will be difficult, perhaps, to get adopted *any* new duplex system until increased traffic calls for a greater number of duplex circuits.

But in countries where duplex working is only just gaining a footing, this mechanical duplex ought to have a splendid field. From its simplicity the system, also, appears particularly applicable to military field telegraphy. Where telegraphic lines are very long, two sets of the above apparatus, suitably connected to the "up" and "down" line, are used to act as a duplex translator.

We understand that the inventors of the Mechanical Duplex will shortly bring out a quadruplex on a similar principle.

Correspondence.

Tele Journal Aug 15 1879

[We do not hold ourselves responsible for the opinions of our correspondents.]

To the Editor of THE TELEGRAPHIC JOURNAL.

SIR,—In your Journal of the 15th April, 1877, a simple and novel system of Duplex working, by J. J. Fahie, is described. Of the many advantages which this system is supposed to possess over other existing systems, as claimed by Mr. Fahie, is a very important one, and that is, that "*no condensers*" are at all required to balance the electro-static capacity of a line. This statement is supported by the results of actual trials on some of the telegraph lines in Persia.

To test the utility of the system, some careful experiments *without condensers* were made on the Indian lines. The results were, as anticipated, utter failures.

The failure was due to the fact that the electro-static capacity of the lines could not be balanced by the batteries as described by Mr. Fahie.

If you, or any of the practical electricians are of opinion that "*condensers*" are *actually not* required in the system, I shall deem it a great favour if an accurate explanation of the *theory* be inserted in the columns of your Journal.

You would also oblige me very much by letting me know the electro-static capacity of the condensers (in microfarads) employed by Edison in the *non-polarised relay circuit* of his Quadruplex system.

Also, I shall feel much obliged if you, or anybody else, will kindly inform me, through the medium of your Journal, on the utility of "Double Current" working, as applied to ordinary circuits, that is to say:—

1. Does "Double Current" working *actually* increase speed and the distance to be worked by eliminating the retardation due to the electro-static capacity of the line; and

2. Does the *negative* current employed in the system *actually lower* the insulation of the line? If the latter be correct,

3. What effect has it on the Quadruplex systems used largely in England, America, and other countries worked on the "Double Current" principle?

Yours truly,
"INDIAN TELEGRAPH."

[*No* duplex system, as far as we are aware, has yet been invented which has enabled condensers to be dispensed with when the apparatus comes to be worked on long circuits. In certain cases, it is true, owing to the mechanical construction of the apparatus the effects of the inductive discharge have been less felt, but they have not been neutralised, strictly speaking, but have only been *disguised*, and when a crucial test has been made, such as you have described, the result has proved that the effect anticipated has not been obtained, and a *correct* examination of the theory of the invention would have proved that the inventor's theory is false. Let all the different duplex systems invented be tried under exactly the same conditions, and we believe the effect of the inductive discharge will be found to be the same in all. Condensers, or equivalents to condensers, such as electro-magnetic shunts are, we believe, necessary in any case on long lines if duplex working is to be efficiently and economically (as regards battery power) carried on.

The non-polarised relay has been superseded, and with great advantage, by Gerritt Smith's compound relay. When the former apparatus was employed, the condenser used to "bridge over;" the kick of the armature varied according to the length of the line; about 1½ microfarads may be taken as the average capacity required.

As regards "Double Current" working on ordinary circuits, the employment of the system does not increase the working speed by diminishing the inductive embarrassment, and even if it did diminish the latter the highest rate at which signals could be sent on any land line, even when retarded, would be much beyond what it would be possible to send by hand or at "key" speed. Double current working is used, not to obtain increased speed but to enable signals to be sent at all under the varying conditions of a long line. In the single current system if the line current varies to any great extent, a constant adjustment of the instrument and armature spring is necessary in order to obtain good signals, or, indeed, to obtain signals at all. With the double current system where polarised relays are employed, the tongue of the latter is set nearly neutral and being equally affected by the "marking" and "spacing" currents, works equally well whether these currents are strong or weak, that is, of course, within certain limits. Also, there being no spring for the current to work against, a very weak current will give good signals.

The negative currents employed in the system do not lower the insulation of the lines, they have no effect whatever on them.]

4590. "Duplex and quadruplex telegraphy." J. MUIRHEAD (communicated by A. Muirhead, J. A. Briggs, and G. Kift Winter, Madras). Dated Nov. 12. 8d. This describes Muirhead and Winter's quadruplex, fully illustrated in the TELEGRAPHIC JOURNAL for July 15. Tele Journal Aug 15 1879

EDISON'S quadruplex system will shortly be tried between Paris and Brussels, under the superintendence of Dr. Cornelius Herz. Tele Aug 15 1879

MESSRS. WINTER AND MUIRHEAD'S QUADRUPLEX IMPROVEMENTS ANTICIPATED BY MR. F. W. JONES.

Journal of Telegraph Sept 1 1879

CHICAGO, ILLS., *Aug.* 15.

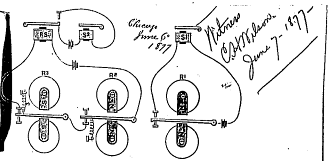
To the Editor of the Journal of the Telegraph:

IN the issue of *The Electrician* for July 26th, 1879, appears a letter setting forth the novelty and efficiency of certain quadruplex arrangements made by Messrs. Winter and Muirhead. Not knowing at what date these gentlemen placed their improvement on record, I beg leave to inclose for the inspection of your readers an original diagram of a similar relay system invented by myself and witnessed by Mr. C. H. Wilson, June 7th, 1877. You may apply to my arrangement the exact description applied in *The Electrician* to the Winter-Muirhead system, and it will be found to fit exactly, inasmuch as they are identical.

"At the receiving station there is a polarized relay adjusted to break the local circuit when the current is plus and to complete it when the current becomes minus; a local sounder or other receiver connected with this relay records the depressions of key A. There is also in the main current (*circuit*) at the receiving station a double tongued relay which is used for completing the circuit of the sounder or receiver intended to respond to the movements of key B. This double relay *which forms an important feature* in our system of quadruplex is so arranged that, in order that the local circuit should be completed, it is necessary for both tongues to be against their respective contact points.

"To accomplish this either the tongues are insulated and the contact between tongue and tongue caused to be completed through the contact points, which in this case are connected electrically with each other, or the contact points are insulated and the contact between point and point is completed through the tongues, which in this latter case are of course connected together."

The action of the Winter-Muirhead relays under various operations of the keys and batteries having been described, said description being perfectly applicable to my system—the statement is made that



F. W. Jones

"on very long lines it may be necessary to use a local relay to work the recorder, the local circuit of this second relay being completed by the relay just described, but this will not be generally necessary;" and that "with sounders there is an inconvenience which can be remedied by using an extra local relay to complete the circuit of the sounder."

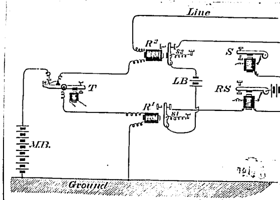
The inconvenient absence of a uniform movement of the relay tongues under different strengths of current is the reason why I turned my attention from the double tongued relay to one of more simple construction and perfect operation. This improved relay, well and favorably known as the Jones' relay, is based on all carefully studied principles of induction and magnetism, intelligently treated by Fleeming Jenkin, F.R. SS., Electricity and Magnetism, pages 74 and 284. It has already been generally adopted in the quadruplex apparatus used by the Western Union Telegraph Company.

F. W. JONES.

A Duplex Arrangement,

To the Editor of the Journal of the Telegraph.

HEREWITH I send you a diagram of a Duplex arrangement, made by me two or three years ago the exact date I regret I have not preserved. It has worked double perfectly for business, and as I have never seen any similar system described at home or



abroad, you may wish to put this upon printed record. The system is only remarkable for its simplicity, and the good character of the signals received at either station on circuits of ordinary length. The diagram shows the wires, instruments and batteries arranged at one station. R 1 and R 2 are single coil relays. T is an ordinary transmitter represented as *open*. R 1 has a tension of spring which allows the tongue to move when the battery of distant station is received. R 2 has a tension of spring holding the tongue against the force of the incoming current, but allowing it to move when both currents are simultaneously sent to line. S is an ordinary Sounder, operated by a repeating sounder RS on the up stroke. LB and LB' are local batteries respectively, whose functions will be well understood by an examination of the cut. When main battery MB is alone sent to line both relay tongues stand open, and Sounder S is not worked, but when the incoming current is received it operates sounder S either through relay R 1 or R 2, MB being open in the former case and closed in the latter. The currents from each station must not oppose each other, and it is practical to connect in way stations duplex, by duplicating the apparatus shown in the figure, and connecting the incoming line in place of the ground.

F. W. JONES.

Chicago, *Sept.* 22d, 1879.

72

nation. This may perhaps be of use to some who are working in the same direction. The sketch (fig. 1) shows the nature of the instrument.

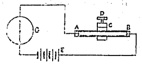


Fig. 1.

A B is a piece of elastic tube containing a weak solution of salt in water, this is held in the clamp, C. By the screw, D, the tube can be compressed an[d] its sectional area altered, and through this its r[e]sistance. G is the galvanometer and E the batter[y]. Finding the instrument to be very sensitive on reflecting galvanometer, I thought that probabl[y] the tube would be a means of transmitting articulate speech. I find this to be the case. In fig. 2, A B is

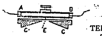


Fig. 2.

an elastic tube similar to the one used i[n] instrument. C C mouth-piece, with di[s] to the tube at E. A B is put in circuit phone and battery. D, screw to regulate on the tube.

Telegraphic Jou
oct 1 18

Correspondence.

DUPLEX TELEGRAPHY.

To the Editor of The Telegraphic

Dear Sir,—I have read with much inte[rest the dis]cussion in your paper on the possibility [of] Duplex without the employment of conden[sers].

It should, certainly, be possible to re[produce by] mechanical means a signal which sho[uld] counteract and neutralise the effect of the [cur]rent in the relay, or other instrument empl[oyed for the] reception of signals.

The rate of magnetisation of similar elec[tro-magnets] in circuits of equal resistance, is much m[odified by a] slight inequality in the electro-static capac[ity of the] two conductors.

That of an artificial resistance of fine wi[re is] very small compared with almost any li[ne of tele]graph, and the latter would, in consequence, [absorb the] potential of the battery in a greater ratic [than the] other at the instant of making battery con[tact; there]fore, a compensating condenser is usually [attached to] the artificial line.

To produce the required effect without [condensers] I devised the following arrangement, and a[s] Messrs. Theiler, in their letter, do not m[ake any] suggestion of any plan prior to their own, th[ey are unac]quainted with the above, which I explain[ed]

TELEGRAPHIC APPARATUS IN USE IN THE BRITISH POSTAL TELEGRAPH DEPARTMENT.

XI.

Direct Writer Duplex System—(*continued*).

It has been generally understood and explained that the principle of the Duplex telegraph system involves the production of an exact balance on the receiving portion of the transmitting instrument, so that when the key of the latter is worked no effect is produced; this is only partially true, that is to say, a balance, but not an exact balance, has to be obtained. To obtain an exact balance is impossible, as can be seen by reference to fig. 50, which represents the general principle of the Duplex system as worked by the Post Office. Referring to this figure, let us suppose the key at the "Up" station to be depressed, then in order that no effect may be produced on the electro-magnet, M_1, at that station, it would be necessary that the resistance, R_1, be equal to:—the resistance of the line, plus the balancing resistance, R_2, at the distant station (which resistance will be equal to R_1), plus the resistance of the two coils of the magnet, M_2. It is obviously impossible that this can be the case, consequently exact equilibrium can never be produced.

In what way then do the balancing resistances enable duplex working to be effected?

Now, although the balancing resistances cannot enable a neutral effect to be produced on the electro-magnet at any one station when the key at the latter is worked, still it can enable a comparatively small effect to be produced on the same, an effect due to the difference in the strengths of the currents passing respectively in opposite directions through the two coils of the electro-magnet, and which can be counteracted by the tension of the armature spring.

But, it may be asked, what values should the balancing resistances have? The answer to this is—the adjustment must be such, that when signals are sent from the distant station, the strengths of these signals must not be altered, on alternately depressing and raising the key at the home station. The values of the balancing resistances necessary to produce this result are of course found by trial, their theoretical value it is unnecessary to determine.

Supposing the required balance to be obtained,

then the action of the apparatus will be as follows:—Supposing the key, K_1, at the "Up" station to be depressed, the one, K_2, at the "Down" station being in its normal position, then the current from the battery, E_1, will split, half going through the resistance, R_1, and the coil of M_1, represented by the . . . . . . line; the other half will go out to Line to the "Down" station and through the balancing resistance, R_2, from thence it will pass through the . . . . . coil of M_2 and back through the coil represented by the ——— line, to Earth, from there it will pass back to the Earth at the "Up" station, and through the ——— coil back to the battery. It will be noticed that the current passing through the two coils at the "Down" station does so in opposite directions, and as the coils are wound in *opposite* directions the full magnetic effect due to the two is produced, consequently the instrument responds. The currents passing through the coils at the "Up" station do so in the *same* directions, consequently a small magnetic effect only is produced, due to the two currents being of unequal strength. This small effect, as was explained, is counteracted by the tension of the armature spring.

If the "Down" station depresses his key whilst the "Up" station key is left in its normal position, then the instrument at the "Up" station of course responds.

Lastly, supposing both keys to be depressed, then since the two batteries have their opposite poles in connection with one another through the line, and through the ——— coils of the electro-magnets at the two stations, these batteries will send a strong current through the coils; also each battery will send a current through the balancing resistances and through the . . . . . . coils, but the strength of the currents going through the ——— coils will be about double that going through the . . . . . . coils, consequently both electro-magnets must respond.

In adjusting the balancing resistances or rheostats the telegraphist at, say, the "Up" station sends signals on his key to the "Down" station, and the latter adjusts his rheostat until he finds that his received signals do not alter in strength when he keeps his own key alternately depressed and raised. If there is too much resistance in the rheostat the received signals will be strong when the home key is at rest, and weak when it is depressed. The telegraphist is thus able to judge whether he must increase or decrease the resistance in the rheostat. When it is found that the signals are uniform the received signals are stopped, and the home station works his key, and increases the tension of his armature spring until his own signals cease to affect his apparatus. A similar operation is then gone through by the distant station.

Now, it must be obvious that when the Down station adjusts his rheostat, after the Up station has obtained his required balance, the latter must be thrown out again. This is true to a certain extent, but the amount by which it may throw the balance out is comparatively small. That is to say, for example, one hundred ohms wrong in the home rheostat would affect the home instrument more than would two or three hundred ohms wrong in the distant rheostat. If this were not the case the balancing would give a great deal more trouble than it actually does.

73

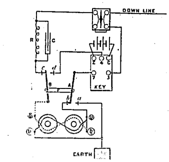


Fig. 51.

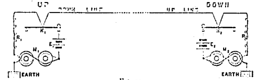


Fig. 50.

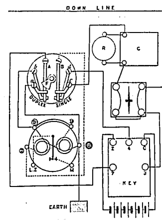


Fig. 52.

Character of article [illegible]

From the [illegible]

Published at [illegible]

Date [illegible] 15 83

AUTOGRAPHIC TELEGRAPHY.

Mr. S. P. Dennison's Apparatus for Transmitting Messages in Facsimile.

Mr. S. P. Dennison, of this city, has recently patented a telegraph instrument by which messages are transmitted in facsimile almost as fast as the message can be transmitted by a good operator in the ordinary way by Morse key. The instrument has been upon exhibition for several weeks in this city and has attracted a great deal of attention. The fundamental principle of the apparatus is the same as that used in all preceding instruments for the transmission of a message in facsimile, namely the use of an ink for the original message which shall interrupt the electric current. The message is written upon thin tin-foil with an ink which forms a complete insulation wherever it makes a mark. The new feature of the apparatus is that instead of a stylus which travels back and forth over a line the width of the sheet upon which the message is written, a steel point is attached to the end of a vibrating arm hung between magnets, which swings back and forth across a tape of paper about the width of that used in the ordinary "tickers." Each instrument is provided with two of these vibrating points—one for sending and the other for receiving. Whenever the point passing over the original message upon tin foil meets with an ink mark, the current is interrupted for the second, and a black mark corresponding to the ink mark upon the tin is made upon specially prepared paper at the other end of the wire. The instrument is far more rapid than those which the Postal Telegraph Company had built a few years ago. When the receiving and sending needles are made to swing over a tape wide enough upon which to write several lines instead of one, as at present the speed will excel that of the best operators working with the old system. The advantages of being able to send a message in facsimile are too obvious to need mention, besides which the apparatus can be used by two merchants at a distance without the intervention of operators.

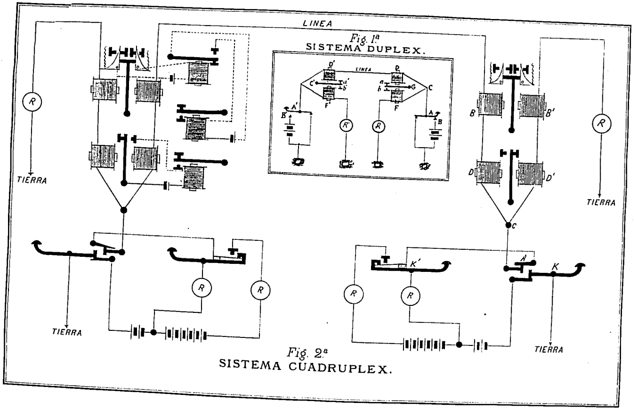


Fig. 1ª
SISTEMA DUPLEX.

Fig. 2ª
SISTEMA CUADRUPLEX.

THE HARMONIC TELEGRAPH.

Recently certain users of telephones along the line of telegraph between this city and Boston have noticed a novel addition to the assortment of sounds which telephone wires pick up by induction from neighboring telegraph wires. The new sound is more musical than welcome, and is obviously made up of several distinct tones singing together, while each is independently interrupted by rapid breaks or short spaces of silence. These breaks correspond with the "dot and dash" sounds of the ordinary telegraphic instrument, so that the message may be spelled out by the interruptions of the singing tone. Tracing these sounds to their source, they are found to be due to a relatively new system of multiplex telegraphy now on trial on the Western Union Telegraph line between New York and Boston. The system is a development of Elisha Gray's original electro-harmonic or electro-acoustic multiplex telegraph, the early history of which is familiar to all who are at all acquainted with the investigations which led to the invention of the first speaking telephone. The tones of the harmonic telegraph are produced by the vibration of steel reeds operated by electro-magnets, the pitch of the tone produced being determined by the number of vibrations the reed makes in a second. The current operating one reed, when passed over a line, will set in motion at the further end a reed exactly corresponding to the first in rate of vibration, and cause it to yield the same note, while a reed tuned to a different note is entirely unaffected. When two or more reeds are sounding separately or simultaneously at one end of a circuit, their counterparts at the other end will exactly respond, each singing or keeping silent as its corresponding vibrator at the other end of the wire is started or stopped. Obviously any interruptions of the current passing through any transmitting vibrator will be produced by its corresponding receiving instrument, but not by any other in the series, causing clearly recognizable breaks in the singing tone emitted by the vibrator. The message spelled out by such interruptions of the current may be read by the receiver in the interruptions of the tone, or the receiving vibrator may be used as a relay in operating an ordinary sounder.

In the practical work, on the Boston line referred to, it has been found possible to send simultaneously by one wire, and analyze at the other end, four distinct tones, thereby transmitting four separate messages in one direction at one time. This offers a signal advantage over the quadruplex system, which transmits two separate messages simultaneously each way, but cannot send four messages one way. In cases of extraordinary pressure of business the full capacity of the harmonic system may be utilized in either direction. It is hoped that the harmonic system will ultimately make possible the simultaneous sending of four or five messages both ways on a single wire; in other words, four tone messages and one ordinary Morse message in each direction, or ten in all. In this way all the tones of the octave will be made use of, and that is the probable limit of the system, unless it be found possible to operate with fractional tones. Scientific American [illegible]

Electrician [illegible] 1880

3. THE DUPLEXING OF LINES BETWEEN GREAT BRITAIN AND INDIA.—The telegraphic communication between England and the Indian Empire is now in a state of thorough efficiency, the Eastern Company having duplexed their main lines throughout. The duplex system has been applied to the following sections:—Porthcurno and Lisbon, Porthcurno and Vigo, Vigo and Lisbon, Lisbon and Gibraltar, Gibraltar and Malta, Marseilles and Malta (two lines), Malta and Alexandria (two lines), Suez and Aden, Aden and Bombay. This gives an enormously increased capacity for business, and though the present daily traffic would a few years ago have seriously taxed the lines within working hours, the Indo-European and Eastern Company's cables have now a margin of capacity exceeding by many times the existing traffic. The efficiency of the staff also has kept pace with science, and we may mention that the daily average time for messages between London and Egypt is frequently only fifteen minutes, a result alike creditable to clerks and cables.

A PATENT has just been issued to Mr. J. E. Fenn, of the electrician's department, American Union Telegraph Company, for an important improvement in duplex and quadruplex working. As the Western Union owned the condenser patent, which is a particularly strong one, the American Union found that to enable it to work its long duplex and quadruplex lines it must have a substitute. So Mr. Fenn set about inventing one, and has just secured a patent for the same, as unassailable as is that of the Western Union.

30

Telegraphic Journal

Tel Journ Nov 15 1880

INDUCTION ON TELEGRAPH LINES.

A TELEGRAM from Mr. Edison has directed our attention to the specifications of two patents taken out by him, one in this country and the other in the United States of America, which in his opinion anticipate the invention of the system for eliminating the effects of induction produced in a set of telegraph lines which was described by Professor Hughes before the Society of Telegraph Engineers, and which formed the subject of an illustrated article which appeared in this journal three weeks ago.* As we were the means through which publicity has been given to Professor Hughes's experiments, we have felt it incumbent upon us, in justice both to Mr. Edison and to Professor Hughes, to examine very carefully the two specifications referred to by Mr. Edison, so as to be able to form a perfectly unbiassed opinion of their bearing upon Professor Hughes's researches, that we might be in a position to place the facts before our readers, showing in what respects the two are similar to one another, where they run in a parallel direction, at what point they diverge, and in what particulars there exist essential differences; and, in order to facilitate the forming by our readers of a still more independent opinion, we have thought it best to reprint *in extenso* the full specification with the accompanying drawings of Mr. Edison's American patent, which will be found on another page, while we subjoin that portion of his British specification—also with the drawing—which has reference to the subject. The examination of these specifications in connexion with Professor Hughes's paper, which we published *in extenso* in the same issue as the article to which we have already referred,† enables, moreover, each of these eminent inventors to speak for himself in his own words and is again of assistance in the formation of a sound opinion.

The whole question involved in a case of priority of scientific discovery or invention, as well as in a case of the infringement of a patent, must rest on the all-important question as to what is claimed as the invention or discovery, and in what way that claim is interfered with by the claims of other parties. It is therefore necessary to determine at the outset of the present inquiry what are the claims of Mr. Edison which Professor Hughes has in his opinion interfered with, and what does Professor Hughes claim as novel in his experiments or in their results. It is due to Mr. Edison to point out that the compensation of induction in a telephone line by means of opposing to it counter inductions by special induction apparatus was included in one of his patents bearing date as far back as July 30, 1877, or close upon twenty months before Professor Hughes's paper describing his researches was published to the world; if therefore the question in dispute between Mr. Edison and Professor Hughes were the application of the broad principle of meeting induction by counter induction, then Mr. Edison's claim to priority would be indisputably established, and the only remaining question to be decided would be whether Mr. Edison had or had not been anticipated by any one else. Fig. 1 is an exact copy of the drawing

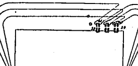


FIG. 1.

accompanying Mr. Edison's British patent to which we have referred, and we may mention in passing that [illegible] in this very interesting specification [illegible] of curious and, in some cases, very beautiful telephones, are figured and described as well as the present well-known form of the phonograph. The arrangement illustrated in the figure for eliminating the effects in a telephonic circuit of induction from neighbouring telegraph wires is so briefly referred to in the specification, that we quote it *in extenso*, and in so doing describe the figure in Mr. Edison's own words. "Where several line wires run near each other, the wire used for the acoustic or speaking telegraph is influenced by induction, and false sounds will be produced. I counteract this tendency by placing one or more electro-magnets 59 (Fig. 28) in the circuit of the speaking telegraph, and one or more electro-magnets 60 in the circuit of the adjacent wires, and bringing the opposite cores of 60 at such a distance from the cores of 59, that a certain magnetic action will be set up in 59 by induction in the opposite direction to the induction currents from the adjacent line or lines.

"By adjusting the distance between these magnets when the speaking telegraph is not in use, until there is not any sound at the diaphragm from the induction currents, then those currents will be neutralised, whether strong or weak, and will not produce any false sounds when the speaking telegraph is in use.

"I also employ double coils of wire for the same purpose, one coil being in the acoustic wire, and the other in the wire to be compensated."* Reference is again made to the same devices at the end of the specification in the last of the thirty claims as follows: "I claim as my invention . . . . . Thirtieth. In combination with an electric circuit containing instruments for reproducing sound, one or more electro-magnets, and one or more compensating magnets for neutralising the inductive effect of adjacent telegraph wires, substantially as set forth."†

It is clear, therefore, from the above that Mr. Edison's claim under that patent is no less and no more than that therein stated, viz., the employment of electro-magnets with magneto-electric inducting armatures for protecting a single circuit from the effects of induction of one or more telegraph lines, and it is also clear that although the compensation of induction by equal and opposite counter induction thrown into the same circuit is the broad principle involved in the invention, still it is not claimed as a part of the patent, for the very simple reason that it did not possess novelty. Again, it is equally clear that no claim is made to the discovery of a method by which a set of telegraph lines are compensated for induction each against the others. It is essentially a system of protection of one particular line against the inductive influence of one or a larger number of other lines, but offers no protection for any others in the group as between themselves. It is a special application of the principle of counter induction to a single circuit, and occupies to the whole question a precisely similar position to the twisted telephone line and return circuit, which was devised independently by Mr. David Brooks, of Philadelphia, and by Professor Hughes, and which is illustrated in Fig. 3 in our article on Professor Hughes's experiments.* Here a telephone circuit is made to protect itself against the inductive influence of other lines, or what is merely the converse of the case, a telegraph circuit is made harmless to other and neighbouring lines by a special system of erection, which is applicable but to one line of a group.

On the other hand Professor Hughes who, like Mr. Edison, makes no claim to the discovery, or priority of suggestion, of the elimination of induction by counter induction, claims to have discovered a method and invented a system by which any

* See ENGINEERING, page 217 *ante*.

† See ENGINEERING, page 212 *ante*.

* Specification of Thomas Alva Edison. "*Controlling by sound the transmission of electric currents and the reproduction of corresponding sounds at a distance.*" Dated 1877, 30th July. No. 2909, page 11.

† *Ibid*, page 13.

number of telegraph lines running in the same direction may be protected each against all from the effects of mutual induction, and we take it that this indiscriminate protection of all the lines constitutes at once the great value of Professor Hughes's invention, and its essential difference from any of the very beautiful devices invented by Mr. Edison for destroying the injurious influences of lateral induction in a telephone circuit, influences which without some such methods of compensation would have condemned the use of the telephone as a trustworthy instrument of communication.

Mr. Edison's American patent, which bears date February 21, 1878, *i.e.*, seven months after the date of that taken out by him for Great Britain, and of which we publish on another page the complete specification, deals with the subject of induction far more fully, in that the whole specification is devoted to the subject, while in the specification of the British patent it is merely touched upon among a large number of widely different subjects. The American specification is a highly interesting one, containing as it does several very pretty methods for the elimination of induction in telephone circuits by means of a combination of electro-magnetic and magneto-electric compensating inductors, and showing that both dynamical and statical electric induction may be got rid of or neutralised by similar arrangements, to which is added the use of condensers. The figures are so clearly explained in the text of the specification as to need no special description in this place; but we would invite more particular attention to Figs. 2 and 4, p. 277, as more conspicuously bearing upon the point at issue. The former is a diagram of one out of several arrangements devised by Mr. Edison for protecting a telephone line against the effects of induction of two or more telegraph circuits, such, for instance, as Nos. 1 and 2. This diagram bears a very close resemblance to that which we published† in illustration of the general principles upon which Professor Hughes bases his induction balance, and if the use of the latter were limited to the protection of one particular line against several others, the two devices would be very similar indeed, and we can well understand that Mr. Edison, having thought out and patented so beautiful a method of compensation, should, on seeing the first account of Professor Hughes's experiments, have been struck with the similarity, and should have assumed the two to be, for all the purposes of a patent, identically the same invention. The presence of the iron core is one point of difference between Mr. Edison and Professor Hughes's apparatus, although, as far as the principle is concerned, a not very important one, and we cannot help thinking that the removal of the iron would be accompanied with decidedly improved results. The counter-induction currents set up in the lines by the apparatus figured in Figs. 2 and 3 of Mr. Edison's specification (p. 277) are produced partly by electro-magnetic and magneto-electric induction, and partly by the ordinary dynamic induction taking place between the coils. The action of the first of these influences may be described as follows: Currents of electricity such as would be employed in the transmission of a telegraphic message would, in traversing the coil marked 2, induce magnetism in the iron core *g* which passes through all the coils and this increase of magnetic intensity in that portion of the core which is surrounded by the coil 3 would induce in that coil a series of currents of electricity which, by being thrown into the line with which that coil is in circuit, would either increase, or tend to neutralise, the effect due to the lateral induction of the line No. 2 with which the coil marked 2 is in circuit.

It is, however, quite probable that there is greater similarity between ordinary dynamical induction and electro-magnetic induction than at first sight appears, and that the latter is but a special case of the former; all dynamical induction being but an electro-magnetic effect due to variations in the intensity of the concentric lines of magnetic force circulating around a conductor conveying an electric current, and which have been so beautifully demonstrated by Dr. Silvanus P. Thompson, Professor of Experimental Physics in University College, Bristol.*

The second arrangement figured in Mr. Edison's specification would very satisfactorily accomplish, we have little doubt, the object for which it was designed, namely, the protection of the upper line against the inductive influences of Nos. 1 and 2, and it would in our opinion accomplish that object even still more perfectly if the iron core were removed, for Professor Hughes's experiments have shown that the presence of iron, or indeed of any conducting material within the coils, disturbs the balance and renders it next to impossible to obtain absolutely perfect compensation. This may be due to the impossibility of insuring the perfect homogeneity of the iron so as to produce uniform electro-dynamic effects in the two coils, but it is more probably due to the fact that the magnetisation of iron is essentially more sluggish than the dynamical induction between the lines, so that the induction currents and their corresponding compensating counter-induction currents are not isochronous, and therefore can only neutralise one another during the periods when their respective durations overlap.

Mr. Edison's drawing, Fig. 4, p. 277, although least resembling Professor Hughes's apparatus in general external appearance, is that which has the closest analogy to it in principle, because in this case the counteracting effect is produced by ordinary electro-dynamical induction, no iron core or other magnetic contrivance being introduced. In this case the wire to be protected, and the wire to be protected against, are wound side by side upon a cylinder of wood or other insulating material, and are connected to their respective circuits in such a way as mutually to neutralise their mutual induction. We would, in Mr. Edison's interest, attach more weight to this arrangement as bearing upon the merits of the case, than to all the rest of his specification put together; but in the absence of an arrangement by which the direction of one circuit is reversed at the moment of transmitting through it a signal, we cannot see how it can be protective against the influence of more than one line.

We believe that it is to Mr. Charles H. Wilson, of Chicago, that is due the honour of having been the first to point out an arrangement by which two telegraph lines may be perfectly compensated for induction, the one against the other, whichever of the two is constituting the primary circuit. This solution of the problem is as beautiful as it is accurate, and Professor Hughes has, we learn from his letter, which we publish in another column, acknowledged the priority of Mr. Wilson's work in the official reprint of his paper, which will appear in the next issue of the *Journal of the Society of Telegraph Engineers.* Mr. Wilson's arrangement is shown in the diagram, Fig. 2, and consists of a bar of soft

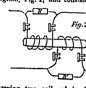


Fig. 2.

iron carrying two coils of insulated wire which are respectively placed in the circuits of the two wires. The effect, therefore of a current traversing one of the coils would be to induce in the other coil a corresponding magneto-electric current, and the coils are so connected to their respective lines that the currents induced by the coils are in a reverse direction to those induced by the lateral induction of the line wires. But, as a magneto-electric current so produced would in most cases produce a more powerful effect than that due to lateral induction, Mr. Wilson adopts the very ingenious device of short-circuiting each of the coils through a resistance box R and R', and these resistances are so balanced against one another, and adjusted for the relative influences of the coils and lines, that perfect mutual compensation is insured. Mr. Wilson also introduces into the circuits electro-magnets to act as condensers for prolonging the duration of the effects produced, so as to make his apparatus equally applicable for long as for short circuits.

There is certainly a remarkable similarity between Mr. Wilson's arrangement and that figured in the second and third figures of Mr. Edison's specification, but, as in Mr. G. B. Prescott's book on the Speaking Telephone and other allied instruments, full credit is accorded to Mr. Wilson for this invention, we take it that, bearing in mind the mutual scientific relationship existing between Mr. Edison and Mr. Prescott, the fact that it finds a place in the work of the latter, is an indication that Mr. Wilson's claim is equally admitted by Mr. Edison. The essential difference between the two arrangements is, however, that they accomplish different objects and are designed for two different purposes. Mr. Edison's arrangement is to protect one wire at the expense of all the others and regardless of what effects the latter have upon one another; for it is clear that although the upper wire is protected from the induction of the others, that evil is greatly increased in the others by the induction taking place among themselves. Mr. Wilson's arrangement is a perfect balancing of two lines, one against the other, but is powerless to protect either or both from the inductive effect of outsiders, or to protect outsiders from the influence of the lines to which the system is applied.

The respective arrangements of Mr. Edison, of Mr. Wilson, and of Professor Hughes represent the solution of three different problems: the first, how to protect one wire such as a telephonic circuit against the inductive influence of other circuits, without regard to their influence upon one another, or to the effect which such a system of compensation would have upon the unprotected lines. The second, how to balance the inductive effect of two lines, one against the other, so that whether either or both are being used the effects of induction taking place between them are eliminated; and the third, how to eliminate for a group of any number of lines the effects of induction, favouring one line no more than any of the rest, but insuring the protection for induction of each and all, whether one or more lines are being worked at the same time. It will be seen, therefore, that the three problems are essentially different and may be connected together for simplicity thus: Mr. Wilson's problem is a special case of Professor Hughes's, while Mr. Edison's is a special case of Mr. Wilson's.

But just as the problems to be solved possess essential differences, so the means employed by each inventor are equally distinct; and, indeed, it must follow from the nature of the considerations involved that the general nature of Professor Hughes's problem must necessarily involve very important differences in the method of solution to that for the more special cases.

What, in our opinion, constitute the characteristic points of distinction between Professor Hughes's balance and all other systems, are just those which he claims in his letter to us—which will be found in another part of the present issue—as being the essential features of his instrument, that is to say, 1st, the reversal of each coil at the transmitting station at the instant that a signal is sent through its corresponding line; and, 2nd, the proportioning of the length and distance apart of the compensating coils to the length and inductive power of the lines to which they are connected. It might, at first sight, be urged, as a weak point in Professor Hughes's apparatus, that if two or more circuits were being worked at the same time, and in the same direction, their coils would, from the construction of the instrument, be reversed together, and, therefore, would not be reversed with regard to one another; but Professor Hughes meets this difficulty by proportioning the strength of the battery to the length or resistance of its line, so as to have as nearly as possible equal strength of current passing through all the lines; for his experiments have substantiated in a remarkable degree the fact discovered and pointed out by Faraday nearly half a century ago,* but too often forgotten since, that the phenomenon of electrical induction between two conductors depends upon differences of electrical conditions existing between them, and that if the conditions of the two conductors be alike no induction can take place between them, and if two currents of equal strength be flowing through two equal conductors, they exercise no disturbing inductive influence upon one another, and this fact is demonstrated very

last week calling attention to those two specifications and stating his belief that they anticipate the experiments of Professor Hughes. It will be seen, therefore, that we are at the present moment in possession of far fuller information respecting what Professor Hughes claims, than respecting what is claimed by Mr. Edison, and we wish for this reason to caution our readers against forming an *ex parte* opinion of the merits of the case before the receipt of Mr. Edison's reply. It may transpire that Mr. Edison has supplemented his inventions by devices identical with or very similar to those by which Professor Hughes's apparatus is rendered applicable to all the lines of a group, and he may have further remarks to make which would altogether modify our opinion respecting the relation between the two inventions. We can only say for the present that our opinion has been formed from those sources of information that were open to us, and we shall have more to say on the subject when we are in possession of Mr. Edison's further opinion of the merits of the case.

THE "THUNDERER" EXPLOSION.

(*Continued from page 262.*)

In our number of last week we showed conclusively that the evidence of the eye-witnesses of the target practice on board the Thunderer was overwhelmingly strong in establishing the fact that two projectiles left the fore turret when the electric broadside immediately preceding the explosion had been fired. We will now bring forward the statements of William Caswell, who was in the turret at

of all the labours of others which bear upon his own researches, that are within his knowledge at the time, or to which his attention has been directed afterwards; and the letter which we publish on another page from Professor Hughes shows, we think, that he is animated by the same honourable feelings, and will be found ready to acknowledge all that Mr. Edison has done. And the very moderate terms in which Mr. Edison has, in the telegram to which we have referred, stated his claim to priority indicates that he is actuated by no personal feeling, but is only anxious as a scientific man that his valuable contributions to an important branch of scientific inquiry should not be passed over by those publishing their discoveries in a similar field of research.

We have in the foregoing remarks arrived at our conclusions of course only from the data in our possession. We have on the one hand, (1) Professor Hughes's paper read before the Society of Telegraph Engineers, (2) his experiments which we have ourselves watched with great interest almost from their commencement, and (3) Professor Hughes's letter to ourselves which we publish in another column. And with respect to Mr. Edison, we have (1) his British specification of July, 1877, (2) his American patent of February 1878, which we also republish on another page, and lastly (3) we have his telegram of

* See ENGINEERING, page 210, Fig. 3, *ante*.
† See ENGINEERING, Fig. 7, page 219 *ante*.

* See ENGINEERING, vol. xxvi., page 392.

* See *Philosophical Transactions of the Royal Society*, Faraday's Bakerian Lecture, 1832.

number of telegraph lines running in the same direction may be protected each against all from the effects of mutual induction, and we take it that this indiscriminate protection of all the lines constitutes at once the great value of Professor Hughes's invention, and its essential difference from any of the very beautiful devices invented by Mr. Edison for destroying the injurious influences of lateral induction in a telephone circuit, influences which without some such methods of compensation would have condemned the use of the telephone as a trustworthy instrument of communication.

Mr. Edison's American patent, which bears date February 21, 1878, *i.e.*, seven months after the date of that taken out by him for Great Britain, and of which we publish on another page the complete specification, deals with the subject of induction far more fully, in that the whole specification is devoted to the subject, while in the specification of the British patent it is merely touched upon among a large number of widely different subjects. The American specification is a highly interesting one, containing as it does several very pretty methods for the elimination of induction in telephone circuits by means of a combination of electro-magnetic and magneto-electric compensating inductors, and showing that both dynamical and statical electric induction may be got rid of or neutralised by similar arrangements, to which is added the use of condensers. The figures are so clearly explained in the text of the specification as to need no special description in this place; but we would invite more particular attention to Figs. 2 and 4, p. 277, as more conspicuously bearing upon the point at issue. The former is a diagram of one out of several arrangements devised by Mr. Edison for protecting a telephone line against the effects of induction of two or more telegraph circuits, such, for instance, as Nos. 1 and 2. This diagram bears a very close resemblance to that which we published† in illustration of the general principles upon which Professor Hughes bases his induction balance, and if the use of the latter were limited to the protection of one particular line against several others, the two devices would be very similar indeed, and we can well understand that Mr. Edison, having thought out and patented so beautiful a method of compensation, should, on seeing the first account of Professor Hughes's experiments, have been struck with the similarity, and should have assumed the two to be, for all the purposes of a patent, identically the same invention. The presence of the iron core is one point of difference between Mr. Edison and Professor Hughes's apparatus, although, as far as the principle is concerned, a not very important one, and we cannot help thinking that the removal of the iron would be accompanied with decidedly improved results. The counter-induction currents set up in the lines by the apparatus figured in Figs. 2 and 3 of Mr. Edison's specification (p. 277) are produced partly by electro-magnetic and magneto-electric induction, and partly by the ordinary dynamic induction taking place between the coils. The action of the first of these influences may be described as follows: Currents of electricity such as would be employed in the transmission of a telegraphic message would, in traversing the coil marked 2, induce magnetism in the iron core *g* which passes through all the coils and this increase of magnetic intensity in that portion of the core which is surrounded by the coil 3 would induce in that coil a series of currents of electricity which, by being thrown into the line with which that coil is in circuit, would either increase, or tend to neutralise, the effect due to the lateral induction of the line No. 2 with which the coil marked 2 is in circuit.

It is, however, quite probable that there is greater similarity between ordinary dynamical induction and electro-magnetic induction than at first sight appears, and that the latter is but a special case of the former; all dynamical induction being but an electro-magnetic effect due to variations in the intensity of the concentric lines of magnetic force circulating around a conductor conveying an electric current, and which have been so beautifully demonstrated by Dr. Silvanus P. Thompson, Professor of Experimental Physics in University College, Bristol.*

The second arrangement figured in Mr. Edison's specification would very satisfactorily accomplish, we have little doubt, the object for which it was designed, namely, the protection of the upper line against the inductive influences of Nos. 1 and 2, and it would in our opinion accomplish that object even still more perfectly if the iron core were removed, for Professor Hughes's experiments have shown that the presence of iron, or indeed of any conducting material within the coils, disturbs the balance and renders it next to impossible to obtain absolutely perfect compensation. This may be due to the impossibility of insuring the perfect homogeneity of the iron so as to produce uniform electro-dynamic effects in the two coils, but it is more probably due to the fact that the magnetisation of iron is essentially more sluggish than the dynamical induction between the lines, so that the induction currents and their corresponding compensating counter-induction currents are not isochronous, and therefore can only neutralise one another during the periods when their respective durations overlap.

Mr. Edison's drawing, Fig. 4, p. 277, although least resembling Professor Hughes's apparatus in general external appearance, is that which has the closest analogy to it in principle, because in this case the counteracting effect is produced by ordinary electro-dynamical induction, no iron core or other magnetic contrivance being introduced. In this case the wire to be protected, and the wire to be protected against, are wound side by side upon a cylinder of wood or other insulating material, and are connected to their respective circuits in such a way as mutually to neutralise their mutual induction. We would, in Mr. Edison's interest, attach more weight to this arrangement as bearing upon the merits of the case, than to all the rest of his specification put together; but in the absence of an arrangement by which the direction of one circuit is reversed at the moment of transmitting through it a signal, we cannot see how it can be protective against the influence of more than one line.

We believe that it is to Mr. Charles H. Wilson, of Chicago, that is due the honour of having been the first to point out an arrangement by which two telegraph lines may be perfectly compensated for induction, the one against the other, whichever of the two is constituting the primary circuit. This solution of the problem is as beautiful as it is accurate, and Professor Hughes has, we learn from his letter, which we publish in another column, acknowledged the priority of Mr. Wilson's work in the official reprint of his paper, which will appear in the next issue of the *Journal of the Society of Telegraph Engineers*. Mr. Wilson's arrangement is shown in the diagram, Fig. 2, and consists of a bar of soft

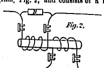


Fig. 2.

iron carrying two coils of insulated wire which are respectively placed in the circuits of the two wires. The effect, therefore of a current traversing one of the coils would be to induce in the other coil a corresponding magneto-electric current, and the coils are so connected to their respective lines that the currents induced by the coils are in a reverse direction to those induced by the lateral induction of the line

* See ENGINEERING, page 219, Fig. 3, *ante*.
† See ENGINEERING, Fig. 7, page 219 *ante*.

wires. But, as a magneto-electric current so produced would in most cases produce a more powerful effect than that due to lateral induction, Mr. Wilson adopts the very ingenious device of short-circuiting each of the coils through a resistance box R and R', and these resistances are so balanced against one another, and adjusted for the relative influences of the coils and lines, that perfect mutual compensation is insured. Mr. Wilson also introduces into the circuits electro-magnets to act as

* See ENGINEERING, vol. xxvi., page 392

condensers for prolonging the duration of the effects produced, so as to make his apparatus equally applicable for long as for short circuits.

There is certainly a remarkable similarity between Mr. Wilson's arrangement and that figured in the second and third figures of Mr. Edison's specification, but, as in Mr. G. B. Prescott's book on the Speaking Telephone and other allied instruments, full credit is accorded to Mr. Wilson for this invention, we take it that, bearing in mind the mutual scientific relationship existing between Mr. Edison and Mr. Prescott, the fact that it finds a place in the work of the latter, is an indication that Mr. Wilson's claim is equally admitted by Mr. Edison. The essential difference between the two arrangements is, however, that they accomplish different objects and are designed for two different purposes. Mr. Edison's arrangement is to protect one wire at the expense of all the others and regardless of what effects the latter have upon one another; for it is clear that although the upper wire is protected from the induction of the others, that evil is greatly increased in the others by the induction taking place among themselves. Mr. Wilson's arrangement is a perfect balancing of two lines, one against the other, but is powerless to protect either or both from the inductive effect of outsiders, or to protect outsiders from the influence of the lines to which the system is applied.

The respective arrangements of Mr. Edison, of Mr. Wilson, and of Professor Hughes represent the solution of three different problems; the first, how to protect one wire such as a telephonic circuit against the inductive influence of other circuits, without regard to their influence upon one another, or to the effect which such a system of compensation would have upon the unprotected lines. The second, how to balance the inductive effect of two lines, one against the other, so that whether either or both are being used the effects of induction taking place between them are eliminated; and the third, how to eliminate for a group of any number of lines the effects of induction, favouring one line no more than any of the rest, but insuring the protection for induction of each and all, whether one or more lines are being worked at the same time. It will be seen, therefore, that the three problems are essentially different and may be connected together for simplicity thus: Mr. Wilson's problem is a special case of Professor Hughes's, while Mr. Edison's is a special case of Mr. Wilson's.

But just as the problems to be solved possess essential differences, so the means employed by each inventor are equally distinct; and, indeed, it must follow from the nature of the considerations involved that the general nature of Professor Hughes's problem must necessarily involve very important differences in the method of solution to that for the more special cases.

What, in our opinion, constitute the characteristic points of distinction between Professor Hughes's balance and all other systems, are just those which he claims in his letter to us—which will be found in another part of the present issue—as being the essential features of his instrument, that is to say, 1st, the reversal of each coil at the transmitting station at the instant that a signal is sent through its corresponding line; and, 2nd, the proportioning of the length and distance apart of the compensating coils to the length and inductive power of the lines to which they are connected. It might, at first sight, be urged, as a weak point in Professor Hughes's apparatus, that if two or more circuits

beautifully and conclusively by Professor Hughes's experimental apparatus.

Summing up in a few words the foregoing remarks with respect to the relation between Mr. Edison's apparatus (see Fig. 2 of his specification, page 227) and that of Professor Hughes. (A). The two inventions are similar to one another (1) in the general application of the principle, claimed as original by neither inventor, of compensating induction by equal and opposite counter-induction, (2) in the employment of one inductor on the wire to be protected and one inductor on each of the circuits to be protected against, and (3) in the general external appearance of the apparatus. (B). The two inventions differ from one another (1) in the object which they are intended to accomplish. Mr. Edison's being designed for the protection of one specially favoured circuit against and at the expense of all the other circuits of the group, while Professor Hughes's protects any one member of a group against all the others, and all the members against one another, making it applicable to telegraphic as well as to telephonic circuits, (2) in the method by which the inductors are connected to their respective lines, for while Mr. Edison's are permanently attached (it not being stated to the contrary) in one position, those in Professor Hughes's are reversible, and must be reversed every time a current is sent through them, and (3) the essential differences of construction by which the lengths and distances apart of the coils in Professor Hughes's apparatus are proportional to the lengths and mean distance apart of the lines to be protected.

While, however (having formed the opinion *from* the data which we have been able to collect that the differences between the two systems are essential and conclusive as affecting the question of priority of invention) we cannot but feel that it is much to be regretted that Professor Hughes did not before publishing his experiments come across Mr. Edison's specification, which is of such a nature as to show the very valuable and important part which Mr. Edison has played in investigating the question of lateral induction. Had Professor Hughes been acquainted with what Mr. Edison had done, he could not have omitted to have placed it on record in his paper, as he has done the work of less important contributors to the science of the subject, and if Mr. Edison's very beautiful devices and interesting labours in this direction had been referred to in their place in the paper, we have no doubt whatever that no sort of difficulty would have arisen. It might be urged that it is the duty of an inventor before publishing a scientific discovery to make himself acquainted with all and everything that has been done in the same field by others, but to those who are acquainted with the labour of searching in the Patent Office for any particular device buried in some specification, of which neither the title, the date, nor the number are known, and especially to those who have to deal with the essential peculiarities of the patent system of the United States, this objection could not be seriously urged against any one who, like Professor Hughes, is engaged in scientific research, and whose time can be more profitably employed in other capacities. It is, however, undoubtedly the duty of any scientific discoverer to make the fullest and most public acknowledgment of all the labours of others which bear upon his own researches, that are within his knowledge at the time, or to which his attention has been directed afterwards; and the letter which we publish on another page from Professor Hughes shows, we think, that he is animated by the same honourable feelings, and will be found ready to acknowledge all that Mr. Edison has done. And the very moderate terms in which Mr. Edison has, in the telegram to which we have referred, stated his claim to priority indicates that he is actuated by no personal feeling, but is only anxious as a scientific man that his valuable contributions to an important branch of scientific inquiry should not be passed over by those publishing their discoveries in a similar field of research.

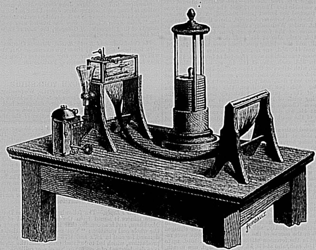
We have in the foregoing remarks arrived at our conclusions of course only from the data in our possession. We have on the one hand, (1) Professor Hughes's paper read before the Society of Telegraph Engineers, (2) his experiments which we have ourselves watched with great interest almost from their commencement, and (3) Professor Hughes's letter to ourselves which we publish in another column. And with respect to Mr. Edison, we have (1) his British specification of July, 1877, (2) his American patent of February 1878, which we also republish on another page, and lastly (3) we have his telegram of

SOEMMERING'S ELECTRIC TELEGRAPH.

The rapid success of Napoleon's Austrian campaign in 1809 was partly attributable to the good use he made of the optic telegraph, and when he had left the country the Bavarian minister suggested to Soemmering, a member of the Academy of Sciences of Munich, that the Academy of Sciences might advantageously turn their attention to the subject of telegraphy, the great advantages of which had been so completely demonstrated before them. Soemmering caught at the idea, and appears to have immediately recognised that electricity was the agent of all others calculated to render the required service. At that time the only known effect of an electric current which was suitable for the purposes of telegraphy, was the evolution of gas, and upon this he commenced to experiment. He first constructed a small apparatus. He made a cable of five wires insulated by sealing-wax. The ends of the wires, at one extremity of the cable, were connected to gold terminals in a vessel of acidulated water, and were marked *a*, *b*, *c*, *d*, *e* respectively. The other ends were placed, two at a time, to the terminals of a voltaic pile, composed of plates of zinc, silver coins, and felt soaked in dilute acid. The contact was followed by the evolution of gas from two of the gold terminals, and thus any two of the five letters could be indicated simultaneously. The possibility of effecting the transmission of words by this system having been demonstrated, Soemmering proceeded to construct the full-sized instrument shown in the annexed illustration, which was sketched from his original apparatus.

It consists of a receiver and transmitter connected by a cable of 35 insulated wires. Here the transmitter has 35 copper terminals in connexion with the conductors, marked with 25 letters and 10 figures. Any pair of these terminals could be connected to the poles of the voltaic battery by flexible connexions not shown in the figure, and thus a circuit established. The receiver had likewise 35 terminals; these were of gold, and were contained in a glass tank of acidulated water. To call the attention of the attendant an inverted spoon was arranged horizontally in the liquid, and collected the gases that were disengaged from certain terminals. When it became sufficiently buoyant it rose, and at the same time turned down a rod upon which there was loosely threaded a ball. The ball slid off, and, falling down a funnel, dropped into a cup at the end of a detent lever on a call-bell worked by clockwork, releasing the mechanism and putting the bell into action. In signalling the gas rose simultaneously from two of the gold terminals, the quantity from one being double of that from the other, and thus two letters were sent at once, it being understood that the one which evolved the greatest quantity of gas preceded the other in the written word. This apparatus was completed in August, 1810, but it was used without the call-bell in July, 1809. The first experiments were made over a distance of 38 ft., and then were rapidly extended to 1000 ft., and as soon as the inventor had perfected the insulation of his cable by caoutchouc dissolved in ether, to 10,000 ft. The telegraph was presented to the Academy of Sciences of Bavaria in August, 1809, to the Academy of Sciences of Paris in December of the same year, and afterwards to various royal personages, but no one took it up, and although it was twenty-five years before a practical system was brought out, yet no one seems to have tried to bring Soemmering's invention into a form from which useful service could be expected.

SOEMMERING'S TELEGRAPH.



GRAY'S HARMONIC TELEGRAPH.

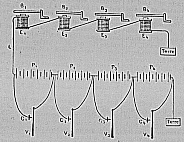


Fig. 1.

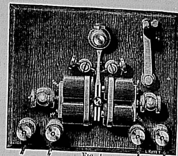


Fig. 4.

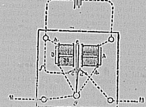
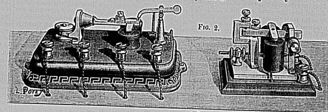


Fig. 3.

Fig. 2.



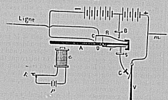
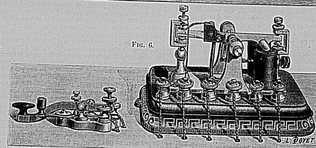


Fig. 5

Fig. 6.



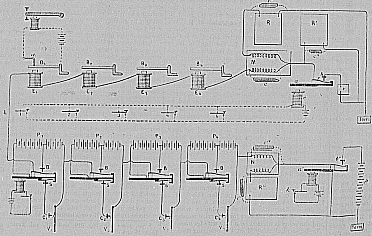


Fig. 7.

One of the most interesting exhibits in the American Section of the Paris Electrical Exhibition was the harmonic telegraph of Mr. Elisha Gray, the well-known Chicago inventor, and the jurors showed their high appreciation of it by awarding him a gold medal. In this system of telegraphy a number of different messages are sent over the same wire simultaneously from the same sending station, and this at the time the wire is being traversed by the ordinary Morse signal currents. Thus the Gray apparatus can be applied to a line which is already being worked on the ordinary system, without interfering with the latter. The reason of this is that the ordinary Morse signals are made by interruptions in a strong continuous current, whereas the Gray receivers are operated by relatively feeble vibratory currents. This principle is not quite a new one, as Mr. C. F. Varley, in 1870, patented apparatus for carrying it out in England; but the American inventor has very ingeniously brought it to a practical success. During test trials made on the Western Union Telegraph Company's wires between New York

80

The Iron Age – Oct. 16, 1884

Siemens' Telegraphic Cable Works.

A large number of the British Society of Engineers recently visited the telegraphic cable works of Messrs. Siemens Bros., at Charlton, where they had the opportunity of witnessing the various processes connected with the preparation of the materials used in the manufacture of these cables, as well as the manufacture of the cables themselves, and also the various kinds of electric telegraphic instruments and apparatus. From the reports of their visit we gather the following particulars concerning the method of making submarine cables:

The principal materials used in the manufacture of telegraph cables are wire, india-rubber, gutta-percha and hemp. In some cases the wire conductors are covered with india-rubber, and in others with gutta-percha, the cores being thus formed. The india-rubber is obtained in its raw state chiefly from Para, and the first process of manufacture is to rid it of its impurities. To this end it is cut into pieces and passed many times through rolls placed in pairs and running at differential speeds, so that a grinding as well as a squeezing action is obtained. A stream of water is continually running on the rubber, which carries away the impurities, and when the water runs clear it is an evidence that the cleaning process is so far complete. After this purification the rubber is dried at a moderate temperature, and afterward rolled into sheets of three classes. One consists of pure rubber sheets, while in the other two sulphur and other necessary ingredients are incorporated with the rubber. The sheets are then cut into strips or tapes ready for use in the covering machines. In the wire-covering department the conductors are incased in strips of these rubbers of one kind or the other, according to requirement, by being passed through machines in which the wire is, so to speak, sandwiched in between an upper and a lower strip, the edges being carefully trimmed off. In one machine wire was being coated with the pure rubber, while in another a conductor was being inclosed first in a white and then in a pink-colored rubber casing. The coverings are afterward solidified and made homogeneous by heat.

Another department is devoted to the covering of the conductors with gutta-percha, which, like the rubber, has to be first purified and prepared. The raw material in this case is obtained chiefly from Singapore, and is first cut up into slices by machinery. It is then soaked and softened in tanks of hot water, after which it is taken to a machine called a "ticker," or "devil," where it is shredded and discharged into hot water. It then undergoes complete mastication in special machines, whence it is transferred to hydraulic presses, where it is forced through strainers of fine wire gauze, which arrest all remaining mechanical impurities. It is again washed and masticated in boiling water. Various kinds of gutta-percha are afterward blended and finally rolled into sheets and stored. The wires are covered with gutta-percha by being drawn through machines having specially-constructed dies, in which the gutta-percha is contained under pressure and kept plastic by heat. As the covered wires leave the dies they pass through troughs of cold water and are led on to a second, and if necessary to a third, machine, according to the number of coats required. The insulated wire or core is conducted to the sheathing department, where it is first covered with hemp and afterward with iron wire by machinery. It is then passed through other machines, in which it is covered with two more layers of tarred hemp wound on in opposite directions. The cable is now completed, and as it is made it is stored in tanks, of which there are eight in the large tank-house, each tank being capable of holding 400 miles of cable. In a second tank-house there are eight more tanks of smaller capacity. From the tanks the visitors saw the cable being payed out to the telegraph cable ship Faraday.

An important feature in the manufacture of deep-sea cables is the testing, which is carried on throughout every stage from first to last, and on board the Faraday as the cable is being stored, so that it is impossible for a fault or flaw to occur without detection. The electrical testing-room of the works was, therefore, inspected with interest, as was also the pressure tank, which is a very ingenious contrivance for testing a cable core under the same conditions, as regards pressure, as those under which it exists at the bottom of the Atlantic in its deepest part. The apparatus consists of a small circular steel tank only about 30 inches internal diameter and some 5 feet deep, but weighing about 24 tons, the cover alone weighing 3 tons. Into this tank a length of about 2 miles of core wound on a reel or drum is lowered and the tank closed and locked by the screwed cover, the ends of the core being connected with the testing-room. Hydraulic pressure is then applied up to 4 tons per square inch—6 tons per inch can be applied if necessary—the core remaining under this pressure for about 10 minutes, during which the electrical testing is carried on. The machinery in what is known as the old cable shop is driven by a pair of compound horizontal surface-condensing engines of 180 horse-power indicated, that in the new cable shop being driven by a beam engine of 80 indicated horse-power. The cable works give employment to about 2000 men, another 1000 being employed in other directions.

81

MORQUET'S FLUVIOGRAPH.

(*For Description, see Page* 431.)

FIG. 1.

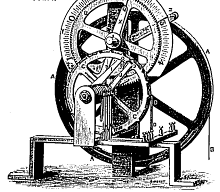
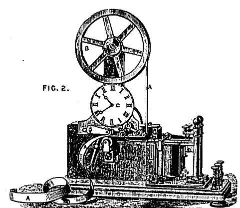


FIG. 2.



tinuous casing of plate metal. Mr. Fritz builds his blast furnace stacks in the same way. There is a considerable increase of strength and durability of shell with a given amount of material, and there is the advantage of making repairs from the outside when required. The cupola is lined up 7 ft. 6 in. in largest internal diameter, and 6 ft. at the tuyeres. There are eight tuyeres of 6⅜ in. diameter placed in a continuous row at 4 ft. 1 in. above the drop-bottom door. The blowing apparatus consists of four number 7½ Baker pressure blowers; the engine (compound) shaft runs direct through two blowers on one side, and two on the other, and makes about 90 revolutions per minute; belting is thus entirely avoided. The blast pressure is 1¼ lb. at the blower, and ⅝ of a pound at the tuyeres. When the new Bessemer plant is running alone, three cupolas going continuously, and three blowers are required to supply it.

The cupola is charged as follows when cold:

	lb.
Bed, charge (coke)	800
" anthracite	8500
Iron	7500
Coke	700
Iron	7500
Anthracite	700

And so on, the fuel being reduced according to the judgment of the foreman as the furnace gets hot. The cupola bottom is usually dropped after a 48 hours' run, so that the patching around the tuyeres shall not be excessive, and on the average 10 lb. of iron are melted with 1 lb. of fuel. Limestones and other fluxes are used as required. After each tapping of iron, the slag tap is opened and kept open until the iron reaches it. The spiegel cupola has 30 in. maximum internal diameter and 20 in. diameter at the tuyeres, which are four in number, and are 4 in. in diameter. This cupola is run with coke exclusively, and otherwise like the large cupolas.

The output of the new Bessemer plant, which was started in its present shape in March, 1881, averages about 3000 tons per week of twelve shifts; the plant has been worked at a higher rate of production. The heats of ingots run from 6¾ to 7½ tons according to the weight of rail. Fourteen inch ingots are bloomed to 7½ in. and cut into four to five single rail blooms for the rail mill. A 48 in. three-high blooming train with a single 65-in. cylinder, 8 ft. stroke, is nearly completed. This will roll much heavier ingots, and will be further described in another article.

TELEGRAPH CONDUCTORS AT THE ELECTRICAL EXHIBITION AT PARIS.

In a recent number we gave a full account of the new underground cable of Mr. Brooks, and in the present article we shall describe the lesser novelties in conducting wires at the International Exhibition of Electricity.

The highly insulating properties of paraffin are being more and more utilised in telegraphy. Mr. Brooks has succeeded in applying the liquid oil, and Mr. Henley is now manufacturing a submarine cable to be laid between Cuba and Belize in which solid paraffin is employed to heighten the insulation resistance. This material has for many years been used as the insulator for separating the tinfoil plates of the large condensers employed in signalling on submarine cables, and for making part of the artificial line in working telegraphs on the duplex system. When pure it has an enormous resistance to the passage of the electric current, and only its frail mechanical qualities have hitherto prevented its use as an insulator for submarine or subterranean cables. It is unfortunately soft and friable like wax, and therefore will not by itself stand the stress of laying and repairing as gutta-percha or india-rubber will. Mr. W. J. Henley, of North Woolwich, has, however, combined it with india-rubber in such a way as to increase the insulating power without impairing the mechanical properties of the rubber. In short, he manufactures an india-rubber covered core in the usual manner, that is, the wire is first covered with pure india-rubber, then with a "separator" of impregnated rubber, and lastly with cured rubber. The core so formed is cooked in the ordinary way, and afterwards it is cooked again in a bath of melted paraffin wax. The fluid paraffin assisted by the heat permeates the pores of the rubber and thus raises its insulation resistance. Some 380 miles of the new cable have already been made, and will shortly be sent out for laying.

Another and more thorough compound of india-rubber and paraffin wax is exhibited in the stall of Messrs. Latimer Clark, Muirhead, and Co., of Westminster. This new insulator is termed "nigrite" from its rich black appearance. It is the invention of Mr. Field, the well-known candle manufacturer, and consists of certain proportions of pure india-rubber and the black earth-wax called "ozokerit." The usual proportions are two parts of ozokerit by weight to one of india-rubber, a proportion which materially diminishes the cost of the compound. Pure rubber and gutta-percha are both comparatively expensive, and the price of gutta-percha especially has risen very much of late years, owing to the increasing demand and the scarcity of the gum. Nigrite-covered wire, we are informed, can be turned out at a price 40 per cent, below that of good gutta-percha core. The mixture of the two substances, india-rubber and ozokerit, is brought about by mastication at a low temperature. The insulation resistance of the compound is very much higher than that of either india-rubber or gutta-percha, while its specific inductive capacity is considerably lower. It is therefore well adapted for insulating telephone lines and subterranean or submarine cables. It stands the atmospheric changes remarkably well, and hence is on demand in America for telephone wires and connexions. One drawback it possesses at present for use as an insulator for submarine cables, and that is its softness as compared with india-rubber and gutta-percha; but the inventor hopes to overcome this fault, and if so, he will have produced a valuable material for this end. Even now, however, it is eminently serviceable for leading wires, and lines for telephonic and electric lighting purposes.

Similar in looks to the nigrite is the black gum exhibited by M. Ernest Mourlot, 70, Rue Lafontaine, Auteuil, Paris. This novel substance is distilled from the bark of the white birch tree, and hence is called "French gutta-percha." The inventor holds that it possesses high insulating properties, entitling it to replace the ordinary gutta-percha and india-rubber for telegraphic use. As a product of our own temperate climate, and of one of our common forest trees, it at least deserves the trial and encouragement of European electricians. Perhaps, too, if the search were continued some other vegetable gum, equally good, or better, might be discovered among our native flora.

The cables of MM. Berthould, Borel, and Co., as manufactured by the Société Anonyme des Cables Electriques, 33, Boulevard Haussmann, Paris, are also worthy of note as another application of wax paraffin to insulating conductors for telegraphic, telephonic, and electric lighting purposes. They are distinguished from other sorts of cable by their construction and low price. The insulator consists of equal parts by weight of paraffin wax and resin. The conductor is served with cotton and then steeped in the melted insulating compound. It is protected by a pipe or envelope of lead, and over that a layer of coal-tar pitch, then a second lead pipe thicker than the first. Lastly, if it is required, an armour of iron wire covered with tarred tape is served over all.

The insulation resistance of a single wire insulated in this manner is about 5000 megohms per kilometre at 16 deg. Centigrade. Single and double wire conductors of this kind are now used for telephonic purposes in Paris. A cable having seven separate conducting strands, each half a millimetre in diameter, is employed for telegraphy, and the mean insulation resistance per kilometre is as high as 29,000 megohms, while the inductive capacity is 0.1 microfarads for the same length. The diameter of the insulated core for such a cable is about ½ in., and the external diameter of the pipe is about ¾ in. The quoted price is 1700 francs per kilometre. For telephonic and electric lighting lines the price is relatively lower, owing to the lower insulation required. For example, a telephonic cable comprising six conductors, each seven-tenths of a millimetre in diameter, costs 800 francs, while one comprising two conducting wires is only 400 francs per

Eng. Mech. & World of Science - July 18/84

MICHELA'S STENO-TELEGRAPH.

THE attempts which have hitherto been made to enlist the telephone in the work of the press have not been altogether successful even in London, where every facility exists and the distances are short; but there is a possibility that the stenograph telegraph of Signor Michela, of Ivrée, will eventually, either by itself, or in an improved form, supplant the present systems of telegraphing. In spite of the wonderful accuracy and speed with which the trained operators despatch long messages by means of Wheatstone's recorder, it is obvious to the thoughtful observer that there is something radically defective in the whole system of telegraphy, for, so far from a single signal representing a word, the majority of the letters which go to make up a word require for themselves two or more signals or marks. The expert telegraphist is a living exponent of what training can do to render possible what might easily be considered impossible; but it cannot be admitted that the present system of telegraphing, perfect as it may be, so far as it goes, is finality. The telephone, over short distances, and with suitable arrangements, beats the telegraph out of the field, but it has the defect that it leaves no record of what has been transmitted; the printing and recording telegraphs have that great advantage, they give up their messages in permanent shape, which can be preserved for future reference and verification. Just, however, as shorthand is to long-hand, so is steno-telegraphy to the string of dots and dashes so puzzling to the novice. The aim of Signor Michela is, in fact, to telegraph by means of a keyboard instrument any speech, no matter in what European language, at the same speed as it is delivered, or say, at the rate of 10,000 words in an hour. Michela's apparatus has been in use in the Italian Senate, and, from a pamphlet before us, written by M. Cassagnes, we learn that experiments with it can be witnessed every day at certain hours at No. 1, Rue Rossini, Paris. It goes without saying that Michela's machine works on the phonetic principle, and depends mainly for its success on the ability which the inventor has disclosed in grouping into series, and representing by combinations of signs, all the phonetic sounds emitted in any language. As soon as the operator hears the words, he decomposes them as it were, and prints their graphic representations in short horizontal lines on a paper band about 1¼in. wide. That is a stenographic record, but, at the same time as the signs are being printed on the paper, they may be telegraphed to a distant station. The machine consists of two parts—the printing mechanism and that for the automatic forwarding of the paper. The latter is of no special character, but the printer consists of two keyboards having 10 keys each (six white, four black); these keys press on 20 studs which are, by a system of levers, connected to as many styles, which carry the signs or characters to be imprinted on the paper. It is stated that a skilled operator can take down with Michela's apparatus 200 words per minute in any language he knows—a speed which is more than sufficient to follow the fastest speaker. For something like three years the system has stood the practical test, so far as stenography is concerned, and now the machine has been connected electrically with an apparatus for transmitting the signals to a distant station as fast as they are made, so that, if the receiver can translate the steno-telegraphic signals with rapidity, a speech might be read at the distant office as fast as the speaker himself delivers it. It is preferred, it appears, to keep each machine for its own special work, that is, the receiving instrument is not used as a transmitter, nor the transmitter as a receiver. The receiver, in fact, has the printing styles but not the keys, the styles being actuated by magnets, excited by currents sent from the transmitter. This arrangement has been adopted because the machine could be made lighter or to require less force to actuate it, and because the use of a combined transmitter and receiver would have interfered with quadruplex and multiplex working. Without details of the mechanism, which indeed would be of little use without diagrams, it must suffice to say that each key may be considered a true Morse key, and the board, therefore, represents a set of 20 Morse instruments, which combined, according to Michela's stenographic method, give a transmitting speed much higher than that of any existing telegraph. The value of this device, assuming that it works successfully in practice, cannot be overestimated; for, to take only the case of Parliamentary reports, it will be possible to send to different newspaper offices in distant towns the actual words of a speaker as fast as he delivers them. The telegraphic shorthand in which they are delivered will need translating, but it is stated that any intelligent person can learn to do that in fifteen days, while to acquire the art of transmitting with facility will need a study and practice of six months. In any case the stenographic signs will be, at least, as easy to learn as the single-needle motions or the dots and dashes of the recording instruments, and, whether Michela's device does or does not meet all requirements, it certainly points out the direction in which inventors should look for a probable improvement in the present system of telegraphy.

Iron - Jan. 13/82

THE NEW ATLANTIC CABLE.—The steamship *Faraday* left the works of Messrs. Siemens Brothers at Charlton on January 10, with the last portion of the new Atlantic telegraph table, which is to be forthwith completed for the American firm of Gould and Co. The cable is of special kind and remarkable for its strength, the shore end weighing 18 tons per mile and the deep sea and intermediate sections being to correspond. More than 1100 miles have been taken on board at the rate of 50 miles per day, and the cable, when completed, will be 3000 miles in length. The *Faraday* has made three voyages on the same work, leaving the end of the cable on each occasion buoyed in the Atlantic, where it has endured the storms of the past year without the slightest injury.

Iron — A TELEGRAPHIC CONTEST. Nov. 7/84

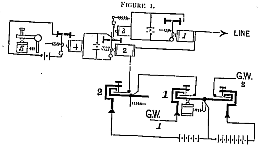
A REMARKABLE contest for fast telegraph transmission took place recently at New York, at the offices of the Western Union Telegraph Company. The prizes offered for competition were three in number, the first being a gold medal, the second a silver medal, and the third a decorated telegraph key. They were given by Messrs. J. H. Bunnell & Co., of New York, and the only condition was that the Morse steel lever key should be the one used. The prizes were for clearness of character and speed combined. At eleven o'clock, when the contest began, over one hundred leading operators and telegraph managers were present. On a printed slip was the work to be done. This consisted of 500 words, 15 periods, and 4 commas,—in all 2,368 characters. The messages were sent on a local circuit. There were ten competitors, all of whom did remarkable work, and at one o'clock the contest was finished. Shortly afterwards the judges announced their decision, which awarded the first prize to Mr. W. L. Waugh, for superior work, each letter and character being perfect, time 11 minutes 27 seconds; the second prize to Mr. W. M. Gibson, for good work, time 11 minutes 3 seconds; and third prize to Mr. F. J. Kihm, for fair work, time 10 minutes 32 seconds. Mr. Waugh belongs to the Commercial Telegram Company, Stock Exchange, Mr. Gibson to the Bankers' and Merchants' Stock Exchange, and Mr. Kihm to the United Press Association. The most remarkable time on record was that of Mr. J. W. Roloson's, an operator of the Bankers' and Merchants' Company. His time was 10 minutes 10 seconds, or at the rate of about 50 words per minute, but his work was too indistinct and unreadable to obtain a prize.

Montreal June 1, 1884.

DUPLEX AND QUADRUPLEX TELEGRAPHY.

A NEW INVENTION BY B. B. TOYE, Superintendent G. N. W Telegraph Co'y., TORONTO.

FIGURE 1.



For the present purpose, we will suppose that the transmitters are at one end of the line and the rest of the apparatus at the other. Transmitter No. 2 sends the weaker current, say one-third of the whole, from the short end of the battery to line, transmitter No. 1 sends the stronger current from the long end the other two-thirds and both together send the whole current of the battery to line. Relay 2 is adjusted the usual way to be operated by the current from the short end, while relay No. 1 is adjusted too high to respond to it. When the stronger current from the long end of battery is sent to line, relay No. 1 responds but No. 2 does not its armature being kept open by the armature of No. 3 falling back, its local being opened by the arm of No. 1. When both transmitters are closed, the additional strength closes relay No. 2 (as well as No. 1) by overcoming the spring of No. 3.

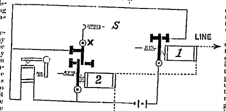
Now suppose both transmitters and relays are closed, if transmitter No. 1 is opened, the long end of battery is taken off line, relay No. 1 opens and simultaneously allows local to retain No. 3 closed, and the short end of battery keeps relay No. 2 closed. Next, when both transmitters are closed, and transmitter No. 2 is first opened, the short end of battery is taken off line. Relay No. 1 remains closed but the arm of No. 3, its circuit being still kept open, opens Relay No. 2, lastly, when both transmitters are opened, there is no current to line and both relays open.

Relays No. 1 and 2 are duplex relays of the usual pattern, although for the sake of simplicity the double wires and artificial line are omitted in the diagram. When both transmitters are open, the line is to ground via spring and arm of No. 2 and spring and post of No. 1 transmitter to G.W. 1.

G. W. 2 puts the long or short end of battery to ground according to the position of the armature of transmitter No. 1.*

When both transmitters are closed the route is from G. W. 2 through spring and back post of transmitter to battery thence through whole battery (the tap wire being disconnected from line at the front spring of transmitter No. 1) to post and spring of No. 2 and line.

FIGURE 2.



Magnets 3 and 4 are dispensed with in this plan, making the system almost as simple as that of a repeater:—

Instead of checking the action of the Armature of Relay No. 2 by holding it back by the arm of 3, it is allowed to play as moved by the currents, when it reaches arm X, under the impulse from the long end of the battery it cuts out the magnets of Sounder 2, so that it fails to respond, but spring S allows it to go no further. When the whole battery is sent to line spring S is overcome and arm X moves off its back stop, so that the battery operates Sounder 2 which then closes

Now let us suppose the short end of battery is to line, transmitter 2 being closed, which of course closes Relay 2, Relay 1 is open being adjusted too high to respond. Next we will suppose transmitter 1 is being worked sending the long end of battery to line; as the short end is already to line, the whole battery goes to line, every time transmitter 1 is closed:— At first sight it would seem that when the arm of Relay 1 closed on arm X, local magnet 2 would be cut out and consequently open, and such would be the case if the arm of 1 rested against the arm X, but here it has another part, and that a paradoxical one to play, as it not only cuts magnet 2 out, but *simultaneously cuts it in again*, (by moving arm X off its back stop,) in so short a fraction of time, that the cutting out actually does not take place at this particular time, and consequently Sounder 2 remains closed. Then on the back stroke of Relay 1 the same apparently paradoxical operation takes place in the opposite direction, arm of Relay 1 in moving back leaves arm X on its back stop, apparently cutting magnet 2 out but at the same instant it breaks contact with it, so that the local circuit remains complete through the arm of Relay 2.

The above is sufficient to give the key to the whole action of the apparatus: perhaps we may return to the subject again.

84

N.Y. Building
May 1885

85

THE OPERATOR

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Experiments in Synchronous-Multiplex Telegraphy.*

BY PROF. EDWIN J. HOUSTON.

A most extraordinary experiment, which is not devoid of practical bearings, has quite recently been made by Mr. Patrick B. Delany with his synchronous-multiplex telegraphic system, which is now in operation between Boston and Providence, a distance of about fifty miles.

As the experiment about to be described almost challenges belief in its possibility, I desire to state that I have seen it myself and can vouch for the accuracy of the facts herein stated.

Wishing to try the adaptability to the synchronous system of the automatic repeaters employed by other telegraphic systems, whereby great distances are overcome, Mr. Delany, on three different occasions during the past two weeks, successfully employed such repeaters with his system, the last trial, viz., that on Monday, the 14th of July, being witnessed by myself.

One of the two wires erected by the Multiplex Company between Boston and Providence was divided into six separate and distinct Morse circuits. The first of these circuits, which we will call No. 1, was operated to Providence, at which place the receiving relay, on that circuit, was connected to the transmitting instrument on No. 2 circuit. In Boston, the receiving relay of No. 2 circuit was connected to the transmitting instrument of No. 3 circuit. In Providence, the receiving relay of No. 3 circuit was connected to the transmitting instrument of No. 4 circuit. In Boston, the receiving instrument of No. 4 circuit was connected to the transmitting instrument of No. 5 circuit. Finally, in Providence, the receiving relay or instrument of No. 5 circuit was connected to the transmitting instrument of No. 6 circuit. Under these arrangements the transmitting instruments at both stations were operated by the receiving relay on the other circuit the same as if worked or operated by an operator; in other words, the six separate and distinct circuits established by the synchronizing apparatus between Boston and Providence were arranged so as to form in reality a continuous wire stretched six times between Boston and Providence, with both of its free ends in Boston.

Mr. Delany then transmitted a message on the No. 1 circuit, from Boston to Providence, which was automatically retransmitted from Providence to Boston on No. 2 circuit; again automatically retransmitted from Boston to Providence on No. 3 circuit; again automatically retransmitted from Providence to Boston on No. 4 circuit; again automatically retransmitted from Boston to Providence on No. 5 circuit, and finally automatically retransmitted from Providence to Boston on No. 6 circuit. Or, in other words, the message sent from Boston on the first circuit, went to Providence, came back to Boston, again went to Providence and came back to Boston, when it again went to Providence and came back to Boston, at which final station it was clearly read by an operator without the loss of a single character, or the slightest impairing of its original clearness, and without the aid of any person except the transmitting operator on the No. 1 circuit in Boston and the receiving operator on the No. 6 circuit in Boston. All this was done over one and the same wire, so that the message traveled in its back and forth journeys between the two cities, about three hundred miles, or six times the distance between the two cities.

A reference to the drawing will render the preceding explanation clearer. The synchronized distributing instruments A and B, situated at Boston and Providence respectively, are connected by the single main line $Q\ Q$. The line is divided into six circuits, which we will call respectively Nos. 1, 2, 3, 4, 5 and 6. For the purpose of rendering the connections clearer, these six circuits have been separately represented with the synchronized distributing instruments connected therewith. It will of course be understood that but a single main line $Q\ Q$, furnished with but two distributing instruments, viz., one A at Boston, and the other B at Providence, exists between the two cities.

This being premised, an inspection of the drawing will show that the main battery $M\ B$, at Boston, split and grounded at X, is connected with the No. 1, No. 3 and No. 5 transmitters, which are respectively connected with the No. 1, No. 3 and No. 5 sextuplex circuits of the single main line $Q\ Q$. At Providence the main battery $M^1\ B^1$, split and grounded at Z, is connected with the No. 2, No. 4 and No. 6 transmitters, which are respectively connected with the No. 2, No. 4 and No. 6 sextuplex circuits of the single main line $Q\ Q$.

At Providence, the No. 1 rece[illegible]er is connected with the transmitter of No. 2 circuit, [illegible] that a message sent from Boston by No. 1 transmit[illegible] would be received by the No. 1 receiving relay [illegible] Providence, when, by means of the local battery $L\ B$, would have its message repeated by No. 2 transmitter, and sent to Boston over the No. 2 sextuplex circuit of the main line $Q\ Q$. This message would be received in Boston by the No. 2 receiving relay, when, by means of the local battery $L\ B$, connected with No. 2 receiving relay, would have its message automatically repeated by the No. 3 transmitting instrument at Boston, over the No. 3 sextuplex circuit of the main line circuit $Q\ Q$ to Providence, at which place it would be received by the No. 3 receiving relay. This relay, in its turn, through the aid of the local battery connected with it, automatically transmits the message through the No. 4 transmitter, over the No. 4 sextuplex circuit of the main line $Q\ Q$, to Boston, at which place it is received by the No. 4 receiving relay. This relay, in its turn, through the local battery $L\ B$ connected therewith, automatically repeats the message to the No. 5 transmitting instrument, over the No. 5 sextuplex circuit of the main line $Q\ Q$, to Providence, where it is received by the No. 5 receiving relay. Finally, this relay, in its turn, through the intervention of the local battery $L\ B$ connected therewith, automatically repeats the message to No. 6 transmitter, over the No. 6 circuit to Boston, at which place it is received by the No. 6 receiving relay, by the operator stationed at the Morse instrument connected with that relay. This receiving relay is, in reality, shown in the drawing as connected with No. 1 transmitting instrument at Boston. The purposes secured by means of this connection will be hereafter explained.

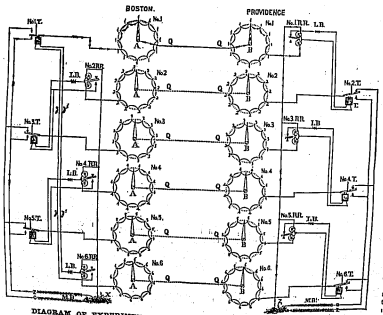

DIAGRAM OF EXPERIMENT IN SYNCHRONOUS-MULTIPLEX TELEGRAPHY.

Briefly, the course taken by the message in its journeys to and from the two cities, is as follows, viz.:

From Boston, by No. 1 transmitter over main line to No. 1 receiving relay at Providence.

From Providence, automatically repeated to No. 2 transmitter, and sent over main line through No. 2 sextuplex circuit to No. 2 receiving relay at Boston.

From Boston, automatically repeated to No. 3 transmitter, and sent over main line through No. 3 sextuplex circuit to No. 3 receiving relay at Providence.

From Providence, automatically repeated to No. 4 transmitter, and sent over main line through No. 4 sextuplex circuit to No. 4 receiving relay at Boston.

From Boston, automatically repeated to No. 5 transmitter, and sent over main line through No. 5 sextuplex circuit to No. 5 receiving relay at Providence.

Finally, from Providence, automatically repeated to No. 6 transmitter, over the main line through No. 6 sextuplex circuit, to the No. 6 receiving instrument at Boston, where it is received by the operator.

It is not necessary, as might be supposed from the drawing, that the characters received on the group of segments comprising No. 1 circuit must necessarily begin to return on the next adjoining segment of No. 2 circuit. Suppose, for example, that a character concluded on the segments of No. 1 circuit, where the trailing contact indicates on the drawing. By the time the armature of the relay has

* Journal of the Franklin Institute, September, 1884.

Character of article Rept
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[illegible]N'S LATEST IDEAS.

Experiments for Telegraphing Between Ships at Sea.

It was rather a weird experience, meeting him. There are but two men besides himself, at night. He was chiefly engaged with his new idea of telegraphing from railroad trains in motion. This is not to be done by a cable laid along the track, on the Phelps plan by throwing the electric current, by induction, to one of the wires alongside the railroad. His experiments have already shown that the sparks can be thrown 180 feet. The regular Morse instrument, with certain appliances, will be used. The battery is to be grounded in the wheels of the car, and on the top of the car there will be condensers, of tin foil spread upon long strips of wood. Arrangements are also progressing for an experiment in telegraphing by the same method from one ship to another at sea.

"But is that possible?" I asked. "How far do you think you can throw the current over the water?"

"I am afraid to say how far," was the answer. "From the data already obtained, the theoretical conclusion is that we can throw it twenty-four miles. Possibly we can throw it more than that."

Then Edison sketched on paper a map of the two continents and the Atlantic, and illustration his plan of telegraphing from ship to ship so as to establish certain communication between the shore and any part of the frequented seas. Not content with this projected miracle, which seems to be near its fulfillment, he is also busy upon improvements in submarine telegraphy. The method now generally in vogue of reckoning words through cable by the flicker of a flame thrown upon a mirror is amazingly insufficient, as is shown on a diagram which Edison displayed. The number of dots indicating letters often has to be judged by operators from the length of time that the flame hesitates. Even the siphon receiver, invented by Sir William Thompson, and used by one or two of the new cables, is not quite satisfactory, although it marks the dots pretty nearly. Edison is trying to devise some means of attaining a higher or better regulated rate of speed so that the record may be made clearer. But "its a tough job," he says.

Perhaps the most interesting thing he had to say was respecting his exploration for a "new force." At present he calls it simply x y z. He does not pretend to know what it is. But he says that there are many phenomena which are not explained by any force yet recognized, and it is these which he is going to investigate. Vibrations of matter at the rate of 30,000 a second produce the highest sound we can hear. Between these and the vibrations which, at the rate of millions per second, cause the sensation of heat, there is a large gap; and between these and the vibrations that give sensations of color there is another gap. These gaps, Edison believes, are filled by vibrations as yet unmeasured, which constitute the new, or unnamed, force he is in search of. He brought out from a drawer sundry loose sheets on which he had sketched a num-

moved in response to this character, and has placed No. 2 circuit in connection with the battery for return transmission, the trailing contact may be on the second or third contact of the No. 2 circuit. This, however, will make no difference, since both the distributing arms are synchronous so long as the rotating arms pass over two or three of the No. 2 segments, while the armature of the transmitting magnet is in contact with either of the poles of the battery.

When we consider that a message made up of many words, each word containing numerous letters, each letter consisting of numerous separate and distinct characters, and each character, under the synchronous-multiplex system, consisting of numerous impulses, was transmitted with certainty over a single wire, back and forth, this number of times, without the slightest interruption the one with the other, the fact almost challenges belief.

While these results may appear almost incredible, what I am about to describe may at first thought seem impossible. I will endeavor, however, to give such a description of this experiment, as I saw it actually made, as will persuade the reader that, so far from being impossible, its possibility must necessarily follow as a natural result of the exquisitely maintained synchronism secured by Mr. Delany's ingenious inventions.

After having successfully established by actual trial, the possibility of the use of repeaters in his synchronous system, Mr. Delany connected the relay of the sixth circuit in Boston, where the message was received, with the transmitting instrument on No. 1 circuit. Now, under these conditions, on making one dot on No. 1 instrument this dot started on its zigzag way to and from Providence, in the manner already described, only, instead of terminating on the sixth circuit in Boston, as in the previous experiment, the same dot was automatically transmitted into the first circuit, and again sent on its journeying between the two cities, only on its arrival at the sixth circuit, in Boston, to be again automatically retransmitted over this same winding route.

An inspection of the drawing will render this connection clearer. Instead of the message being received by an operator stationed at No. 6 receiving relay at Boston, this instrument is furnished with a local battery $L\,B$, and connected by means of the conducting wire $z\,z$ and $z'\,z'$ with the No. 1 transmitting instrument at Boston. By this means, therefore, the operator at the No. 6 receiving relay is dispensed with, since this receiving relay again automatically sends the signal, by means of the No. 1 transmitting instrument, on its zig-zag way between the two cities until the No. 6 transmitter at Providence again sends it to the No. 6 receiving relay at Boston which again automatically repeats it by the No. 1, transmitter, over the six circuits between the two cities, and so on indefinitely.

In this manner, then, the original signal kept passing from city to city over the different circuits in perfect rotation, without the intervention of any operator save the one who first started the signal on its ceaseless journeyings.

Timing the intervals of the returns of the original signal between the two cities over the sextuplex circuits, it was observed that it traveled between Boston and Providence over these six circuits 300 times, or covered the distance between Boston and Providence 1,800 times in each minute, thus making an entire distance of 1,500 miles a second, or 90,000 miles a minute; or for five minutes that a dot was kept going, the original signal in that short time traveled no less than 450,000 miles, or eighteen times as far as the entire distance around the world at the equator.

Of course it will be understood that most of this time was taken up by the automatic movements of the armatures of the receiving relays, and the levers of the transmitting instruments. The experimental figures so obtained, however, furnish interesting data as to the rapidity, precision and certainty with which these masses of matter may be influenced by the electric current.

An observer, noticing the progress of this experiment and reflecting on the numerous complex conditions requisite for its successful accomplishment, cannot but be singularly impressed by its extreme weirdness. Bearing in mind the exceeding complexity of structure of the synchronous-multiplex message, and the necessity for maintaining practically absolute synchronism between the distributing and receiving instruments at each end of the main line, a feeling of incredulity almost unconsciously arises in the listener's mind. Surely this weird traveler must miss some of his numerous connections; and once missed, his journeys are at an end forever. But when the signals are heard recurring with their automatic regularity, as though tossed to and fro between the cities by a mighty juggler; when they are heard as mysterious whisperings in the air, that follow too rapidly on one another to permit more than a part to be intelligently received, we almost lose sight of the actual conditions of the experiment, and begin to vaguely doubt whether Mr. Delany has not received a visit from Puck, who is bewildered by the rapidity with which he is forced to travel; and when the strange repetitions of the original signal follow one another with such rapidity and regularity as to produce a kind of a prolonged but mysterious murmur, we are almost disposed to believe that these sounds are the plaints of the Wandering Jew as he ceaselessly speeds on his never-ending journey.

Arrival of Sir William Thomson.

Sir William Thomson, the great English scientist, arrived here on the steamer Servia on the 18th ult. He is well known by repute and by his writings to all our readers. His main contributions to science have been made between 1850 and the present time. They consist of papers on "The Distribution of Electricity in Spherical Conductors," "Electro-dynamic Properties of Heat," "Thermal Effects of Fluids in Motion," "Mathematical Theory of Electricity," "Rigidity of the Earth," "Determination of a Ship's Place at Sea from Observations of Altitudes," "Approach Caused by Vibration," and on other scientific subjects. He is also the inventor of the mirror galvanometer and the siphon recorder.

In 1866, on the completion of the Atlantic cable, he was knighted and presented with the freedom of the city of Glasgow. The universities of Glasgow, Dublin, Cambridge, Edinburgh and Oxford subsequently conferred upon him the honorary degree of Doctor of Laws. He is also a fellow of the royal societies of London and Edinburgh, and received from the former the royal medal and from the latter the Keith prize. In 1871 he was President of the British Association, which met in Edinburgh, and in 1872 of the Geological Society, which met in Glasgow. In 1877 he was appointed Foreign Associate by the Paris Academy of Sciences, and in 1881 presided over the meeting of the mathematical and physical sections held in York. The latest appointment held by him was that of British Commissioner for the Electrical Exhibition held at Vienna in 1883. He was in this country in 1876.

Sir William's visit to this country is for the purpose of attending the Congress of Electricians, which will be held this month at Philadelphia. At present he is in Montreal with the British Association.

The subjoined is part of of an interview with Sir William Thomson:

"Has it ever struck you, Sir William, that it would be advisable to have distinct professorships of electricity and magnetism established in the leading schools and universities?"

"That is a good idea, sir; and it might well be carried out as far as possible. Some universities have such a professorship, but not all. To lecture fittingly on electricity and magnetism a man should be thoroughly grounded in most of the other sciences, and that is the reason, I presume, why a single professor is sometimes required to give instruction on all the modern sciences. The world, however, is rapidly recognizing the fact that most of the great modern inventions are due to electricity, and that it is going to be 'the science of the future,' and it is certain that every year its study will be more insisted on by all nations."

"How long do you intend to remain here, Sir William?"

"Until November. I go to Montreal at the close of this month to preside over the mathematical section of the British Association. My main duties will be to introduce Lord Rayleigh, who has been appointed president of the association, and to deliver an address entitled 'Step Toward a Kinetic Theory of Matter.' The choice of Lord Rayleigh as president is very significant, as he is by far the ablest mathematician in England. By a 'kinetic theory of matter' I mean a theory which maintains that all the properties of matter are merely attributes of motion. After leaving Montreal I go to Johns Hopkins University to deliver a course of lectures on higher physical mathematics. After that I keep a few other engagements and return home in November to resume work at the University of Glasgow."

"What scientific work are you engaged in at present?"

"I am inventing some measuring instruments which ought to be of some practical use. I am also engaged in reprinting my lectures. The most curious, though not, perhaps, the most important, of my inventions, is the siphon recorder, which has worked something of a revolution in telegraphy."

POSTAL TELEGRAPHS.—Mr. D. H. Bates, Executive Manager, and Charles Selden, Superintendent of the United Telegraph Lines, and Capt. Whitney, of the Western Union Company, had a long conference at Washington, on the 26th, with Postmaster-General Gresham, relative to fixing the rates for Government telegraph service. During the discussion of the question, the fact was developed that the rates charged by the Western Union Company were 100 per cent. greater than those offered by the United Telegraph lines. The Postmaster-General displayed great interest in the subject, and closely questioned the representatives of the rival interests.

ANOTHER CHANGE OF FRONT.—A dispatch from Milwaukee of Aug. 27 says: "It is reported in business circles this afternoon that the Western Union Telegraph Company had purchased the lines lately [illegible] between Chicago and Milwaukee and Madison and Minneapolis for the Bankers and Merchants' Telegraph Company. Considerable color was given to the report by the arrival here by special train from Chicago shortly before 1 o'clock of several prominent officials of the Western Union. The party included Col. R. C. C[illegible]owry, of Chicago, General Superintendent of the Western Division of the Western Union; M. C. Bristol, of Chicago, General Superintendent of Construction; Frederick Tubbs, of Chicago, Superintendent of the First District, and E. P. Wright, of Cleveland. The gentlemen interviewed would neither deny nor affirm the report. The purchase has undoubtedly been made, and [illegible] is rumored that the Western Union will own the entire system of the new company before many days.

The Providence Clam Bake.

In August, 1879, Mr. Eugene F. Phillips invited a few of his friends and customers to Providence, to partake of a genuine Rhode Island Clam Bake with him. There were only a few in the party, but they enjoyed themselves so well and had such a general good time, that a similar dinner has been given every year since. As nobody has yet been found who, having attended one of Mr. Phillips' clam dinners, would willingly stay away from another, it of course goes without saying that each succeeding bake has been more largely attended than its predecessor.

At the sixth of these occasions, which was held on Wednesday of the present week, the guests numbered more than a hundred. They came from all sections of the country, even as far as the Pacific Slope. In years gone by we were able to give a pretty complete record of those present, but the list this time is so formidable and the columns of THE OPERATOR are so crowded that we must be content to say that every large town or city with a telephone exchange or an electric light station seems to have sent a delegate.

The bake was held on the grounds of the Vue d'Eau Club, about five miles from Providence. These were reached by boat after a brief sail down the Narragansett. The time before luncheon and between luncheon and dinner was principally devoted, as usual, to various kinds of outdoor sports, though some sat in the shade enjoying the beautiful scenery or watching the steamers and sailing craft going up and down the river, while others renewed pleasant acquaintances of former years.

At three o'clock the bake was opened, after a brief address of welcome by Mr. Phillips and the Rhode Island Secretary of State. The bill of fare was got up in an exceedingly neat and tasteful manner, while the badge which each guest was supplied with was particularly handsome. It was of white silk, and bore in blue letters the legend "The Sixth Annual Bake. Complimentary to Telephone, Telegraph and Electric Light Men. Tendered by American Electrical Works. E. F. Phillips, President. Providence, R. I., 1884." This was fastened at the top to a piece of copper wire rope, from which depended a miniature telephone cord. The dinner consisted of half a dozen courses, and there can be no doubt about every one enjoying it. During the meal one of the waiters inquired if there was a Mr. Merriman present. "Merry man!" replied Mr. Stephen D. Field, "can't you see that we are all merry men?"

We were much interested in learning from Mr. Phillips something about the origin and development of the electrical wire department of his business. It was in 1870 that he first began covering wire. He had previously been manufacturing gas tubing, and is still, we believe, the only manufacturer of that commodity in this country. A Providence man not connected with the electrical business, but who saw there was a demand for something of the kind, suggested to Mr. Phillips that he should cover some wire and send it to the Gold & Stock Telegraph Co. of New York. The first he made very much resembled in appearance a wire coated with sleet or snow, and the paraffine was in the habit of peeling off in flakes. Still, there was a market for it, and later on the surface was made much smoother by pressing, and subsequently came in vogue the patent finish which renders the office wire of to-day such a thing of beauty.

There was but little business done in covered wires until 1878, when the District companies were started. The greatest development, however, came with the introduction of the telephone, and the business advanced still more with the advent of the electric light. It will probably surprise even electricians to know that this one concern now turns out almost a ton of electrical wire every working day. We asked Mr. Phillips for an estimate of his product, and after reckoning up he gave it as being about 300 tons a year. When it is remembered how many other manufacturers of covered wire there are in this country, some idea may be formed of the importance of this industry.

TELEGRAPH INSTRUMENTS IN FRANCE.—*L'Electricité* says that there are at the present time 7,703 Morse instruments at work in France. The Baudot apparatus, which works between Paris and Marseilles, transmits 1,800 messages per diem.

BEECHER PORTABLE TELEPHONE.—Capt. Beecher had an interview with army officers during the week as to experiments with his portable telephone, and will visit them next Monday, for the purpose of making arrangements for its use by them. A great deal of interest is being shown in the invention by both branches of the service.

OPERATIONS IN NEW JERSEY.—The Philadelphia & Seaboard Telegraph Company laid a second cable between Philadelphia and Camden on the 26th containing ten copper conductors. The Clay Commercial Telephone Company will employ some of these wires in connecting their exchanges between the two cities. The officers of the Philadelphia & Seaboard Company are as follows: William G. Perry, No. 728 Arch street, President; Henry C. Terry, 110 South Third street, Vice-President and Solicitor; C. A. Wilson, of Luzerne Oil Refinery, Treasurer; J. E. Otis, banker, Second Vice-President; John J. Burleigh, Secretary; Heber C. Robinson, General Manager. The above gentlemen, including Mr. Charles M. Burns, are Directors. The Company own and control the underground, submarine and aerial cables invented by George B. Pennock, the General Superintendent of the Company. The Reading Railroad are using one of these underground cables, and pronounce it a perfect success.

84

162

moved in response to this character, and has placed No. 2 circuit in connection with the battery for return transmission, the trailing contact may be on the second or third contact of the No. 2 circuit. This, however, will make no difference, since both the distributing arms are synchronous so long as the rotating arms pass over two or three of the No. 2 segments, while the armature of the transmitting magnet is in contact with either of the poles of the battery.

When we consider that a message made up of many words, each word containing numerous letters, each letter consisting of numerous separate and distinct characters, and each character, under the synchronous-multiplex system, consisting of numerous impulses, was transmitted with certainty over a single wire, back and forth, this number of times, without the slightest interruption the one with the other, the fact almost challenges belief.

While these results may appear almost incredible, what I am about to describe may at first thought seem impossible. I will endeavor, however, to give such a description of this experiment, as I saw it actually made, as will persuade the reader that, so far from being impossible, its possibility must necessarily follow as a natural result of the exquisitely maintained synchronism secured by Mr. Delany's ingenious inventions.

After having successfully established by actual trial, the possibility of the use of repeaters in his synchronous system, Mr. Delany connected the relay of the sixth circuit in Boston, where the message was received, with the transmitting instrument on No. 1 circuit. Now, under these conditions, on making one dot on No. 1 instrument this dot started on its zigzag way to and from Providence, in the manner already described, only, instead of terminating on the sixth circuit in Boston, as in the previous experiment, the same dot was automatically transmitted into the first circuit, and again sent on its journeying between the two cities, only on its arrival at the sixth circuit, in Boston, to be again automatically retransmitted over this same winding route.

An inspection of the drawing will render this connection clearer. Instead of the message being received by an operator stationed at No. 6 receiving relay at Boston, this instrument is furnished with a local battery *L B*, and connected by means of the conducting wire $z\ z$ and $z^1\ z^1$ with the No. 1 transmitting instrument at Boston. By this means, therefore, the operator at the No. 6 receiving relay is dispensed with, since this receiving relay again automatically sends the signal, by means of the No. 1 transmitting instrument, on its zig-zag way between the two cities until the No. 6 transmitter at Providence again sends it to the No. 6 receiving relay at Boston which again automatically repeats it by the No. 1, transmitter, over the six circuits between the two cities, and so on indefinitely.

In this manner, then, the original signal kept passing from city to city over the different circuits in perfect rotation, without the intervention of any operator save the one who first started the signal on its ceaseless journeyings.

Timing the intervals of the returns of the original signal between the two cities over the sextuplex circuits, it was observed that it traveled between Boston and Providence over these six circuits 300 times, or covered the

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N. Y. Building
May 85

THE Port Morris branch of the New York & New Haven Railroad have perfected a system of telegraphing by which messages can be sent and received on a running train. Mr. Lucius J. Phelps is the inventor. The present system extends twelve miles, but it is expected to extend it to the main line.

Character of article Rep.
From the Grit
Published at Williamsport
Date July 5/83

THOMAS EDISON is now experimenting with an invention of his, designed to prevent collisions by railroad trains. The new device is intended to permit engineers of trains to communicate easily with one another when the trains are a mile apart and in motion. The medium of communication is the telegraph wires along the railroad and an instrument in the engineer's cab. This instrument resembles the telephone in some respects. It is to be hoped that Mr. Edison will succeed in this humanitarian undertaking.

85

Character of article Rept
From the Register
Published at Wisconsin
Date July 4th 1885

N'S LATEST IDEAS.

Experiments for Telegraphing Between Ships at Sea.

It was rather a weird experience, meeting him. There are but two men besides himself, at night. He was chiefly engaged with his new idea of telegraphing from railroad trains in motion. This is not to be done by a cable laid along the track, on the Phelps plan by throwing the electric current, by induction, to one of the wires alongside the railroad. His experiments have already shown that the sparks can be thrown 180 feet. The regular Morse instrument, with certain appliances, will be used. The battery is to be grounded in the wheels of the car, and on the top of the car there will be condensers of tin foil spread upon long strips of wood. Arrangements are also progressing for an experiment in telegraphing by the same method from one ship to another at sea.

"But is that possible?" "I asked. "How far do you think you can throw the current over the water?"

"I am afraid to say how far," was the answer. "From the data already obtained, the theoretical conclusion is that we can throw it twenty-four miles. Possibly we can throw it more than that."

Then Edison sketched on paper a map of the two continents and the Atlantic, and illustration his plan of telegraphing from ship to ship so as to establish certain communication between the shore and any part of the frequented seas. Not content with this projected miracle, which seems to be near its fulfillment, he is also busy upon improvements in submarine telegraphy. The method now generally in vogue of reckoning words through cable by the flicker of a flame thrown upon a mirror is amazingly insufficient, as is shown on a diagram which Edison displayed. The number of dots indicating letters often has to be judged by operators from the length of time that the flame hesitates. Even the siphon receiver, invented by Sir William Thompson, and used by one or two of the new cables, is not quite satisfactory, although it marks the dots pretty nearly. Edison is trying to devise some means of attaining a higher or better regulated rate of speed so that the record may be made clearer. But "its a tough job," he says.

Perhaps the most interesting thing he had to say was respecting his exploration for a "new force." At present he calls it simply x y z. He does not pretend to know what it is. But he says that there are many phenomena which are not explained by any force yet recognized, and it is these which he is going to investigate. Vibrations of matter at the rate of 30.000 a second produce the highest sound we can hear. Between these and the vibrations which, at the rate of millions per second, cause the sensation of heat, there is a large gap; and between these and the vibrations that give sensations of color there is another gap. These gaps, Edison believes, are filled by vibrations as yet unmeasured, which constitute the new, or unnamed, force he is in search of. He brought out from a drawer sundry loose sheets on which he had sketched a num.

ber of machines he had projected, which respond to some influence still undefined. "I jot these down as they occur to me," he said, "and when I get enough of them together I shall have the machines made and try to generalize my observations."

Think of it! A man in this skeptical century who dares to believe in a discovery beyond all discoveries. Here is student of nature who is not afraid to have the spirit of a Galileo or a Keepler or an Isaac Newton. Perhaps we shall learn from him that in returning to faith and insight, aided by bold and patient experiment, we may go forward by going backward. "What do you think as to the nature of matter?" I asked, unscrupulously. The answer was prompt: "I do not believe that matter is spirit, acted upon by an outside force. To me it seems that every atom is possessed of a certain amount of primitive intelligence. Look at the thousand ways in which atoms of hydrogen combine with those of other elements, forming the most diverse substances. Do you mean to say that they do this without intelligence? When they get together in certain forms they make animals of the lower orders. Finally, they combine in man, who represents the total intelligence of all the atoms."

"But where does this intelligence come from originally?"

"From some power greater than ourselves."

"Do you then believe in an intelligent Creator, a personal God?" was the next question.

"Certainly," said Mr. Edison. "The existence of such a God, in my mind, can almost be proved from chemistry."

Lucretius thought that all atoms were moved by feelings of love or hate—what we call attraction or repulsion. Edison's idea is far more subtle, since he allows the atoms only a germ of intelligence. It also seems to be quite in keeping with the doctrine of evolution, while it contains nothing that is not in harmony with the idealism of the Platonists. And so we discover down on Avenue B, in the prosaic city of New York, a philosopher who believes in a personal God, and is at the same time the foremost exponent of applied science. Curious that he should be at work here, night after night, in the midst of a million of people, only a few hundred of whom know how he is employed during the nocturnal hours. As a usual thing he works until 5 or 7 o'clock in the morning, his supper basket remaining untouched beside him, and sometimes it is 9 o'clock of the next day before he leaves the bench of the laboratory. "I can't think out anything," he says "except when I'm experimenting. I have a library of 7000 scientific works, but somehow I can't find what I want in books. How do I make calculations? Well, I don't know exactly. I can't do it on paper. I have to be moving around."

So there he goes, moving around, thinking and working with his hands, in the big, sombre building, while the city is asleep. He is the controlling power of several large factories, a millionaire, a man of business, a marvelous inventor; yet he is as simple and happy as a child; when wrapped in an old seersucker dressing gown, he can manipulate at will and without interruption, the mysterious forces and properties of nature. In meeting him I thought of him more as a poet or a musician than as a machinist and electrician. Like the Brahmin I saw last week, he deals with occult powers, in quite a different way, but perhaps to the same end of perfecting man's control over the elements that shape life. It was significant that we climbed a dark stairway to reach his topmost place of light and intelligence. Americans are practical and skeptical. It ought to amuse them greatly to learn that the champion of their inventive genius is largely a be-

Character of article Rept.
From the Times-Democrat
Published at New Orleans
Date July 5/85

Thomas A. Edison, says the New York Tribune, is experimenting on Erastus Wiman's Staten Island Railroad, with what he calls "Grasshopper electricity." He proposes to telegraph from one moving train to another moving train. The system is similar in some respects to the Phelps induction telegraph, but unlike it in that Mr. Edison proposes to use the rails of the road as the means of conducting the current of electricity. He "jumps" it from one rail to the next; hence the peculiar name which he has given it. Mr. Edison has also made an important discovery and contrived an improvement on his quadruplex telegraph. His quadruplex machine enables him to send simultaneously several messages over a single wire provided all started from the same point. The improvement enables an operator at any station to break in at any time and have a portion of the wire for his particular current. Mr. Edison asks the Western Union $10 a year for each station as a royalty on the patent he has already secured.

Character of article Rep
From the Tribune
Published at Chicago
Date July 11, 85

The New Magneto Telegraph.

[From the Fort Worth Gazette.]

The new magneto telegraph and telephone instrument, a description of which is given below, was invented by Mr. F. H. Brown of this city. Mr. Brown has been working on this invention for some time, and perfected it in February last. The test that he made of the instrument at that time proved satisfactory, so he at once secured a patent, and made another public test about a week ago between Fort Worth and Cleburne. This test was made at the request of stockholders in the Bell and Baxter Telephone and the Western Union Telegraph Companies, and also proved perfectly satisfactory.

This invention is certainly a wonderful thing and threatens to revolutionize the whole system of telephoning and telegraphing. In one of his tests Mr. Brown attached his instrument to the telephone wires here and talked with perfect ease and distinctness to Decatur. Mr. Brown has already disposed of interests in his invention in nearly all foreign countries.

Ever since the days telegraphy by batteries commenced scientific men have been striving in vain to telegraph without battery currents. During wars this was very desirable to aid

El. World. N. Y.
3-6-86.

The Parcelle System of Multiple Telegraphy.

A new system of multiple telegraphy, based on the invention of Mr. Albert L. Parcelle, of Boston, has recently attracted much attention from electricians and telegraph men. While using the two arms revolving in unison over two circular tables of contacts at the two ends of the line, as has been done in the attempts to accomplish multiple telegraphy, the other features of this system are said to be so radically new as to be of considerable public interest in view of the end aimed at.

The essential points in a multiple telegraph system are, first, to provide two motors capable of running very closely together and thus keeping the revolving arms at the two stations very nearly in unison; and, secondly, to provide an absolutely reliable means of correcting the arms when one gets ahead of the other and bringing them into unison again. The first point is gained by using as the motors for the two arms two strips of brass, called reeds, with armatures on the end, driven electrically; two reeds of exactly the same dimensions, as is well known, will have exactly the same rate of vibration and will, therefore, keep time with each other regardless of the amount of current used. Heretofore, reeds have been used merely as circuit breakers; but, in this system, they are driven in an entirely novel manner, which makes it possible to drive the revolving arm by direct mechanical action from the reed by means of an anchor lever and ratchet wheel. The next point, after securing approximate uniformity in the movement of the arms, is to provide for correcting them when the slight variations which are inevitable occur. The advantage claimed is that it accomplishes this by a positive movement that cannot fail. When one arm is in advance of the other it abuts against a detent lying in its path; this forms a circuit which holds the reed firmly at one end of its swing, where it remains until the other arm catches up, when it is released and starts off again at its regular rate of vibration, this process being repeated as often as necessary.

The work of building the machine has thus far been carried on in New York City under the direction of the National Electric Company, formed here to control the inventions for the United States; but a new company has just been organized to work the inventions in Europe, having on its board of directors a number of well-known Boston men; and work for that company also is now being carried forward.

The inventions have many important applications besides the multiple telegraph. The extension of long-distance telephony makes them, it is thought, of much importance in the telephonic field. The method of driving a reed has been applied also with great success to the pendulum of a clock, thus dispensing entirely with the spring and train and making, it is claimed, a time-piece of great simplicity, cheapness and accuracy, run locally by a single cell of gravity battery. A clock has been completed and has been exhibited in successful operation here for several months, where it has attracted much notice. These inventions cover likewise new forms of printing telegraphs and stock reporters, said to be simple and cheaper of construction and more reliable in operation than any yet devised.

The names subjoined show the character and standing of persons composing the company: President, William F. Drake, Supt. N. Y. Stock Exchange; Vice-President, Henry E. Alexander, Latham, Alexander & Co.; Treasurer, Charles C. Allen, Member N. Y. Stock Exchange. The above, with Josiah Quincy, attorney-at-law, Boston, and Albert A. Drake, member N. Y. Stock Exchange, constitute the full board of directors.

N. Y. World.
3-14-86.

"What's a 'phonoplex'?" I inquired as that strange word was boxed about my ears the other day in a company of electricians. "It is the latest telegraphic device—Edison's," explained A. O. Tate. "Its effect is to make a single wire do double duty. But it is nothing like the duplex, which can be worked from terminals only. The phonoplex enables us to work on a wire already in use for despatches, and we can telegraph either way on it and chip in anywhere along the line. We use static electricity, the same as in the air-telegraph, but substitute a metallic diaphragm for the Morse sounder. Two lines are already phonoplexed in this city, and the new wrinkle has been added to the Montreal and Toronto line."

"We are rather scared about Edison," said one of his recent electrical associates to me the other day. In reply to questions, he continued: "We haven't heard a word from him. It is three weeks now since he married that Buckeye girl and he has taken no notice whatever of us in all that time. We have written to him. We have telegraphed him. We get no response. He has cut us dead. We ask him questions requiring immediate attention and that is the last of it. We are running the concern without him. He ignores the telegraph and despises the mail. It doesn't look as if his young wife had a rival in science or was being neglected for any new-fangled contrivance, does it? If we don't hear from him pretty soon we shall send an ambassador down there or a thoroughly equipped committee."

W. A. CROFFUT.

N. Y. El. World.
4-17-86.

MR. EDISON'S "Phonoplex," or "Way Duplex," which we describe in another column, is a most ingenious application of the varying action of the telephone when subjected to currents of different qualities. It is somewhat strange that the telephone has not been more generally introduced into railroad service, but this new adaptation of it is one step in the right direction. The entire independence of the operation of both kinds of signals from the condition of the line, evidently makes it possible to send and receive from any point without altering the condition of any of the office apparatus. The system is specially adapted to railroad work where a large number of offices are looped in on the same line, and where heretofore only one could be communicated with at a time. The application of the telephone to the purposes of a telegraph sounder, the loudness of which exceeds even that of the ordinary "giant" sounder, is destined to a wider application than would appear at first sight. Such sounders being very sensitive, and that only to the momentary high-potential currents sent over the line, might with equal propriety be substituted on the ordinary single lines instead of the relay and sounder. The battery required is practically the same for all distances, and is far less than is necessary with the Morse system. Altogether the invention is a very promising one, and while not entirely original in principle, it is nevertheless a new application of considerable originality, in a department where Mr. Edison has done some of his best work.

News Dealer, Wilkesbarre, Pa.
Feby. 16, 1888.

EDISON's latest is a harmonic telegraph, by means of which any number of messages may be sent over the same wire simultaneously in either direction. He has been eleven years perfecting it. The Western Union people have purchased its exclusive use.

N.Y. Morning Sun.
Feby. 14, 1888.

Edison's New Harmonic Telegraph.

Thomas Edison, as inventor, and the Western Union Telegraph Company, as owners, have received letters patent on a new harmonic telegraph, a method of transmission by which two or more messages may be sent the same or different directions on the same wire. The principle involved has been known to inventors, and was experimented with by Varley and Gray. Mr. Edison applied to the department for a patent on May 15, 1877, and since then has worked intermittingly upon his invention.

Times, Oskaloosa, Iowa.
April 26, 1888.

EDISON's latest is a harmonic telegraph, by means of which any number of messages may be sent over the same wire simultaneously in either direction. He has been eleven years perfecting it. The Western Union people have purchased its exclusive use.

Courier, Buffalo, N.Y.
April 25, 1888.

QUADRUPLEX TELEGRAPHY.

The General Principle Upon Which Edison's System is Operated.

At a meeting of the Electrical society last evening A. C. Terry of the Western Union telegraph described to the electricians present the method of operating the Edison quadruplex telegraph.

The general principle, Mr. Terry said, upon which the system is worked is based upon the fact that two sets of signals can be sent in the same direction over one wire by combining reverse current and a single current working in such a manner as to cause one receiving instrument to be operated by the reversal of currents only, irrespective of their strength, whilst another instrument will respond to changes only in the strength of the current regardless of its polarity. This method of double transmission in the same direction is known as duplex telegraphy. By combining this with the duplex, Mr. Edison, in the year 1874, gave to the world the quadruplex system of telegraphy which has since come into such general use in the United States and Europe.

Hereafter the society will hold its meetings in the rooms of the Society of Natural Sciences in the Buffalo Library building, arrangements having been made whereby it becomes a branch of that society, holding the same relation to it as does the Microscopical club, the Field club and other organizations devoted to the investigation and advancement of any of the departments of physical or natural science.

Avalanche, Memphis, Tenn.
Nov. 2, 1887.

Long Distance Telegraphing.

On the heels of the news of the absorption of the Baltimore and Ohio Telegraph Company by its rival, the Western Union comes some comforting information with regard to the progress made in long distance telegraphing. It is authoritatively stated that success has at last been reached by three discoveries—the manufacture of a hard-drawn copper wire of great tensile strength and high conductivity; the long-distance transmitter, an adjunct to the system which generates the electrical impulse by which the great invention of Alexander Graham Bell is operated, the result of the united labors of Blake, Edison, Berliner, Grilliand, Hughes and others; and the elimination of all inductives and disturbing influences, by the American Bell Telephone Company, who built a test line from New York to Boston, and fully demonstrated the practicability of two wires in metallic circuit, protected from ground connections.

Long distance outfits are being rapidly placed for interchange of communication between big cities and suburban places. By means of the terminal connecting lines, New York business men can be placed in immediate and direct speaking communication with any of the subscribers to the telephone exchange in Philadelphia and the cities and towns in New York, New Jersey, Connecticut, Massachusetts, and other states. Very heavy lines are now being constructed to points in New England and to Albany. The Boston circuit will be opened in three weeks, with thirty wires, and the communication will be as direct as it is now between New York and Philadelphia. It is expected that the service to Albany will be opened on January 1. The lines will be extended through the state to Buffalo, to Cleveland, to Cincinnati and to Chicago. So perfect is the system that talk can be carried on as easily between points 500 miles apart as 100 miles. Tests recently made show that such a performance is entirely practicable. There are newspaper offices in New York and Philadelphia furnished with long distance outfits, and news matter is transmitted daily. Single wires from New York to Philadelphia are now rented at $100, those to Boston will command double that price. The New York Times tells a story of a recent achievement on long distance telephoning which illustrates the uses to which it can be put. A railroad company got up a new time table, which was put in type 200 miles from the executive office there. The proof was read and corrected by copy over the telephone wire with almost as much facility as if the company's representative had been in the printer's office. Those who have watched the development of the telephone are enthusiastic over the possibilities of the long distance system, and say it is destined to work a revolution in professional and commercial circles.

Tribune, Chicago, Ill.
March 25, 1888.

PROF. ELISHA GRAY'S TELAUTOGRAPH.

It Was Not Exhibited Yesterday—A Description of the Instrument.

Some three months ago THE TRIBUNE gave a description of Prof. Elisha Gray's wonderful new instrument for the transmission of handwriting. He calls it the telautograph. He was to have given a trial exhibition yesterday to a party of Eastern gentlemen, but not all of them came and the event was deferred until the first of the coming week.

The little instrument which threatens to revolutionize both the telephone and the telegraph is in its general appearance a stand or table with duplicate parts. On one of these parts are the appliances for transmitting and the other for receiving. Each is a disk covered with specially prepared paper. The operator writes on the paper as on an ordinary sheet and the message is reproduced on the connected instrument. If the adjustment is [illegible] the chirography will be reproduced in perfect fac-simile, just as a telephone transmits the voice. The power of the instrument is equal to that of the telegraph, and a longer range of connection is possible than with the telephone. An advantage of the instrument will be that it will facilitate commercial business, and letters which are now handled by mail can be sent over the wire with the convenience of telephone transmission.

Prof. Gray developed the instrument some time ago and applied for patents. His claims were passed upon some time ago, and the only protection he seeks now is that of the old countries.

Times-Democrat, New Orleans, La.
Feby 2, 1888.

NEW SYSTEM OF TELEGRAPH.

Another Invention [illegible] a Moving [illegible]

Special to The Times-Demo[illegible]

LAREDO, TEX., [illegible] some time past Lieut. Ives, of Fort McIntosh, has been arranging the wire, etc., along the line of the Mexican National from the depot in this city to a point three miles distant, for the demonstration of a new mode of railway telegraph invented by himself and Capt. C. W. Williams, also of the United States army.

Yesterday afternoon the method was practically demonstrated in the presence of quite a number of gentlemen; among the number was Mr. J. N. Galbraith, assistant superintendent of the Mexican National, and is pronounced a success, proving that telegraphing to moving trains on railways will eventually come into vogue. The Ives-Williams method differs from that of Edison and Phelps in several particulars, principal among which is the doing away with the use of a telephone receiver. A strong, low tension current from a battery on the car is made to work a repeater on the ground, which retransmits the ordinary Morse signals over the main line.

The method is composed of a series of consecutive sections, each containing a repeater, and by using short sections, with a low tension current, grounding is avoided. The line conductor was a bare wire stretched along and spiked to the crossties, and though the ties and ground were both wet from recent rains, there was comparatively no grounding. The current passing through the car consists of the rails, a wire stretched parallel to the train, and means for preserving contact between this wire and the moving car.

This is done by placing at intervals of thirty feet contact surfaces, electrically connected to the line wire; on the car, stretching taut from the front to the rear a brass wire which slides on the contact surfaces as the train moves along. This brass wire is electrically connected through a battery, key and relay with the truck frame. At the station a wire is carried through the repeater from the rails to the wire stretched parallel to the track. The messages transmitted to and from the car were received by ordinary Morse sounders, and this is one of the main advantages of this class of railway telegraphy. [illegible]

Journal, Indianapolis, Ind.
Nov. 26, 1888.

[WH]AT is Edison doing that he has allowed [a So]uth American electrician to come in [ahead] of him with so important a discovery as of telegraphing without a battery? The [coun]try has depended on Edison to keep the [lead] in such matters.

Ledger, Phila. Pa.
Aug. 6, 1888.

PROF. GRAY'S TELAUTOGRAPH, with which telegraphic messages are to be sent in one's own handwriting, is said to be based on a newly-discovered electrical principle, and is also reported to work so accurately and rapidly as to give promise of being commercially successful. Several attempts have been made to devise apparatus of this kind, and Edison had so far succeeded six or eight years ago that at Menlo Park, with laboratory apparatus, autograph messages were sent with entire success, so far as the reproduction of the message at the other end of the line was concerned. It worked at a fair rate of speed, but not as rapidly as was desired. Edison's other work drew him away from this apparatus at a time when it seemed to be approaching perfection. Prof. Gray has no doubt reached the same end by other means.

Herald, Chicago, Ill.
Aug. 5, 1888.

Writing Afar.

The glory of the telephone is the glory of Chicago, for we of this city heard the music coming out of Elisha Gray's empty box a year before the Bells and Edisons were thought of. It is, therefore, with feelings of especial pleasure that the success of Professor Gray's tel-autograph is assured. Once more the greatest of inventors stands before the world the admiration of nations and the ornament of the most ingenious age.

What Eastern buccaneer will undertake to patent a tel-autograph the same day Professor Gray gives up his secret to a Patent Office clerk? The plan worked well with the telephone, and there were millions in it.

Yet, since the Supreme Court stands with a Chicago man in the panel, it is doubtful if so bold a foray would succeed the second time.

Herald, Chicago, Ill.
March 21, 1888.

BEATS THE TELEPHONE.

ELISHA GRAY'S LATEST INVENTION.

By the Telautograph a Man Can Escape All the Horrors of the "Hello" Machine—A New Telephone Switch Board—The Case of Gray Versus Bell.

Professor Elisha Gray, of Highland Park, has just completed an invention scarcely less wonderful and valuable than the telephone, of which he was also the inventor, but of which he was defrauded. "Within a few days," said the Professor yesterday, "I shall give a private test of my new telautograph, an invention which will largely supplant the telephone. I have already tested it to my satisfaction, over and over again, and on Saturday I shall give an exhibition to some gentlemen from the East. I have just taken it to pieces to make some slight alterations, or I would show it to you now.

"By this invention you can sit down at your office in Chicago, take a pencil in your hand, write a message to me, and as your pencil moves a pencil here in my laboratory moves simultaneously and forms the same letters and words in the same way. What you write in Chicago is instantly reproduced here in fac-simile. You may write in any language; write in shorthand if you like, use a code or cipher, no matter, a fac-simile is produced here. If you wish to draw a picture it is the same—the picture is reproduced here. The artist of your paper can, by this device, telegraph his pictures of a railway wreck or other occurrence, just as a reporter telegraphs his description in words. The two pencils move synchronously, and there is no reason why a circuit of 500 miles cannot be worked as easily as one of ten miles.

"This telautograph will supplant the telephone for many purposes. It can be worked in exchanges, just as the telephone is, or by private wire. It has many advantages, too. It is noiseless and devoid of the many annoyances so common to the telephone. It will be much less affected by induction. There will be no trouble in catching words or syllables, letters or figures. No misunderstandings will result. Besides, it leaves a record at both ends of the wire, and there can be no dispute about what was said. For all commercial transactions this would be an invaluable feature. In ordering goods, or sales of stocks or grain, or in transmitting names or addresses its superiority over the telephone is obvious. For desultory conversations, it is true, it would not be so rapid of working, for the reason that one cannot write as fast as he can talk, but, on the other hand, it would save many of the delays and annoyances incident to telephonic communication.

"When one person wishes to communicate with another by the telautograph he pushes a button, which rings an annunciator in the exchange, or in the office of the person with whom he wishes to converse. Then the first party takes his writing pencil from its holder—and this may be pen or pencil—and writes his message upon a roll of paper. As he writes so writes the pencil at the other end of the wire. Finishing his message, he adds a cross, or any other simple token that he has finished, when the second party takes down his pencil and writes a reply. Thus a conversation can be carried on easily and quickly, and when it is finished another simple word—say the telegraphic signal "30"—will indicate the end. Both parties have a full record of the conversation, and each possesses the others autograph.

"In writing," continued the professor, "your pen or pencil is attached to two small wires, and these wires regulate the currents which control the pencil at the other end of the wire. But these wires give you no trouble. You hardly know they are there, and can write with as much facility as if they were absent."

"Can this invention be used to advantage commercially?"

"Yes. It will not cost more than $15 or $20, and is easily kept in order. I have tried it again and again, and it works more perfectly than the telephone, and is much less liable to have its usefulness interfered with by induction."

But this is not the only great invention Professor Gray has in hand. He has just completed also an automatic switch-board for telephonic exchanges by which the user of a telephone or telautograph can put himself in communication with any other instrument. To do this he has simply to touch a button a certain number of times corresponding to the number of the other instrument. If the wire leading to that instrument is already in use he is informed of that fact by the ringing of a bell, and he then waits a few minutes, as he is now so often compelled to do, and then pushes the button again. By this invention one person in an exchange can do the work of thirty or forty under the present system, the duties of the one being merely to keep the automatic apparatus in order.

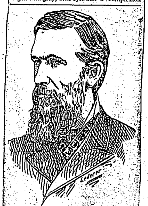
Herald, Chicago, Ill.
March 26, 1888.

ELISHA GRAY'S PATENT.

HIS CLAIM TO THE HELLO MACHINE.

A Visit to His Home and Laboratory at Highland Park—The Story of His Eventful Life—Did Bell Filch from Gray's Caveat?

Professor Elisha Gray, the inventor of the speaking telephone and the telautograph, lives in a handsome home, surrounded by walks, drives, water-courses and shrubbery, in the charming suburb of Highland Park. The Professor is a man of fifty, genial, companionable, a good talker and exceedingly modest concerning his own achievements and successes. His kindliness and generosity have made him a universal favorite among Highland Parkers, and his mastery of the most mysterious and wonderful of arts has caused him to be admired by all who know or have heard of him. The Professor is six feet tall, straight, with a rather long face, expression thoughtful, simple manners, lips which often part in smile and are seemingly incapable of giving utterance to harsh words, hair and beard plentiful and now tinged with gray, blue eyes and a complexion



PROFESSOR ELISHA GRAY.

warm and ruddy with health. His home is full of flowers; large windows let in plenty of sunshine; throughout the house are electrical toys and a diversity of ornaments made with his

own hands; in his library is a mineral collection and a great store of electrical books, and on the walls hang several medals and diplomas awarded him in this country and abroad for his great inventions, among them the decoration of the French Legion of Honor. The Professor barely mentions these, and real pride is exhibited only when he points to the portraits of his mother, his wife and of his beautiful daughters, two of whom are at Oberlin College, where their father holds the chair of electrical science.

But it is in his workshop that the Professor feels most at home and is most interesting. An electric bell at the door of a cottage in a ravine is marked "Professor Elisha Gray—laboratory." The upper story of this cottage is filled from floor to roof with tools, drawings, strange devices, little tables, boxes, castings of brass, lathes, forges, blow-pipes, electric jars, wires and all the paraphernalia of the workshop of a master of the science of electricity. Professor Gray not only thinks but works. He is an excellent mechanic. His hands, to all appearances, are as soft and white and unblemished as a baby's, but there are callouses in their palms. Only the skillful workman can keep hands like his.

"I am afraid I could never have accomplished much," he says, "had I not been able to work to advantage with my hands. A man, in my opinion, is never fully educated or properly equipped until he knows how to use his hands as well as he does his brain. I think I had the advantage of being born a mechanic. From my earliest recollection I was profoundly interested in all the phenomena of nature, and whenever I saw any manifestation of physical force I could not rest content until I had solved the secret of its operation. Whenever I saw a piece of machinery I at once set about making one like it. As a boy I made a great number of machines, ranging from a saw-mill run by water power to a Morse telegraphic apparatus. From the first electricity had a wonderful charm for me. I read everything I could get hold of on this subject, and spent so much time with my reading and experimenting that my parents used to scold me and try to convince me that I was wasting opportunities to learn something useful. Of course I couldn't blame my mother. It was not pleasant for her to find that whole skeins of flaxen thread, which she had spun with her own fingers, had been used up in making belts to run a boy's toy machinery, or to discover that her best case knife had been notched into saw teeth with which to equip a miniature saw-mill. I couldn't blame mother for scolding when she found her only quart bottle—quart bottles were scarce in those days—converted into a cylinder for an electrical machine, or when she saw that the copper bottom of her wash boiler had been cut up to make the plates of a galvanic pile. I even believe I would have invaded the sacred precincts of mother's band-box, which was only opened once a week, if I could have found anything there useful in my experiments."

Professor Gray's parents saw that he was a mechanic, but as they had no dreams of the possibilities which the future offered for his devices, they apprenticed him to a blacksmith. But that work was too laborious. The youth had not a very strong body, and he says he never knew how to hold up a horse's leg with any satisfaction to himself or to the horse. That was at Barnesville, Ohio, where he was born in the year 1835. Later on his parents removed to Brownsville, Pa., and Elisha there served a full apprenticeship as a carpenter, joiner, and boat-builder on steamboats designed for the Mississippi trade.

All this time he was restless and dissatisfied. There was a new world of which he had had a glimpse, and which he longed to enter and explore. He wanted knowledge. His evenings were spent in study, and after serving his apprenticeship of four years to the ship carpenter, he went to Oberlin College, paying his expenses there by working off days and vacations at a carpenter's bench. While his classmates studied natural philosophy by book and theory he with his own hands constructed and carried into class such simple apparatus as would best illustrate the principles under consideration. Of course a man like this must become an inventor. It has been said that inventors, like poets, are born, not made. But Elisha Gray could not have mastered the mysteries of electricity and produced a telephone and a telautograph had he not possessed courage, industry, will and spirit. He became a great inventor by first becoming a master of the science and the art toward which his boyish inclination led him. For six or seven years after leaving college he was an invalid, practically unable to continue his labors, but his mind was constantly active, and almost immediately began that long series of discoveries and applications in electricity, of which, happily, the end has not yet been reached. His first patent was taken out in 1867, and since that time forty patents have been issued in this country on electrical devices of his, and half as many in foreign countries. Numerous valuable devices have not been patented, and from them all the Professor derives but a comfortable income. He began work in Cleveland, Ohio, being connected with the Western Union shops there, but came to Chicago fifteen years or more ago and became president of the Western Electric Company, a concern which made more money out of his inventions than he did. An earnest and enthusiastic delver in the magic mines of electricity and magnetism, he cared little for business success. He forgot himself and his financial interests, and sometimes neglected his meals and his bed. Various electrical appliances for telegraphy, among them telegraph repeaters, dial telegraph instruments, multiplex telegraphy, a telegraphic printer, which was extensively employed by the Gold and Stock Exchange Telegraph Company, a telegraph switch and various forms of electric annunciators now in general use, came rapidly forth as the products of his busy brain and hand. Had he received even a small royalty on these devices he would now be a very wealthy man, and had he cared less for art and more for pelf A. Graham Bell would not now be enjoying the millions which the telephone has brought him.

N.Y. Herald,
Dec. 16, 1888.

WRITING SENT BY TELEGRAPH.

ELISHA GRAY'S INVENTION FOR SENDING FAC-SIMILE WRITING BY WIRE.

Electricity is the good genius of this century. Those who know most about it say that what we have done with it in the past is but a trifle compared with what we may hope to do with it in the future. There are people who expect some day to be able to call a distant friend by wire, see his image in a mirror, hear his voice, and, if desired, get his exact signature to a subscription paper or a check.

These things may all come. At present we get along with an intermittent and exasperating repetition of the voice over the wire, having no means of determining the identity of our interlocutor, no certainty of getting his words accurately and no record of what he says. Cases are reported where ingenious rascals have secured considerable sums by cleverly imitating over the telephone the voice of wealthy business men; in other cases orders to buy or sell goods or securities have been repudiated by those who gave them by telephone, while the simple blunders caused by faulty telephonic transmission would fill volumes.

Elisha Gray, the well known Illinois inventor, recently patented a device to insure accuracy and accountability over the electric wire. The sender of a message can write it out at his desk, and an exact reproduction of the writing will be made at the other end of the circuit. There have been previous attempts at transmitting fac-similes of writing, but inventions which depended upon a variation in the intensity of the current or upon revolving cylinders proved unsatisfactory.

Mr. Gray's device consists of two current interrupters at the sending end and a pair of electro motors at the receiving end. The sender uses either pen or pencil, near the point of which are attached two threads running at right angles to each other. These threads are kept at an even tension automatically, and each one passes to a current interrupter set into the telegraphic circuit. When the pen moves to the right the current is broken a great number of times for a small movement. When it moves to the left the current is reversed and is similarly interrupted. The same arrangement prevails on the movement of the pen up and down. The writer can write or sketch as rapidly and as freely as if he had no telegraphic attachment.

At the receiving end there are two electro-magnets fitted with rods set at right angles to each other, so pivoted as to give any motion desired to the pen which they carry at their intersection. When a series of breaks in the current is caused by a motion of the sending pen to the right, the magnet draws the lateral rod also to the right. Similarly upward motion is given by the vertical rod. Left handed or downward strokes of the sending pen are reproduced by the receiving pen in the same manner. Consequently every motion made on the paper at one end of the wire is copied with faultless exactness at the other end. When the pen is taken off or a new line is begun an automatic device operates with the same result on the receiving pen.

The telautograph, as Mr. Gray calls his invention, therefore not only insures accuracy, but it so exactly copies the sender's handwriting as to hold him accountable for what he has written, while he retains for his own guidance the original of the message transmitted. The experiments made show that there is no difference in the handwriting at the two ends of the wire except that which is incident to the use of a stylographic pen at the receiving end.

Herald, Chicago, Ill.
March 25, 1888.

Telegraphic Wonders of the Future.

"I'll tell you what we'll have in this country in five or ten years," said a Chicago patent lawyer who keeps a keen eye on all things pertaining to telegraphy, "and that is a government postal telegraph with many thousands of miles of wire and using a printing telegraph or some such invention as that of Professor Elisha Gray, described in THE HERALD of Wednesday. Professor Gray, I understand, has great faith in his telautograph, and if it proves a success, commercially and intrinsically, it will revolutionize telegraphy. With that system, and with plenty of wire capacity, messages can be sent without the interposition of an operator. The writer of the message will be his own operator, merely sending his letter by wire instead of by mail, and his missive appearing at the other end in his own handwriting. I can easily see how, with some such system as this, the cost of messages can be brought down to 5 cents, and perhaps to 4 or 3 cents. This is not at all improbable, and I expect to see the day when the government lines will transmit a short business message by wire from Chicago to New York, delivering there by carrier as it now delivers letters, for 3 cents, and longer messages for from 5 to 10 cents. In practical operation it will probably not be found desirable to send all messages by telautograph, and operators will be used. Here the printing telegraph will come in. In a few years you'll see girls sending messages by typewriter, the copy appearing at the other end neatly printed. In fact, that can be done now. Professor Gray has invented such a machine, and a young inventor from the country, backed by a syndicate of Chicagoans, of whom Superintendent Tubbs, of the Western Union, is one, is perfecting a marvelous printing telegraph, working night and day in his shop on Fifth avenue. I'll tell you one thing, Western Union people expect postal telegraphy. They know it is coming and are getting ready for it. If the government doesn't buy them out, watered stock and all, they will fight, putting rates right down to government notch. The danger is that before the government gets ready to do anything, Western Union will have bought up all these patents and thus get possession of the field for many years."

N.Y. Times

TELEGRAPH WITHOUT BATTERIES.

PANAMA, Nov. 10.—Señor Piedrahita, an electrician of Bogota, has patented a telegraphic instrument which, he claims, will revolutionize telegraphy, as it works without batteries. The Government appointed a committee of experts to examine into the merits of the machine. In their first report they say: "On the 12th of October we proceeded outside the city and placed the new apparatus in connection with the telegraph to the city, and without a battery we held communication with the main office. On Oct. 16 we practiced another test, and sent messages over a wire 600 meters long, which was hung on posts without insulators, and some portions of which were allowed to trail along the ground. Once our machine was in order, we sent messages over this wire in Spanish, French, and English, and they were received without difficulty. The strength of the current received from us was tested, and it showed a density of 400 ohms, equal to a distance of 7½ leagues, and over this range we could have communicated had our wire stretched that distance."

State Republican, Lansing, Mich.
Jany. 16, 1889.

THE REAL INVENTOR.

Are We Indebted to Professor Morse for the Electric Telegraph?

A full and complete account of the invention of the telegraph appeared in The Century Magazine for April, 1888, and recently, in examining an old file of The New York Sun for the year 1857, I found the following editorial in the issue of Sept. 25, of that year, written by Moses S. Beach, the then proprietor and editor, and who knew from personal knowledge whereof he wrote. The article was entitled "Honor to Whom Honor Is Due:"

"The laying of the Atlantic cable has waked up hundreds of claimants for honors bestowed upon Professor Morse, and while each is so loudly telling his story, and is so impatient that it is coldly received, we will mention a few incidents connected with Professor Morse's own experience which we have never seen in print, and which lose none of their interest from the unassuming modesty of the other parties referred to.

"Soon after Mr. Morse's invention of the telegraph which has made him famous he was a professor in the University of New York City. As yet the invention was merely an idea, without material form. Among the students there was a son of Judge Stephen Vail, of Morristown, N. J., Alfred Vail, and the worthy professor had no auditor more interested in his supposed to be vagaries. Alfred was a young man of an active turn of mind, and he readily espoused Professor Morse's ideas. But the professor had no means; his brother Sydney looked upon him as a chimerical dreamer who deserved no help, and so Alfred Vail set about overcoming that difficulty. He told the story—visions and all—many times over to his father. The judge was, as he is now, a liberal and generous man, with no small degree of contrivance about him. He became interested and invited the professor to his house. The result was a personal friendship and a year's experimenting at Judge Vail's expense.

"Alfred Vail entered into these experiments with his whole soul, and to him is Professor Morse indebted quite as much as to his own wit for his ultimate triumph. It was Alfred Vail who invented the far famed alphabet, and he, too, was the inventor of the instrument that bears Morse's name. But whatever he did or contrived went cheerfully to the great end. Alfred felt rewarded in seeing the gradual accomplishment of the dream.

"Judge Vail had a small factory near his house and separated from the Speedwell Iron Works, belonging to him, with water power, and in it, the experiments were carried on. Three miles of copper wire, about four times as large as that used in the Atlantic cable, were purchased at Belleville, N. J. The wire was sent to New York and wound with cotton, under the supposition that it could not otherwise be made serviceable. Then the first clumsy registering machine was devised, and with it the writing machine, with its mechanical action by means of types. Their construction and abandonment for something better took place in the same factory, and there in an upper room, the remains of them—cog wheels, ratchets and slides—may, or a few days since might, still be seen.

"The first telegraph message ever sent under the so called Morse system was both sent and received in that same 'upper room,' and was dictated by Judge Vail—'A patient waiter is no loser.'

"Thence came the apparatuses subsequently exhibited in New York and elsewhere with such electrical effect. We have in our possession now a piece of that original three miles of wire, and we prize it as a memento—much more than our 'foot' of the Atlantic cable.

"The original plan for laying the lines of telegraph was by cables submerged in the ground. For this purpose the wire was to be inclosed in lead pipe and preparations were made for the introduction of the wire in the pipe simultaneously with its manufacture. Experiments showed, however, that with submersion the necessary insulation of the wire would be difficult, if not impossible, and the cheaper and more effectual method of suspension was adopted.

"Another incident and we are done. Morse was in those days, if he is not now, no mean hand at painting. To testify his appreciation of the kindness and invaluable 'material aid' rendered by the judge and his son Alfred, he painted a series of family portraits, and these specimens of his skill still adorn the walls of Judge Vail's parlors, and though not the perfection of art they display more than ordinary skill in the use of the brush.

"Judge Vail and his worthy son still live. The judge is as hale and hearty at 80 as most men at 50, and enjoys a well earned affluence in the old style—quiet retirement.

"Alfred Vail retains in maturer age the characteristics of his earlier years, and is now turning his attention to authorship."

With the statement that concludes your correspondent's article, that "a nephew of Mr. Morse is one of the best known duck hunters about town," I know of no reason for disagreeing, and will only express the hope that his claim to that distinction is more solidly based than was that of his uncle to being "the inventor of the telegraph." As a son of Alfred Vail I am naturally desirous that justice should be accorded his memory.—Stephen Vail in New York World.

Times-Star, Cincinnati, Ohio
Feby. 18, 1888.

Edison's latest is a harmonic telegraph, by means of which any number of messages may be sent over the same wire simultaneously in either direction. He has been eleven years perfecting it. The Western Union people have purchased its exclusive use.

N.Y. Journal
Aug. 12, 1888.

HAND AFAR, WRITING HERE

Professor Gray's Wonderful Invention, the Telautograph.

Messages Can Be Wired Any Distance in the Handwriting of the Sender—The Instrument's Utility.

In the invention of the telautograph Professor Gray has produced an instrument, or combination of instruments, the most wonderful by far yet devised for the control of that subtle yet illusive force known as electricity, and it is safe to say has paved the way for revolutionizing the existing system of telegraphy.

With the aid of these instruments every man becomes his own telegrapher, and the recipient of the message can fold his arms with the serene confidence that whatever is written by his correspondent will be instantaneously reproduced before his eyes, no matter how far away his correspondent may be, without his taking any part in the operation except to answer the message when it is received, or ask questions, as the message may suggest.

The telautograph is destined at no distant day to revolutionize the existing system of telegraphy. For newspaper publishers the telautograph is of still greater utility. The out-of-town correspondent can transmit his telegrams to his paper in his own handwriting in the very act of writing them, thus saving the loss of time involved in writing it out for the telegrapher in the transmitting office and of the rewriting by the telegraphic operator in the receiving office.

Even this, however, is not all. A correspondent of the Associated Press, for example, may report a debate in Congress at Washington and have that report reproduced simultaneously with his writing in

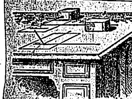
Professor Elisha Gray.

the newspaper offices of a dozen different cities.

Nor is the work of the telautograph confined necessarily to the transmission of written messages. The artist on the scene of railroad disaster or on the grand stand or the review of a procession may utilize it to send finished pictures of the scenes before him direct to the office of his newspaper. The idea of the telautograph first pre-

sented itself to Professor Gray about seven years ago, and he then went to work to produce a set of instruments capable of carrying out his purpose. After a long series of experiments he became satisfied that his control of the electrical current was not equal to the end he had in view, and he thereupon abandoned all attempts to perfect the instrumentality and devoted himself entirely to devising means for a better control of the current. Having obtained complete control of the current, Professor Gray again addressed himself to the task of perfecting the instruments which he has called the telautograph.

This combination of instruments consists of a transmitter and receiver. These are shown in the accompanying drawing, the transmitter being designed by the letter A, and the receiver by the letter B. The



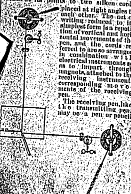
The Telautograph.

mechanism of each is also shown by drawings, and the reader who has any acquaintance with electricity will have no difficulty in getting therefrom a general idea of their operation.

The Transmitter.

The transmitter is simply a pen or pencil such as is ordinarily used in writing, attached at its points to two silken cords placed at right angles to each other. The act of writing reduced to its simplest form is a repetition of vertical and horizontal movements of the pen, and the cords referred to are so arranged in combination with electrical instruments so as to impart, through magnets attached to the receiving instrument, corresponding movements of the receiving pen.

The receiving pen, like the transmitting pen, may be a pen or pencil



held between two rods placed at right angles to each other as shown in the drawing. These rods are controlled by magnets already spoken of and impart to the pen an upward or downward or horizontal movement corresponding with like movements of the transmitting pen; it follows from this arrangement that every movement of the transmitting pen is simultaneously and accurately reproduced by the receiving pen, and that the writer of the message may have his handwriting reproduced by the receiving instrument in either small or large characters at his will. The receiving pen can be so adjusted as to enlarge or diminish the fac simile of the transmitting pen.

The instruments are so constructed that the operator may write either on a pad in successive lines, as in ordinary writing, or on a continuous ribbon. In either case the paper rests upon a surface that moves downward as the pen is pressed upon the paper and upward as the pressure is relaxed. This upward and downward movement of the writing surface is utilized by means of appropriate mechanism to raise or lower the receiving pen, so that when the sender of a message lifts the transmitting pen entirely from the paper he at the same time lifts the receiving pen, and as by the mechanism connected with the cords already referred to he controls the lineal movements of the receiving pen, it follows that the movement of the transmitting pen from right to left or crosswise is accompanied by the corresponding movement of the receiving pen.

It is evident, therefore, that he can turn back to any place upon the sheet or ribbon and make either erasures, interlineations or corrections at will. The receiver is also provided with means, which is under control of the operator at the transmitter, for shifting the paper after the completion of each line of writing, so as to bring it in proper position to receive the next line, and so on. The mechanism for shifting the paper is operated by pressing a button on the table beside the transmitting pen.

It is clear from what has already been said that both the transmitting and receiving pens, as well as the paper written upon by each, are under the perfect control of the person sending the message, and that it requires no special education or training to operate the telautograph. On the contrary, any one who can write can send a message. The operation of the instrument is thus described by Professor Gray:

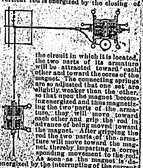
"The operator will take the transmitting pen in his hand and form the characters in proper sequence in the usual manner, moving the pen up and down and from left to right in forming the characters and writing the line the same as an ordinary writing. As the pen makes the down strokes in forming the characters the vertical cord will be unwound from the shaft of the interrupter attached, thereby revolving the shaft and moving a brush over a disc interrupting the current over the circuit repeatedly and in quick succession, the number and rapidity of the interruptions being determined by the speed and extent of the movement of the pen.

"As the pen makes the upstrokes a spring attached to the shaft will rewind the cord and move the brush in the reverse direction, interrupting the current in the same manner."

The Receiving Instrument.

The following is the operation of the receiving instrument: Located adjacent to each of the rods which hold the receiving pen are a pair of reversely arranged receiving electro-magnets.

"When the magnet connected with the vertical rod is energized by the closing of



the circuit in which it is located, the two parts of its armature will be attracted toward each other and toward the cores of the magnet. The connecting springs are so adjusted that one set are slightly weaker than the other, so that upon the magnet becoming energized and thus magnetizing the two parts of the armature, they will move toward each other and grip the rod in advance of being moved toward the magnet. After gripping the rod the two parts of the armature will move toward the magnet, thereby imparting a corresponding movement to the rod. As soon as the magnet is deenergized by the interrupting of the current over the circuit the weaker of the two sets of springs will draw the two parts of the armature apart, thereby releasing the rod, and the other springs will draw the parts back again against the back stop.

"This operation will be repeated as often as the [illegible]

rupted, so as to energize and de-energize the magnet, and thus the rod and the pen will be moved with a step-by-step movement, the number and rapidity of the steps being determined by the number and rapidity of the interruptions in the current over the circuit. The movement thus given to the pen will constitute its upward movement in forming the characters. Whenever the second of this pair of magnets is energized or de-energized the same operation will take place, except that the rod and the pen will be moved in the reverse direction."

It is quite practicable to transmit drawings as well as written messages by the telautograph, and Professor Gray says that the transmission can be made over five hundred miles as readily as over five hundred feet.

We present herewith a specimen of a written message from the receiving pen, which

J. W. Cushing Esq
Dear Sir
This is a sample of the
experimental writing
done by Elisha Grays
Telautograph
Yours Truly
L. McPherson

Specimen of Telautograph Writing from Receiving Pen.

will give the reader an excellent idea of the perfect character of the work done by this marvellous instrument.

Professor Gray is of Quaker origin. He was born at Barnesville, Belmont County, O., on August 2, 1835. In early life he was a carpenter's apprentice, and it was then said of him that he was somewhat of a social nuisance because of his proclivity to acids and laboratory stuffs. At the age of twenty-one he entered Oberlin College, where he studied diligently for five years.

After finishing his collegiate education his health became very poor, so that it was not until he reached his thirtieth year that his attention was wholly devoted to electrical mechanism.

N. Y. Star, Dec. 11, 1888.

PRESIDENT GREEN EXPLAINS.

Inside Facts Concerning Some of Edison's Inventions.

The attention of President Norvin Green of the Western Union Telegraph Company was yesterday called to the following statements in an article on the early days of Thomas Edison, the inventor, published in a morning paper:

"The public doesn't know it, but there are in the safes of the Western Union patents which, if applied, would nearly double the efficiency of the telegraph in the interests of public convenience. They are not used because it costs money to put them into use, and there is no competition to compel the Western Union to do the best it knows how to do. The company buys Mr. Edison's inventions, partly because they may want to use them some day, but chiefly because they don't want them to get into the hands of people who might use these means to become dangerous competitors. They have to pay a fortune for each invention, and don't expect to use it when they get it, but the retention of their secure monopoly makes the policy a paying one."

"The Western Union," said President Green, "has not, to my knowledge, purchased an invention or patent of Mr. Edison during the past eight years. The company at one time had a contract with him, by the terms of which he was to receive, and did receive, a salary from the company, and the company, of course, had the refusal of all of his inventions during the time for which the contract was made. That contract expired eight years ago. It was made under the administration of my predecessor. I am not aware that we have suppressed any of the inventions of Mr. Edison. He is a versatile genius, and can make one thing in half a dozen different ways. He made an instrument to do the work of the quadruplex. The underlying principle was the same as that of the quadruplex, but it was constructed differently. To protect our property in the quadruplex we purchased this invention.

"Then Mr. Edison invented an improvement on the Bell telephone. We purchased it. Blake's transmitter was then introduced, and we regarded it as an infringement on Edison's patent. A lawsuit resulted. It was finally settled in this way: Bell's telephone was practically worthless without the Blake transmitter, and it was evident that the Blake transmitter was an infringement on Edison's patent. The Bell company could prevent us from using the Edison improvement, and we could prevent the Bell company from using Blake's transmitter. As the Bell telephone could not get along without the Blake improvement a compromise was effected, by which the Western Union receives a royalty of 20 per cent. for the use of the Edison improvement (the Blake transmitter).

"There may have been other inventions bought by the company under the terms of the contract, but nothing was bought for the purpose of suppression. The Western Union is constantly improving its service, and is always on the lookout for electrical appliances calculated to improve the facilities of its lines."

News, Lynchburg, Va. Nov 11, 1888.

Edison in an Emergency.

Soon Edison's mechanical skill became so noted in the office that he was made superintendent of the repair shop. It was not long before the value of his services was fully shown. The several telegraph companies then in existence—the Franklin, Bankers' and Brokers', Southern and Atlantic and Atlantic and Pacific—were using the Page sounder, the sole right to which was claimed by the Western Union company. Owing to the Western Union's success in a patent fight over the Page sounder, there came a time when an injunction was obtained, silencing all sounders of that type in the hands of rivals and practically putting a stop to our business. Edison was called into the president's office and the situation explained. For a long time he stood chewing his tobacco, looking first at the sounder in his hand and then falling into a brown study. At length he picked up a sheet of tin used as a "back" for manifolding on thin sheets of paper, and began to twist and cut it into queer shapes; meanwhile we stood around looking on. Not a word was spoken. Finally Edison tore off the Page "sounder" on the instrument before him, and substituting his bit of tin, began working. It was not so good as the patented arrangement discarded, but it worked. In four hours a hundred such devices were in use over our lines, and what would have been a ruinous interruption to our business was avoided.—New York Star.

Herald, Baltimore, Md. Aug. 28 1888

BUSY INVENTIVE GENIUS.

The wonders of inventive genius have not yet been exhausted, nor are they likely to be for some time to come. In no branches of the arts and sciences are the inventors more prolific or more bent upon radical changes in existing methods than in telegraphy or phonography. The announcement that the Gray telautograph would soon be upon the market, providing a system that would enable the sender of a message to reproduce his own handwriting, at any distance by an electrical medium, caused much surprise, but no more than the announcement, some years since, that a quadruplex transmitter could be used upon a single telegraphic wire.

A New York expert, Mr. Craig, ex-manager of the Associated Press, has recently perfected an appliance which will enable 2,000 words per minute to be transmitted over a single wire and recorded in ordinary Morse system characters, which can be deciphered easily by an expert telegrapher at the rate of about 100 words a minute. By this new method, it is claimed that the cost of telegraphy can be reduced to two cents for 1,000 words, without materially interfering with methods now in vogue. By such a means, and including all the expense of labor, paper and other essentials, the total cost of sending 1,000 words from New York to California would be twenty-five cents, a vast difference existing between such a rate and that at present paid.

An inventor has now, with the Edison instrument as a basis, fixed up a device that will not only absolutely reproduce spoken words, but reduce them to printable copy, thus doing away, if successful, with the system of shorthand as at present constituted. A public trial is to be shortly given this remarkable discovery. Truly, it seems as if the field of invention is absolutely illimitable.

Journal, Kansas City, Mo. May 14, 1889

A New Telegraph Instrument.

The freight office of the Burlington, in this city, is supplied with one of the new phonoplex instruments recently patented, by means of which two or more messages may be transmitted over the same wire at the same time. The instrument makes it possible for the operator in Kansas City to wire St. Joseph or any station between these cities at the same time that the wire is being used to send a message to Creston, Ia. Not only can two messages be sent over the same wire at the same time, but they may be sent from opposite directions, and by means of this instrument in connection with the ordinary Morse instruments, messages pass each other on the same line without interruption.

The phonoplex is operated by means of an induced current and can be successfully used upon lines 100 miles and less in length. It can also be used in connection with duplex and quadruplex wires, making a long stretch of wire to be used in connection with intermediate stations. The whole equipment for an office takes up but little more room than a Morse machine and costs about $1.50 per month additional.

The advantages of the system lie in the fact that an operator can break in on the wire and reach any intermediate station without affecting through business. The Burlington is the only road in the city using the system and the operator, E. Pringle, is much pleased with the work that can be accomplished by its use. The phonoplex emits a peculiar, sharp sound that is very distinct and in sharp contrast to the sound of the Morse transmitter.

Free Press, London, Ont. April 11, 1889

ADVANCE IN TELEGRAPHY.

A new and important advance has recently been made in the interest of telegraphy, by the invention of an instrument called the phonopore, by means of which electrical effects are produced under conditions which, previously to this discovery, had been thought to make them impossible. If a telephone be inserted in a wire situated near to a line of telegraph wires, every passing current will produce noises in the telephone, notwithstanding that the telephone wire is perfectly insulated from the telegraph wires. These noises are known as induction noises, and it was while investigating the phenomena of induction, with the view of devising means to obviate its effects in telephones that Mr. Langdon-Davies made the discovery which has led to the important result referred to. His investigations led him to the conclusion that induction was caused by some form of electrical force, which might be separated from currents and which would pass freely through insulations impassible by currents. He further concluded that if this were so, a new series of instruments might be constructed for the utilization of this force, and capable of being put in operation in company with current instruments on the same wire. His conclusions have been proved to be perfectly correct by what has since resulted from the development of the principle. Instruments have been made which represent a system of communication of the highest practical utility, and by means of which Mr. Langdon-Davies has added a distinct and independent chapter to the history of electrical development. The only form of electrical force which finds free passage through these instruments appears to be always capable of being associated with sound. The inventor has therefore denominated the force "phonoporic impulse," and the instrument

the "phonopore." Suppose a telegraph line to be in full working order from one town to another, and that, owing to increase of business, it becomes necessary to provide some additional means of communication. All that is now necessary is to attach to the line at each end a phonopore, without in any way altering the existing instruments, batteries, or line. The phonopore can be worked at the same time as the ordinary telegraph instruments, and one line is thus made to do the work of two. If the line is already duplexed by ordinary duplex telegraph instruments, the addition of the phonopore will quadruplex it. If the line is—as a few trunk lines are—quadruplexed, the phonoporic instruments will "sextuplex" or "octuplex" it. Indeed, it would seem difficult at present to assign any limit to the multiplex carrying capacity of the new system. In some recent experiments, says the London *Times*, messages were transmitted first by the ordinary telegraph instruments alone, and secondly by a phonoporic instrument alone. In the next place, the ordinary telegraph instrument and the phonopore were worked together in opposite directions, duplex, after which the ordinary instruments and the phonopore were worked together in the same direction duplex. The final experiment consisted in the ordinary telegraph and both the phonopore telegraphs being worked together simultaneously through the single line. The three messages were perfectly transmitted, although some of the operators had not previously used the phonoporic instruments. These experiments proved not only the complete possibility of simultaneous working, but that the phonopore can be arranged to work ordinary telegraph instruments, and that when used in duplex or quadruplex work it requires no special regulating or balancing. They also proved that any wire already provided with an ordinary service can instantly be duplexed by merely attaching the phonopore instruments. On a second artificial line there were installed two harmonic phonopore sounder telegraphs, constituting a duplex service without any arrangements whatever to balance the lines, and working through a resistance equivalent to that of about 6,000 miles of telegraph wire. Messages were perfectly transmitted through this line in both directions at the same time.

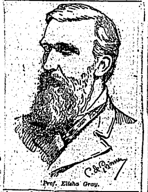
THE TELAUTOGRAPH.

AN INSTRUMENT WHICH TRANSMITS HAND-WRITING AND PICTURES BY WIRE.

Prof. Gray's Greatest Discovery—An Invention Which is Expected to Revolutionize the Art of Telegraphy.

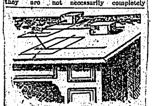
Written for The Republic.

In the invention of the telautograph Prof. Gray has produced an instrument or combination of instruments the most wonderful by far yet devised for the control of that subtle and illusive force known as electricity, and it is safe to say has paved the way for revolutionizing the existing system of telegraphy. With the aid of these instruments every man becomes his own telegrapher, and the recipient of the message can fold his arms with the serene confidence that whatever is written by his correspondent will be instantaneously reproduced before his eyes no matter how far away his correspondent may be, without his taking any part in the operation, except to answer the message when it is received or ask questions, as the message may suggest. The saving of time by this new system of telegraphy is so manifest that it needs only be referred to, and its advantages over the telephone and the existing method of telegraphing are, on the one hand, its applicability to long distance as well as short distance messages and the preservation of the message in the handwriting of the sender; on the other hand, its noiselessness and the confining of knowledge of the message to the sender and the recipient, and, over both, its absolute protection against leakage. From this brief general statement it is evident that there is no exaggeration of the truth in saying that the telautograph is destined at no distant day to revolutionize the existing system of telegraphy. For newspaper publishers the telautograph is of still greater utility. The out-of-town correspondent can transmit his telegrams to his paper in his own handwriting in the very act of writing them, thus saving the loss of time involved in writing it out in the first instance for the telegrapher in the transmitting office, and, in the second instance, of the rewriting by the telegraphic operator in the receiving office. Even this, however, is not all. A correspondent of the Associated Press, for example, may report a debate in Congress at Washington and have that report reproduced simultaneously with his writing in the newspaper offices of a dozen different cities. Nor is the work of the telautograph confined necessarily to the transmission of written messages. The artist on the scene of a railroad disaster, or on the grand stand or the review of a procession may utilize it to send finished pictures of the scenes before him direct to the office of his newspaper. This is certainly the crowning triumph of telegraphy to which electricians up to the present time have looked forward with feeling akin to the dreams of visionaries.



Prof. Elisha Gray.

The steps by which Prof. Gray has reached this achievement have been neither sudden nor accidental, but rather the steps of the explorer who climbs a toilsome ascent. The idea of the telautograph first presented itself to Prof. Gray about seven years ago, and he then went to work to produce a set of instruments capable of carrying out his purpose. After a long series of experiments he became satisfied that his control of the electrical current was not equal to the end he had in view, and he thereupon abandoned all attempts to perfect the instrumentality and devoted himself entirely to devising means for a better control of the current. As he says himself in the application for his patents, "variations in the constancy of the batteries or other generators of the current and in the strength of the currents, due to defective insulation, rain and other causes, occurred, which caused aberrations in the movement of the receiving pen, making the recording of a message uncertain and defective. The transmitting and receiving pens have been capable of only sufficient or slightly more than sufficient movement to produce a single character, the successive characters to make up the words and sentences being produced one after another in the same or substantially the same fluid." The difficulty in the way was that the professor found at his disposal a vibratory or variable current, uncertain and uncontrollable in its action. This is the current on which all previous attempts to produce a writing machine have been based. By years of study and innumerable experiments, Prof. Gray finally succeeded in producing what he calls a pulsatory current; that is to say, not an intermittent but a steady current, strengthened or weakened or removed, according to the requirements of the instrument. Prof. Gray says on this subject: "It is to be understood that when the currents are referred to as being broken or interrupted, they are not necessarily completely broken so as to entirely stop, but only that the currents are sufficient to interrupt it to release the armatures of the receiving magnets."



The Telautograph.

It is not necessary in this connection to go into a description which would be too technical for the ordinary reader of the means by which Prof. Gray has acquired this superior control of the electrical current. It is sufficient to say that he has accomplished the result by combination of instruments which the student of electricity can see for himself by reference to the reports of the Patent Office. Having obtained a complete control of the current, Prof. Gray again addressed himself to the task of perfecting the instruments which he has called the telautograph.

This combination of instruments consists of a transmitter and receiver. These are shown in the accompanying drawing, the transmitter being designated by the letter A, and the receiver by the letter B, the mechanism of each is also shown by drawings, and the reader who has any acquaintance with electricity will have no difficulty in getting therefrom a general idea of their operation.

The transmitter is simply a pen or pencil, such as is ordinarily used in writing, attached at its points to two silken cords placed at right angles to each other. The act of writing reduced to its simplest form is a repetition of vertical and horizontal movements of the pen, and the cords referred to are so arranged in combination with electrical instruments so as to impart through magnet, attached to the receiving instrument corresponding movements of the receiving pen. The receiving pen, like the transmitting pen, may be a pen or pencil held between two rods placed at right angles to each other as shown in the drawing. These rods are controlled by magnets already spoken of, and impart to the pen an upward or downward or horizontal movement corresponding with like movements of the transmitting pen, and it follows from this arrangement that every movement of the transmitting pen is simultaneously and accurately reproduced by the receiving pen, and that the writer of the message may have his handwriting reproduced by the receiving instrument in either small or large characters at his will. The receiving pen can be so adjusted as to enlarge or diminish the fac simile of the transmitting pen.

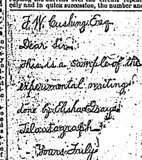
Prof. Gray's own description of the operation of the telautographic is as follows: "The transmitting pen is connected to operate circuit making and breaking devices, termed interrupters, located in two electric circuits and arranged to interrupt the currents passing over the respective circuits at short intervals, producing pulsations therein as the pen is moved in two directions crosswise of each other in forming characters the number of pulsations in the respective circuits being determined by the distance which the pen is moved in the respective directions.

These two circuits pass through the receiver and include electro motors termed receiving magnets, the armatures of which act through suitable connections to impart a step by step movement to the receiving pen in two directions, crosswise of each other, the number of steps in each direction being determined by the number of times the respective circuits are interrupted. By this means the movements of the transmitting pen in the two directions operate through the interruptions and currents passing over the circuit to impart corresponding movements to the receiving pen and thus reproduce the matter written or traced by the operator."

But while these devices provide for the synchronous movements of the transmitting and receiving pens, they do not provide for the wider control of the pens which enables the writer of a message to dot his I's and cross his T's and turn back and erase and correct what he has already written. The instruments are so constructed that the operator may write either on a pad in successive lines as in ordinary writing or on a continuous ribbon. In either case the paper rests upon a surface that moves downward as the pen is pressed upon the paper and upward as the pressure is relaxed. This upward and downward movement of the writing surface is utilized by means of appropriate mechanism to raise or lower the receiving pen, so that when the sender of a message lifts the transmitting pen entirely from the paper he at the same time lifts the receiving pen, and as by the mechanism connected with the cords already referred to he controls the lineal movements of the receiving pen, it follows that the movement of the transmitting pen from right to left or crosswise is accompanied by the corresponding movement of the receiving pen.

It is evident, therefore, that he can turn back to any place upon the sheet or ribbon and make either erasures, interlineations or corrections at his will. The receiver is also provided with means, which is under control of the operator at the transmitter, for shifting the paper after the completion of each line of writing so as to bring it in proper position to receive the next line, and so on. The mechanism for shifting the paper is operated by pressing a button on the table beside the transmitting pen.

It is clear from what has already been said that both the transmitting and receiving pens, as well as the paper written upon by each, are under the perfect control of the person sending the message, and that it requires no special education or training to operate the telautograph. On the contrary, anyone who can write can send a message. The operation of the instrument is thus described by Prof. Gray: "The operator will take the transmitting pen in his hand and form the characters in proper sequence in the usual manner, moving the pen up and down and from left to right in forming the characters and writing the line the same as in ordinary writing. As the pen makes the down strokes in forming the characters the vertical cord will be unwound from the shaft of the interrupter attached, thereby revolving the shaft and moving a brush over a disk, interrupting the current over the circuit repeatedly and in quick succession, the number and



Specimen of Telautograph.

rapidity of the interruptions being determined by the speed and extent of the movement of the pen. As the pen makes the upstrokes a spring attached to the shaft will re-wind the cord and move the brush in the reverse direction, interrupting the current in the same manner. So long as the up or down movement of the pen continues the vertical cord acting upon a pulley will hold an arm against one of the stops and the local circuit will remain closed or broken, as the case may be, so that the pole changer will not be operated and the polarity of the current passing over the circuit will not be changed. As soon, however, as the movement of the pen is reversed, i. e., changed from up to down, or down to up, the movement of the pulley will be reversed and the arm will be rocked against its other stop, thereby changing the condition of the local circuit and operating the pole changer so as to change the polarity of the current passing over the circuit, and this change in the polarity of the current will take place as often as the up and down movement of the pen is reversed. As the pen is moved from right to left and left to right the horizontal cord and the spring attached will operate the brush of the interrupter connected therewith to interrupt the current over that circuit in the same manner, and this cord acting on its pulley will act to close or break the other local circuit and thus operate another pole-changer to change the polarity of the current passing over the circuit whenever the movement of the pen is reversed, the same as described in connection with the pole changer attached to the vertical cord.' The following is the operation of the receiving instrument: Located adjacent to each of the rods which hold the receiving pen are a pair of reversely-arranged receiving electro-magnets. When the magnet connected with the vertical rod is energized by the closing of the circuit it which it is located, the two parts of its armature will be attracted towards each other and toward the cores of the magnet. The connecting springs are so adjusted that one set are slightly weaker than the other, so that upon the magnet becoming energized, and thus magnetizing the two parts of the armature, they will move towards each other and grip the rod in advance of being moved toward the magnet. After gripping the rod the two parts of the armature will move toward the magnet, thereby imparting a corresponding movement to the rod. As soon as the magnet is de-energized by the interrupting of the current over the circuit the weaker of the two sets of springs will draw the two parts of the armature apart, thereby releasing the rod, and the other spring will draw the parts back again against the back stop. This operation will be repeated as often as the current over the circuit is interrupted so as to energize and de-energize the magnet, and thus the rod, and the pen will be moved with a step-by-step movement, the number and rapidity of the steps being determined by the number and rapidity of the interruptions in the current over the circuit. The movement thus given to the pen will constitute its upward movement in forming the characters. Whenever the second of this pair of magnets is energized and de-energized the same operation will take place, except that the rod and the pen will be moved in the reverse direction. From this it will readily be seen that in order to cause the up and down movements of the receiving pen to conform with the corresponding movement of the transmitting pen, it is only necessary to cause the interruption in the connecting circuit occasioned by the movement of the brush as the transmitting pen is moved upward to de-energize and energize the first magnet, and the interruptions in the same circuit occasioned by the reverse movement of the brush as the transmitting pen is moved in the reverse direction, to de-energize and energize the second magnet. To effect this the circuit, which, as before stated, includes both of these magnets, also includes another magnet of the polarized relay, the polarized armature of which is connected by a wire with the circuit between the two magnets first spoken of. A similar pair of reversely arranged receiving electro-magnets are located adjacent to the horizontal rod and included in another circuit and provided with armatures arranged to act upon this rod in exactly the same manner as the armatures of the other pair of magnets act upon the vertical rod, so that the energizing and de-energizing of the first of this second pair of magnets operate through its armature to move the horizontal rod and the receiving pen from left to right, while the energizing and de-energizing of the second magnet operates in a similar manner to move the pen in a reverse direction. This circuit is also provided with a polarized relay similar to that of the other circuit, which is arranged and acts to short circuit one or the other of the second pair of magnets whenever the polarity of the current passing over the circuit is changed, the same as described in connection with the other circuit. This polarized relay is so arranged that so long as the transmitting pen is moved from left to right, the current passing over the circuit will pass through the first of this pair of magnets and act to move the receiving pen in the corresponding direction, and that when the movement of the transmitting pen is reversed and the polarity of the current changed the current will pass through the second magnet of the pair and act to reverse the movement of the receiving pen.

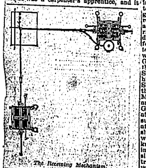
"It has now been explained how the movement of the transmitting pen along or at right angles to the line upon which the message is being written in either direction will cause the receiving pen to move in the same direction,

the movements of the latter pen being made up of a series of short steps. From this it follows that any movement of the transmitting pen in any direction oblique to the line or intermediate between these two directions will cause the receiving pen to move in a corresponding direction, but with a compound movement made up of a number of steps taken at right angles to or crosswise of each other, the relative number of steps in each direction depending upon the obliquity of the direction in which the transmitting pen is moved. By this means the receiving pen is caused to follow any movement of the transmitting pen and thus reproduce a fac simile of whatever is written or traced by the latter."

It has already been stated that the range of the receiving pen can be made greater or less according to the requirements of the occasion, and from what has just been said it is plain that the receiving pen must correspond both as to range and pressure to the movements of the transmitting pen. From this it follows that it is quite practicable to transmit drawings as well as written messages by the telautograph, and Prof. Gray says that the transmission can be made over 500 miles as readily as over 500 feet. We have not been able to secure any specimens of drawings transmitted through the telautograph, but we present herewith a specimen of a written message from the receiving pen, which will give the reader an excellent idea of the perfect character of the work done by this marvelous instrument.

We give also an excellent portrait of Prof. Gray in connection with the subjoined biographical sketch. The professor's name is well known to the American public through the controversy over the invention of the telephone, and he is known to electricians the world over by his system of Harmonic Telegraphy. There is an erroneous popular impression that a recent decision of the Supreme Court of the United States settled the question of the invention of the telephone in favor of Prof. Bell. The fact of the matter is that the court did not pass on that question at all. It merely passed on the merits of a suit brought by the Bell Telephone Company against certain persons for infringement of patents, and Prof. Gray's name was lugged into the dispute without authority. The question of the invention of the telephone was brought up before the Commissioner of Patents not long ago on a motion to reopen the issue of the patents. The Bell people opposed the taking of testimony on this matter, but the Commissioner decided against them, and the testimony is now in his hands awaiting his decision.

Prof. Gray is of Quaker origin, and in his person bears the distinguishing evidences of his descent in a certain placidity and directness of manner born of his temperament and character. He was born at Barnesville, Belmont County, O., on August 2, 1835. In early life he was a carpenter's apprentice, and it



The Receiving Mechanism.

was then said of him that he was somewhat of a social nuisance because of his proclivity to acids and laboratory stuffs. At the age of 21 he entered Oberlin College, where he studied diligently [illegible] for [illegible] years. His mental bent then was strongest in the study of natural philosophy, and to this he devoted all his spare hours. After finishing his collegiate education his health became very poor, so that it was not until he reached his 30th year that his attention was wholly devoted to electrical mechanism. This science fascinated him and monopolized his time, and he began to invent, his first attempt being to seek by internal mechanism a relief from the difficulties then embarrassing all telegraph lines arising from defective insulation. He constructed a self-adjusting relay, and it was a success. It was not largely used, however, as there was soon no necessity for the demand. In 1870 he invented (and two years later perfected the patent) the needle annunciator for hotels, which are now so largely used. The electrical annunciator for elevators was also invented by him about the same time. His next invention was an instrument for private telegraph lines, so constructed that any person who could read and spell was enabled to transmit messages upon it, by merely fingering keys similar to those on the type-writing machine of to-day. During the years 1873-75, Prof. Gray's attention was devoted to developing a system of "electro-harmonic telegraphy" for the transmission of sounds over the wires of a telegraph. He finally succeeded in sending over a wire of 500 miles in length, nine different messages at the same moment, each message having a distinctive note, and each capable of being taken off at any number of intermediate points by simply tuning the receiver to the key-board on which each was transmitted. Theoretically, the number of messages that can be sent over a single wire may be increased to as many notes and semi-tones as the range of the gamut will permit. Prof. Gray was led to these investigations by a domestic incident, and among the earliest discoveries in connection with the experiments was the fact that not only simple but composite tones could be sent through the wire and received, either on a metal plate or a magnet. By his method, different messages may be sent simultaneously, and a tune, with all its parts, may be sent hundreds of miles by wire, and be distinctly audible at the receiving end. This discovery underlies the whole system of telephones now in use, and is a splendid proof of Prof. Gray's right to priority of the invention. On February 14, 1876, Prof. Bell filed an application for a patent, and described his new invention in general terms as "new and useful improvements in telegraphy." In it he nowhere claims as an invention that it will transmit articulate vocal sounds or words. On the same day Elisha Gray filed a caveat, describing his invention as an "art of transmitting vocal sounds telegraphically." This was the earliest application of the kind in the world. Mr. Gray thus specified his invention: "It is the object of my invention to transmit the tones of the human voice through a telegraphic circuit and reproduce them at the receiving end of the line, so that actual conversation can be carried on by persons at long distances apart. Mr. Bell secured this information, and the Department of Patents afterward improperly issued him a patent, to which he was in no manner entitled. Mr. Gray brought the matter to the attention of the Interior Department, and the United States brought suit against Mr. Bell to vacate his telephone patent. The case is still in the Superior courts, but there is no question but that right and justice will eventually place Mr. Gray in full possession of the privileges and benefits of his invention. In 1869 Mr. Gray formed the firm of Gray & Barton, at Cleveland, O., dealing in electrical supplies. They removed to Chicago soon after, and continued their business until shortly after the great fire of 1871. The firm was then consolidated in the corporation known as the Western Electric Manufacturing Company. Mr. Gray held the official position of general superintendent and electrician with the company until 1874, when he withdrew in order to devote his whole time to the protection of his patents on the telephone. He has made several improvements on the telephone, and when the great controversy is settled, and Mr. Gray secures his just right, he will doubtless give to the public an instrument vastly superior to that now in general use. Mr. Gray is president of the Chicago Electric Underground Company, but pays almost undivided attention to the litigation now in the United States courts. Mr. Gray's characteristic as an inventor is in avoiding mere mechanical devices to accomplish results. Intricacy, in his mind, is a failure. He seeks to make electricity do his work, and therefore endeavors in his devices to train and harness it for that purpose. In 1878 he received the grand prize at the Paris exposition, and was conferred the degree of Chevalier and the decoration of the Legion of Honor by the French government. At the Electrical Exhibition at Paris in 1881, he was again honored with the gold medal for his inventions. Prof. Gray was conferred the degree of A. M. at Oberlin College, Ph. D. at Ripon (Wis.) College, and is a professor of electrical science in those institutions at the present time. He was also conferred the degree of Sc. D., and from Blackman University the degree of L. L. D. He is a member of the American Philosophical Society, the Society of Electrical Engineers of England, and the Society of Telegraph Engineers of London. He belongs to the Calumet and Union League Clubs of this city. He is a frequent contributor to the press, and has prepared several pamphlets, essays, etc., and issued a small volume entitled "Electrical Researches." Prof. Gray was married on January 1, 1862, to Miss Delia M. Shepherd of Oberlin, O. They have four children—Minnie, Annie, Edward and David.

Menlo Park Scrapbook, Cat. 1045

No. 31. "Telegraphy - Fire and Burglar Alarms"

This scrapbook covers the years 1873-1882. The material relates primarily to the use of telegraph devices for alarms and signals. There are also clippings about gas lighting, electric clocks, electric railway signals, and Alexander Graham Bell's photophone. The book contains 140 numbered pages.

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1045

Telegraphy

Fire & Burglar Alarm.

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Tel Journal May 15, 1878

Improvements in Electric Gas-lighting.—The various appliances that are now so successfully employed in lighting gas-lamps in halls, theatres, and in the streets, usually aim only to furnish the spark or hot wire that will fire the gas. The supply of gas must be turned by hand or by some mechanical means, and thus a part of the work of gas-lighting must still be performed at a waste of time, labour, and gas. To obviate this, and to save the gas thrown away after it is turned on and before it is lighted, a new system of electric gas-lighting has been brought out that turns on the gas, and at the same time sets it on fire. The same apparatus will also shut off the gas and extinguish the light, and by attaching it to a clock it can be made to light and put out the lamps automatically at any hour at which the clock may be set. The apparatus consists of a small electro-magnet, designed to be placed on the gas-jet just over the gas-cock, and a vibrating armature, and platinum wire for lighting the gas. The gas cock is a two-way valve, and having a small ratchet wheel in the place of the usual handle. This wheel is placed on one side of the gas pipe, and the electro-magnet is put on the opposite side; between them is hung a rocking-bar, supported on pivots on the pipe; at one end of this bar is the armature of the magnet, and at the other end is a pawl, playing in the ratchet wheel; a spring is also added to give the bar a vibrating motion when the magnet is excited by the current from the line. When the circuit is made by the battery at the station, the rocking-bar vibrates, and by means of the pawl turns the wheel part way round, and thus lets on the gas. The same current that sets the bar in motion also inflames the gas at the same instant. The gas being turned on, an eccentric on the side of the well breaks the circuit, and the wheel stops, leaving the gas turned on. After all the lamps in the circuit have been lighted in turn, the circuit is broken, and everything remains as it is till it is again closed. This second closing of the circuit produces the same effect on each apparatus in turn, but with the reverse effect in the lamp, for the wheel is pulled round by the vibrating bar, and the gas is shut off and the lamps extinguished. This same arrangement may be attached to single lamps in the house by omitting the electro-magnet, and substituting a small chain, that may hang below the lamp. On pulling this chain by the hand the pawl plays in the ratchet-wheel and turns on the gas, and at the same time lifts the platinum wire into contact with the jet, and the resulting spark fires the gas. To shut off the gas the chain is pulled again, and in the same manner the wheel is carried part way round, and the gas is shut off. This apparatus is designed for lighting street lamps by a cable laid just under the pavement, and from lamp to lamp. Circuits of 200 street lamps may be turned on and lighted, and turned off in a few seconds from a central office or the police station, either by hand or by means of clock-work. By a simple arrangement the same cable may also be exposed at each lamp-post, so that the police on beat may communicate by telephone with the station.—*Scribner's Monthly.*

9

June 15, 1877.]

THE TELEGRAPHIC JOURNAL.
Vol. V.—No. 105.

ELECTRIC CLOCKS.

The invention of electric clocks was a natural consequence of that of telegraphs. The idea seems to have been realised nearly simultaneously, like many other inventions which are based upon a new discovery, by several philosophers, Wheatstone, Bain, and Steinbeck among others, and a plentiful crop of most ingenious mechanical contrivances for effecting the desired ends was the result.

Electric clocks had for their principal object the multiplication of the indications of a single standard clock on numerous dials, which could be placed at any distance from; but in electrical communication with, the standard clock. This, we say, has been the principal object in view, but it has not been the only one. Very many ingenious devices were invented, and much mechanical skill shown, in producing clocks which would work without springs or weights, the motive power driving them being a galvanic battery. Very partial success was the result of the numerous efforts made, the principal cause of failure being the want of an efficient form of battery to produce the motive power. Even this seems to have been overcome, or was thought to have been so, as an electric clock company, which manufactured clocks driven by a battery, will still be recollected by most of our readers.

A little careful consideration of the utility of such forms of clocks can hardly fail to give rise to the conclusion that such an arrangement can be nothing more than a philosophical toy, and probably it was regarded as such, for the trouble of keeping a battery in order can hardly compare favourably with the trouble of winding up a clock weekly, or even daily. The novelty and not the utility of the invention must have been, after all, the inducement which led the curious to invest in such a form of timepiece. If the driving power of a clock in the first instance had been a battery, and afterwards weights or springs had been brought forward, there can be but little doubt that the former would at once have been cast aside. Such forms of clocks are now things of the past, though attempts have been, and are made, to again introduce them.

The multiplication of the indication of a single clock on several dials has met with much more favour, and indeed may be considered as a successful invention. The great advantage which such a system possesses is that it is only necessary for the standard clock to be a good time-keeper.

Bell

Continued

The methods adopted for carrying out a system of the kind are threefold. By one method the standard clock synchronises the swings of the pendulums of the companion clocks, as they are called, with its own pendulum, the clocks still being driven by weights or springs. This was the plan invented by the late Mr. Alexander Bain, and it is one of the best systems which has been tried, though it has not come into extensive use. Another method, which is the most common, is that of moving the clockwork of the sympathetic clocks by a step by step motion, worked by an electro-magnet, through which intermittent currents pass, governed by the motion of the standard clock. Lastly, we have the system which has received an impetus lately through the energy of Messrs. Barraud and Lund, and which, although not new, has not long been put into a thoroughly practical form. In this latter system the position of the hands of the clock are corrected at every hour, and although it is not such a refined arrangement as that of Bain, it is, perhaps, the most practical form which has yet been introduced.

The synchronising of clocks by electricity, although it must hold its own in cases where the different dials are at long distances apart, yet is likely to have a dangerous rival in pneumatic clocks, which have proved so successful at the hands of M. Meyer, of Vienna, and also, we learn, previously at the hands of Mr. Wenzel, of San Francisco. Whichever system proves the best there can be no doubt that there is a very large field open for workers in this particular branch of horology. The wonder is that more has not been done, but, as in every other invention, there is usually a period of mushroom growth, and then a period of stagnation, to be followed in time by a steady, though slow, progressive advance. The idea of time being laid on like water or gas can hardly be regarded as otherwise than chimerical; but there is usually a grain of probability in prophecies of this kind, and it is quite possible to conceive that most large warehouses will in time take advantage of a system which will keep all their timepieces in order and accurate in their rate of going with but little expense.

Jour Tel Apl 15, 78

ELECTRIC CLOCKS.—A correspondent of the *Scientific American* proposes to employ the Bell telephone principle of induced currents to the control of clocks by one standard time-piece. Under the pendulum of the standard is to be placed a magnet, wound with coils of wire, in circuit with a similar arrangement at each of the other clocks, so that when the iron bob of the standard pendulum swings past the coils at every stroke, a current will be induced in them, which will traverse the entire circuit, and operate on the pendulums of the dependent clocks, by means of their electro-magnetic coils and iron bobs.

Tel Jour Aug 15 73

UNITED STATES.

138,965. H. E. Walter, Richfield Springs, New York. *Electrical burglar alarm.* Dated December 10, 1872. A peculiar arrangement of latch and stop mechanism, in connection with an alarm clock, is under the control of an electro-magnet, so that on the interruption of the electrical circuit by the burglarious opening of a door or window in suitable connection, the armature is released by gravity and the alarm is sounded. A stop operated by the clock prevents the alarm being sounded after a given hour in the morning.

Electrical News Aug 12 1875

American Artizan. Vol. xix., No. 7. July, 1875.

Bean's Pneumatic Electric Gas Lighting Apparatus.—The novelty of Mr. Bean's invention consists in a combination of compressed and rarefied air to open and close the gas-cocks, and an electro-galvanic current, affording at the same instant a spark to light the gas flowing through the gas jet, so that a single operator can, without leaving his office, at will light or extinguish all the street-lights of a city or town.

Electrical News July 15 1875

Electric Signalling and Recording Apparatus.—William J. Philips, Philadelphia, Pa., April 28, 1875.—Arranged so that a watchman may send in a signal to central office, announcing his visit to any post, and at the same time register by suitable devices the time of the visit upon a dial in the box, all in an ordinary district alarm system. 1. The combination, with an electric signalling or alarm mechanism, of a recording mechanism, for registering at the transmitting station the time of transmittal of a signal therefrom, substantially as set forth.—2. The double-faced signal-box, provided with the signalling mechanism and the clockwork register, substantially as set forth.—3. The combination, with the circuit-breaking wheel and motor train thereof, of a pencil or other marking point of a registering mechanism and suitable connecting devices, substantially as set forth.—4. A double-faced signal-box, provided with the flanges R S and bolts U, substantially as and for the purposes set forth.—5. In the registering mechanism, the pencil-arm M, composed of the rigid parts *m m'*, united by a spring slip or piece, *n*, substantially as and for the purposes set forth.—6. The combination, with the arm M, provided with projection *e*, of the standard Q, provided with bevelled upper edge or end, substantially as and for the purposes set forth.

Electrical News Sept 9 1875

Les Mondes. Vol. xxxvii., No. 15. August 12, 1875.

Contains a description of MM. Voisin and Dronier's Electro-Catalytic Lamp-lighter, which was invented and patented some months ago. Briefly described it is as follows:—A small glass vase contains an exciting liquid, and is placed inside a small wooden box, to the lid of which are attached two carbon plates and a zinc plate. The zinc plate is fastened to a rod projecting through the lid, and is kept above the liquid by a spiral spring, and the poles of the battery are led out from the box over above a small spirit-lamp of highly volatile spirit, such as paraffin; the two poles being connected by an excessively fine piece of platinum wire. When the rod is pressed down, the zinc plate at its end is immersed into the liquid, and the current engendered renders the platinum wire incandescent. The inflammable gas which surrounds the wick of the lamp, being immediately under the red-hot wire, becomes ignited, and the lamp so lighted is ready for use.

Fire-Telegraphs.

That a properly organised system of Fire-Telegraphy forms a most important adjunct to the operations of a fire brigade, can, we think, hardly be doubted by any who has given the subject a moment's consideration.

It has, on careful examination of practical and scientific facts, been deemed correct to state, that the difficulty in extinguishing a fire under ordinary circumstances varies at least with the square of the time that elapses between the outbreak of a fire and the arrival of the brigade at the spot. Further, there can be no question, that if the necessary steps were taken to quell a fire immediately it broke out, it would be well-nigh a matter of impossibility for the fire to assume serious proportions.

Bearing these two facts in mind, it requires but little perception to recognise the paramount importance of a speedy transmission of an alarm, upon the outbreak of a fire, to the nearest fire-station, whence immediate orders can be issued for its suppression. It is for this purpose that electricity can be and has been applied, and, theoretically speaking, a perfectly efficient system of Fire-Telegraphy would in this direction leave nothing to be desired.

In England Fire-Telegraphs are still a thing of the future, though in America and on the continent they have long been, and still continue to be, employed with success. The city of Boston, in America, was the first to employ them in that country in 1851; and from that time their use has spread over the whole of that continent, until Fire-Telegraphs now keep guard over no less than seventy-nine cities, while in Germany no town of large population is unattended by them.

Let us examine how London stands with respect to cities protected by a system of Fire-Telegraphy in the matter of slight and serious fires. London is served by a brigade with a well-earned reputation for bravery and ability, and the water-supply is most efficient, the total number of hydrants erected being at present 4,211. Yet here are the statistics:—

Year.	Small Fires.	Serious Fires.	Percentage of Great Fires.	
1866	1,012	323	24·2	
1873	1,382	166	10·7	10·1
1874	1,419	154	9·8	
1875	1,366	153	10·	

The above table, although showing that, notwithstanding the increase in population, the fire-brigade has succeeded in lessening by more than one-half, the proportion of serious to small fires, yet betrays the fact that 10 per cent. of our fires are serious ones. This number is far too high. Take, for instance, the statistics of the town of Berlin, which is not so efficiently served either with engines or water as London, but in which a system of Automatic Fire-Telegraphy is in operation:

Year.	Small Fires.	Serious Fires.	Percentage of Serious Fires.	
1873	873	28	3·11	2·82
1874	966	26	2·79	
1875	983	26	2·57	

In these tables by the term "Serious Fire" is meant one for whose extinction more than two engines or reels were required. Hence we find that in Berlin, which is not specially picked out as a favourable specimen, and only one of the many instances indicated by the copious statistics met with in the paper, the proportion of serious fires is less than one-third of that for London.

Having, it is hoped, thus shown the necessity for a system of Fire-Telegraphy, we may turn our attention to another portion of our subject—namely, the most efficient system of Fire-Telegraphy.

In order to guide us in our examination of the different systems, we may glance at those actually in operation.

In Hamburg there are two central stations, one in the hands of the Fire Department, the other in the hands of the police. Both are in immediate connection with each other and with seven district lines which run radially through the town and suburbs. On these lines are placed automatic annunciators and speaking stations, and from any of these an alarm can be immediately sent to the central fire-station, whence the necessary orders are issued.

The Automatic Fire-Annunciator as in use on the Continent is a simple mechanical contrivance, whereby a certain signal can, by the pulling of a handle be transmitted to the central station. It consists of a box closed by a glass front. It is opened by a key entrusted to the police or other officials, but in practice the glass front has to be broken in order to allow the signal to be sent. Inside is fixed a smaller cast iron box perforated below by holes through which pass three cords, two of which sustain a weight. To a third is attached a handle, which, when pulled, allows the weight to descend a certain distance. In descending, the cords which sustain the weight move round a simple system of pulleys in the interior of the cast iron box, thereby causing a cam or toothed wheel to revolve on the outside of the case. The teeth of this wheel are so cut, that when the cam revolves, it makes contact at certain points on its periphery with a spring, in connection with the line. The duration of these contacts determine the signal registered on the self-starting Morse-inker at the central station, and each annunciator has a different cam, in order that the signals received may be identified with that given by a certain annunciator. The cam is made to revolve twelve times when the handle is pulled, and when at rest it permanently touches the above-mentioned spring, so that a current is continually flowing through the line, ceasing only when a signal is sent. Each annunciator contains in addition, a galvanoscope, a lightning protector, and a Morse key, whereby messages can be sent.

Fifty cells of the Meidenger type are in use on each line.

There are in Hamburgh fifty-three Automatic Annunciators and fifty speaking stations, and the total length of the lines is 339,400 feet, consisting of overhead and underground wire.

Except when messages are being sent none of the Morse instruments are in circuit, except at the central station. Bells, however, remain in their place. Immediately a signal is received at the central station, the official in charge sends by means of a magneto-electric inductor, a Fire-alarm signal to all the speaking stations on the circuit, or, if need be, by means of a special commutator to all the stations on the seven circuits simultaneously. The operator at each of the various stations hearing his alarm-bell ring, takes up his position at the table upon which his instrument is fixed, and presses his foot upon a lever beneath, thereby cutting the bells out of circuit, and inserting his instrument. He is then ready to receive such directions as the central station shall think proper to issue. As soon as he leaves the table the lever, disengaged, returns to its former position, thus re-establishing the bells in the circuit.

The entire system has been erected at a cost of only £8,028, and is maintained at a yearly expenditure of £80.

The Fire-Telegraphs in Amsterdam differ only in the system of circuits. The whole town is divided into three circles, upon which are fixed speaking stations,

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Electrical News Aug 12 1875

A project has been set on foot to connect all the public clocks of Paris with the chief clock of the Observatory. A telegraphic wire will unite it to the Luxembourg clock; which will in turn, by means of a series of wires, communicate its time to the Exchange, Law Courts, Town Halls, Churches, and most of the public buildings. The Observatory regulating time-piece is placed in the catacombs, so as to be away from the trembling influence of the ground; the time-piece scarcely varies one-tenth of a second in a year.

Electrical News Sept 30 1875

165,918. *Signal-Boxes for Fire-Alarm Telegraphs.* Moses G. Crane, Newton, Mass. Filed July 9, 1875.—Boxes in normally closed circuit. On the breaking of the circuit the armature levers are withdrawn by a spring. On taking against the fingers, closes a short circuit outside of magnet and circuit-breaking wheel, thus preventing a signal being given by any except the box first operated. In such box the mechanism is released by raising a lever having a lug in recess of the wheel, a tooth taking against a lever and locking it, to prevent the formation of the short circuit in each box. 1. In a fire-alarm signal-box the lever G, with its lug V and hook *t*, the flange *p*, and its notches V', the lever *b*, insulated plate *c*, and magnet D, all combined and operating as and for the purpose specified. 2. The combination of the lever H, the lever G, and the wheel F, whereby the said wheel is liberated and allowed to revolve under the stress of the motor C, as and for the purpose specified.

Electrical News Sept 16 1875

165,090. *Burners for Electrical Gas Lighting.*—Saml. Gardiner, jun., Washington, D.C.—1. The insulated globe holder I, in combination with the wires J and K, the one connecting with one burner, A, through its electrode E, and the other with the next succeeding burner by the electrode F, with the said holders in the circuit throughout the series of burners, substantially as described. 2. The negative electrode E, as a part of, and a prolongation of, the separate metallic nipple C, and in combination with the burner-tip D, substantially as and fot the purposes herein set forth. 3. The combination with the burner and the metallic globe holder I, of the wires J K, connecting said globe holder with the negative electrode E and the insulated wire G' of the positive pole passing through and beneath the globe holder, whereby a single burner may be lighted through the medium of said globe holder, as herein set forth.

THE ELECTRIC BELL SYSTEM.—The *Manchester Evening News* says that the electric bell system has been carried out on a larger and more elaborate scale at the Manchester City Hall than in any building in which that apparatus has been adopted. Wire of more than ten miles in length has been extended throughout the hall, all the departments being embraced by the system, while, however, each department has its own independent system.

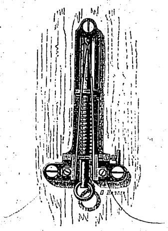
Electrical News Sept 30 1875

165,923. *Telegraphic Fire-Alarm Repeaters.* John N. Gamewell, Hackensack, N.J., M. G. Crane, Newton, and E. Rogers, Boston, Mass. Filed July 9, 1875.—1. The combination, with a break-circuit wheel of a telegraph repeater, upon which the lines of two or more circuits converge, of a governor, whereby, when a signal is being given over any one of the circuits, and repeated over the other circuits, the armatures of the magnets in such other circuits are locked in position, thereby preventing interference between the several circuits, as and for the purpose specified. 2. The auxiliary escapement movement, in combination with the governor J and the break-circuit wheel, whereby the reverse movement of the governor is not permitted to take place during several successive revolutions of the said wheel, as and for the purpose specified. 3. The auxiliary escapement movement, the circuit-wheel and its shaft, and the lever 25, combined and operating as described, whereby, after the winding up of the escapement by the revolution of the circuit-wheel shaft, the reverse motion of the said lever is prolonged and graduated, as specified. 4. The combination, in an electro-telegraphic repeater, of two electro-magnets in the same circuit, one of which has a larger core than the other, whereby there results an appreciable difference in the periods required for them to be charged and discharged, respectively, as and for the purpose specified. 5. The device described, whereby the breaking of any one of several circuits connected with the repeater for the purpose of signalling occasions the break-circuit wheel to be cut out from that circuit by closing the same over auxiliary fingers *x x'*, all combined and operating as and for the purpose specified. 6. The auxiliary magnets F F', with their armatures and hooked lever M, in combination with the armature lever H and swinging lever D, as and for the purpose specified. 7. The combination of the swinging lever D with its two stop pins, and the arm *l*, with its two fingers *s s'* upon the break-circuit wheel shaft, as and for the purpose specified. 8. The combination of the cam 28, levers 22 and 25, and sliding bar 18, as and for the purpose specified. 9. The combination of the governor J, bar 18, lever 25, and latch 37, as and for the purpose specified. 10. The lever I, with its short arm 10, the armature lever H, and lever D, and the governor J, combined and operating as and for the purpose specified. 11. The auxiliary escapement *y y'*, with its train 31 32, in an electro-telegraph repeater, employed to graduate the movement of the mechanism by which said train is actuated relatively to the movement of another telegraphic repeating mechanism.

(22) E. T. H. asks: 1. I want to make a magnet to place in a fire alarm telegraph circuit. The circuit is composed of about 6 miles of wire, with 15 stations. Of what size shall I make my magnet? A. Make the coils of copper wire, and let the resistance be 25 or 30 ohms for each magnet. 2. In a late number of your paper, Mr. Sawyer says that it requires 10 cups of Grove's cells to heat a fragment of platinum wire. In a former number, in an illustrated description of an hydro-electric lamp, the illustration shows only 1 small cup. What is the smallest amount of battery power required to heat platinum wire to a red heat? A. That depends upon several circumstances. A single cell of bichromate battery (without porous cup) will heat from a quarter to half of an inch of No. 46 platinum wire to a white heat.

La prévoyance humaine s'est depuis longtemps inquiétée de moyens qui, sans empêcher la déclaration de l'incendie, puissent du moins en donner le signal et permettre d'apporter de prompts secours. Les procédés mécaniques et chimiques que différents inventeurs supposaient propres à remplir ce but, furent aussi vite abandonnés que conçus; et les efforts se portèrent sur cet agent merveilleux : l'Électricité.

MM. de Gaulne et Mildé présentent un appareil avertisseur d'incendie électrique qui réunit les qualités les plus désirables : son organisme est simple, solide; il ne peut être altéré par un usage des plus prolongés. Basé sur le principe de la dilatation des métaux, il est donc d'une très-grande sensibilité, ses effets sont certains et instantanés.



Sur un fort bâti métallique triangulaire, deux lames sont fixées parallèlement par leur base, au moyen de plats qui les tiennent élevées de un centimètre du bâti. Celle de droite articulé à sa base, où se trouve une vis micrométrique avec un index qui parcourt un secteur portant les divisions thermométriques des divers degrés dans lesquelles peuvent s'effectuer les effets de l'appareil. Celle de gauche est fixée sur son plat et isolée du bâti par une rondelle en ébonite; ces lames sont composées de trois métaux qui ont entre eux les plus grands différents coefficients de dilatation : l'acier trempé, le cuivre rouge et le zinc. Cette composition trimétallique est nécessaire, elle permet d'obtenir des effets de dilatation et de contraction réguliers; ce qui serait impossible si les lames étaient composées d'acier

139,692. J. Vansant, San Francisco, California. *Electrical Gas Lighting Apparatus.* Dated February 3, 1873. The gas valve at the burner is operated directly by an electro-magnet, whose helix is also employed in exciting a secondary induction coil for igniting the gas by a spark. A permanent magnet is employed with the electro-magnet, so as to obtain both attraction and repulsion; and to preserve the permanent magnet from deterioration it is surrounded by a coil whose direction of current is never reversed. The apparatus, including the gas burner, is insulated from the gas-pipe by an interposed tubular section of non-conducting material. By the use of a peculiar circuit breaker and switch the battery power is successively transferred to several series or districts of street lamps.

raréfié se précipite rapidement dès qu'un commencement d'incendie se manifeste; les lames en communication directe avec cet air ambiant sont instantanément impressionnées : car ces couches supérieures peuvent promptement atteindre 10 à 15 degrés d'élévation de plus que celles inférieures.

Outre son caractère essentiel d'avertisseur d'incendie, l'appareil de MM. de Gaulne et Mildé se prête encore merveilleusement à trois applications importantes de l'électricité aux besoins de la vie :

1° Formant tirage, il sert d'appel dans les installations de sonneries électriques aux usages administratifs ou domestiques;

2° Placé dans les théâtres, musées, arsenaux, banques, usines, etc.; il remplit l'office de contrôleur de rondes;

3° S'agit-il de la surveillance d'un chauffage général, soit dans les établissements publics ou particuliers comme hôpitaux, prisons, bains, étuves, serres-chaudes, etc, l'appareil, avec une rigoureuse exactitude, prévient chaque fois que les degrés de *maxima* et de *minima* auront été dépassés.

Par ses services multiples et son extrême bon marché, la sonnerie électrique s'est aujourd'hui tant généralisée que l'application de ces appareils ne nécessite point d'installations spéciales et coûteuses, telles qu'ont entraîné tous les essais en vue de prévenir des premières atteintes de l'incendie. Leur prix minime (12 fr.) n'augmente que très-insensiblement la dépense d'un service de sonneries électriques; ils s'adaptent parfaitement aux services existants sans en rien modifier.

C'est particulièrement à ses diverses fonctions que cet appareil doit sa supériorité sur ceux mis à l'essai jusqu'à présent, car son usage journalier comme tirage d'appel ou de contrôle, permet à chaque instant de juger du bon état de l'installation; et, à chaque fonctionnement, un index métallique entraîné lors du tirage, s'interpose par frottement entre les surfaces de contacts des deux lames, les tient ainsi en bon état de propreté; condition essentielle au passage du courant. Tandis que si l'appareil devait se borner au seul rôle d'avertisseur d'incendie, après quelque temps de son installation, les surfaces de contacts se couvrant d'oxyde, de poussières ou d'autres corps isolants, par suite des condensations de vapeur qui s'opposeront au passage du courant, il ne pourra donc y avoir de signal, lors même que les lames se toucheraient, parce qu'à leur surface de contact il y aura solution d'agrégation moléculaire.

C'est, en effet, ce qui s'est toujours produit dans les essais antérieurs. L'insuccès fut encore plus grand avec les appareils à mercure; car, outre que le mercure est un des métaux les plus oxydables, mais encore le tube de verre dont il est enveloppé, étant très-mauvais conducteur de calorique, rend tout au moins les effets tardifs et les ravages de l'incendie seront déjà bien considérables lors même que le signal serait donné.

Les services multiples et la sûreté des effets de l'appareil

AVERTISSEUR ÉLECTRIQUE D'INCENDIE

Système de Gaulne et Ch. Mildé.

Chacun est journellement saisi au récit des désastres que laisse sur son passage l'incendie. Nos salles de spectacles s'écroulent, nos manufactures sont dévorées par ce fléau destructeur; et nos plus belles œuvres d'art deviennent sa proie, sans qu'un secours salutaire ne vienne apporter d'autre remède que de circonscrire le désastre.

14

FIRE ALARMS.

What more dreadful death can be imagined than that by burning? Witches and devotees were burned at the stake because cruel persecutors could contrive no more dreadful form of death. The shock which was given to humanity all over the country when, on the 13th of January, the tidings spread that a family had been burned to death in New York City, in one of the centers of civilization, in an elegant residence provided with all the modern improvements, and filled with every luxury that wealth could furnish, will not be quickly forgotten. It, too, has a lesson, both to builders and to the public. Four lives were sacrificed because the fire had gained too great a headway before it was discovered, and had cut off the means of escape. Against the insidious attacks of suffocating gases from leaking gas pipes or defective flues we cannot be warned by any sort of alarm, but fire is a force capable of making known its presence, and of awakening the inmates before it is too late. Several different forms of fire alarms have been suggested, such as torpedoes or muskets which should go off with a loud report when the heat reached a certain point. Fuses to ignite at any temperature above summer heat, and thus communicate with some explosive substance, or set in operation an electric bell, have been patented, but not very frequently used.

A very simple fire alarm, which is cheap and practical, has been suggested by Dr. Van der Weyde. A small weight of lead or iron is made to adhere to the ceiling of each room with a piece of wax. When the temperature becomes elevated above that of the ordinary atmosphere, the wax will lose its adhesiveness and allow the weight to drop. The weight can be attached by a wire to all the bells in the house, or to sound any alarm extemporized for the purpose. The weights should be kept away from stovepipes and out of the sun, and one should be placed in each room and hallway. They will not fail to give the alarm when there is an excessive increase of temperature, and no house should be without them. This alarm is not patented, and is free to be used by all without money and without price.

It might be objected by some that these strings with weights attached would not be ornamental. This would depend on the style of weight employed; for the parlor it could take the form of a little hanging basket with flowers; for the nursery it might resemble a jumping jack; in the library a thermometer or paper weight; in the smoking room a cigar holder; for other rooms appropriate objects will suggest themselves.

Persons who have the wires of the American Dispatch Telegraph Company in their houses should combine them with one or other sort of automatic fire alarm. In offices and manufactories, if night watchmen are not employed, this would be especially useful, and would save millions of dollars' worth of property.

As prevention is better than cure, fireproof paints, and timber saturated with salts which prevent its rapid combustion, suggest themselves, as also increased means of exit in case of the stairs taking fire, as happened in Mr. Jacob Steiner's house.

GAS PRESSURE ALARM.—When two neighboring buildings are illuminated by gas derived from the same source it frequently happens that the extinction of the lights in one building causes the pressure of gas in the other to become greatly increased, and sometimes to result in accident. M. Launay proposes, as an alarm to give warning of this over pressure, a bisulphate of mercury battery, in which the liquid is in communication with the gas by means of a siphon, so that the pressure of the gas, in varying, raises or lowers its level. If the pressure is above a certain fixed limit, the liquid is raised so as to come in contact with the metallic portion of the battery, establishing a current which sounds an electric alarm. M. Launay also suggests that a simple method of determining leaks in gas pipes throughout a building is to force some strongly odorous smoke into the supply pipe. The fumes of incense, for example, escaping in any room, would be readily distinguished from gas, and the locality of the leak discovered.

The Electrical Railway Alarm.

THE bell rope commonly used on our railways, while it is very serviceable for short trains, is not of much use on long freight trains, because the weight and friction of a long cord is such that the rear portion of the cord may be broken without moving the forward portion. Thus, if the coupling of the rear cars of a long freight train breaks and the train separates, no alarm will be sounded on the engine gong, because the rear portion of the cord breaks while the front portion, to which the bell is attached, is not moved. An improvement which overcomes this difficulty consists in placing a magnetic bell hammer upon the engine, together with a small electrical battery, and in providing each car with a set of wires, joined by flexible joints, so arranged that while the train remains united all is well, but should any of the car couplings or wires break, the gong on the engine will instantly commence ringing. The same device may be employed by the conductor to give any signals that he may desire to the engineer,

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BURGLAR ALARMS

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J. A. Oct 75

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L. a Oct 75

June 76

ELECTRIC ALARM AGAINST SUFFOCATION BY ILLUMINATING GAS.

Burglar alarms have come into extended use, in this country at least, and to them have been added fire alarms, to go off when a certain temperature is reached; and it has been suggested that a suitable alarm for coal gas from leaky stoves could be added, making use of the property that carbonic oxide possesses of precipitating palladium salts. Another modification has been invented by Ansel, for detecting the escape of street gas in a room. It possesses the advantage of simplicity, and its operations depend on a physical law, not a chemical one, namely, that the lighter a gas is the more rapidly it diffuses through a porous membrane.

The apparatus consists of a pear-shaped vessel covered with a porous membrane or unglazed earthen plate. This vessel has attached to it a U-shaped tube filled with mercury. One pole of the battery dips into the mercury, the other terminates just above the surface of the mercury in the open end of the tube. If this apparatus is placed in a room where coal gas is escaping, the gas enters through the porous plate more rapidly than the air can escape; a certain pressure is produced, which causes the mercury to rise in the open leg and complete the circuit, thus giving the alarm. It is said that a comparatively small amount of gas in a room will set the apparatus in motion. A similar apparatus with the opposite arrangement of the terminating wires could be employed for detecting a large escape of carbonic acid from any source, for this gas is so heavy as to at once produce a partial vacuum in the pear-shaped vessel, and, of course, a fall of mercury in the open leg. The amount of carbonic acid requisite to vitiate an atmosphere is, however, so small that it would probably be without effect on this instrument. There may be other cases where the pressure of gases much heavier or lighter than air could be detected more quickly by this than by the ordinary methods, as in coal mines and wells; while an advantage is that signals may be automatically conveyed to any desired distance. This seems, at least, a promising field for inventive genius and research.

3705. Magneto-electric Telegraph Signalling, G. Zanni, Highbury.—Dated 1st November, 1875.

The first part of this invention relates to improvements in magneto-electro apparatus applicable for signalling between the captain of a vessel and the engine-room and steersman, and for railway and other signalling purposes. For this purpose a magnet is arranged in combination with a crank and axis actuated by hand or by the steam engine of the vessel or the locomotive of a train or by other suitable motive power in connection with keys for transmitting the proper signals from one situation to another as may be required. In place of employing a magnetic current as previously described, the apparatus may be actuated by a voltaic current by means of a suitable battery or batteries, the mechanism being slightly modified for this purpose. The apparatus previously described may be employed for telegraphing type printing purposes in accordance with another part of these improvements. The magneto apparatus in this arrangement is actuated by means of a small crank in connection with a key-board of suitable form, having as many keys as there are figures or characters to be transmitted. The same result as that previously described may be obtained in accordance with this invention for employing battery power in place of magneto-electric apparatus, suitable modifications being made in the apparatus for this purpose. Another part of these improvements relates to magneto-electric telegraphic apparatus known as the A B C instrument. In this apparatus a suitable transmitting key-board is employed, with a crank axis which gives motion to a disc for making and breaking contact, having as many conducting and non-conducting divisions as there are letters or characters in the receiving dial. The above described apparatus may also be actuated by battery power in place of magneto-electric apparatus by suitable modifications of the transmitting apparatus. The apparatus previously described may be arranged so as to carry a disc or other signal in place of a pointer, in order to exhibit signals upon a line of railway for working the block system of signalling, in combination with the arrangements of apparatus described in the specification of letters patent granted to the inventor, dated 2nd November, 1872, No. 3292.

doubt, to a very great extent, the irregularity in the results of serious fires, as shown in tables which I have compiled. From these we see that some towns with imperfect telegraphic arrangements give a lower percentage of serious fires than other towns in which an almost perfect system of fire-telegraphs exists. This is, however, only exceptionally the case, and we shall always find that efficiency of the brigade, abundance of water-supply, solidity in the construction of buildings, or a judicious choice of fire-proof materials, are the reasons for these apparently contradictory results.

For "absolute security" the highest perfection of these five conditions is required, and therefore these tables can only be considered as demonstrating the results of one of the conditions; they go to prove that where fire-telegraphs are in operation much better results are obtained than where they are not in operation.

There is yet to be considered the other difficulty in the way of a true comparison of the results in the percentages of serious fires, viz., the want of a standard unit to determine a "serious fire." My classification is, as far as possible, based upon the definition that a "serious" fire is such as requires more than two engines or fire-reels for its extinction.

From statistics we see that towns with perfect fire-telegraph systems have their serious fires reduced to an average percentage of 4; the less perfect systems show more frequently serious fires, reaching an average number of 17; while the percentage in towns possessing no fire telegraphs reaches as high as 29.

It could easily be shown that the percentage of fires resulting in "total destruction" must likewise be exceedingly high in towns without fire-telegraphs, but it suffices to give a single case, which well represents the average of their class, viz., the town of Antwerp, in Belgium, with 160,513 inhabitants. The total number of fires during the two years of 1873 and 1874 was 37, with 5 "total destructions:" thus giving the alarmingly high result of 13·5 per cent. of fires ending in total destruction.

The city of Paris, on the other hand, furnishes ample proof of the reduction of fires resulting in total destruction after the introduction of fire-telegraphs. I regret that I have not been able to obtain a classification of the Paris fires according to the basis adopted in this paper, viz., proportion between "total number" and "serious fires;" but I have obtained from the chief office of police, statistics which are classified according to the value of damage done. This list shows that the average "total destruction" have diminished 50 per cent. since the year 1870, the time in which the fire-telegraph was introduced.

One of the strongest arguments in favour of a fire-telegraph system is the saving on insurance, which must naturally follow from a reduction in the percentage of serious fires. It would be departing from my subject too much if I were to lay before you an estimate of the millions that have been saved, or the millions that may be saved, by the adoption of fire-telegraphs. Such calculations I leave to the insurance companies, and will only endeavour to show by a few data the financial and economical value of the system. In the town of Brunswick in Germany, in one year, when there were no serious fires, only £282 was paid by the insurance companies. In two other years, when there were four serious fires, £17,000 extra was paid:—

Year.	Fires.	Serious.	Insurance Value.	Insurance Paid.
1873	95	2	£9,093,870	£1,939
1874	96	0	9,746,648	282
1875	104	2	10,498,338	15,364

I may add to this table the most recent communication which I have received on this subject. The Superintendent of the Salford, England, fire-brigade, Mr. Robert Hall, wrote me on the 17th October last year: "The complete system of telegraphs in this borough has enabled me to save many thousands of pounds in cases of fires."

In America the same result is obtained. The Superintendent of the St. Louis Fire Telegraphs, H. C. Sexton, in his report of 1860, says: "A comparison of the two years' working of the department prior to the establishment of the electric alarm, with the two subsequent ones, shows the following results: "From 1856 to 1858 the amount of losses was $1,803,315, against $710,404 from 1858 to 1860, showing a diminution of $1,097,911, or $548,955 annually, and, on the principle that prevention is better than cure, we claim for the fire-alarm telegraph a large share of the credit in saving that amount." The chief of the Montreal fire-department, A. Bertram, in his report of 1866, says: "As the simplest illustration of the great value of the fire-alarm telegraph we have the fires and loss for a fair average before and since its introduction:—Before, 85 fires, $140,088 loss; since, 99 fires, $35,428 loss." Mr. Joseph L. Perley, Chief Engineer of the fire department of New York City, and now President of the Board of Fire Commissioners says: "It would be difficult to estimate the value of the fire-alarm telegraph. I have known cases where lives have been saved by the quick method of communicating the intelligence of fire—the value in money would amount to millions." The Honourable J. C. Cuyler, one of the Fire Commissioners of Albany, testifies: "I give it as my opinion, from my knowledge of the localities in which fires have occurred, the character of the buildings, and the nature of their contents, that it would be a moderate estimate to say that it (the fire-alarm telegraph) has effected in Albany a saving of at least one quarter of a million dollars annually;" and the chairman of the Board of Fire Commissioners of Hartford says: "To the best of my judgment, our losses since the introduction of the fire-alarm telegraph have not been one-tenth of what they were before."

That the necessity for extended fire-telegraph systems is equally felt in Great Britain may fairly be judged from a report of 1875 from the chief of the Dublin Corporation Fire Brigade Department, Mr. Robert Ingram, who says:—"I furthermore would recommend that the different police stations throughout the city be connected by magnetic telegraphs with the chief fire-station, with coloured signals attached to alarm bells. By this means we should be enabled to get quicker intelligence of the locality of fire, as at present the police are obliged to take the first means of conveyance, such as a car or cab. It is my impression, from my knowledge of the city, that a vast amount of property might be saved by this means of communication with the brigade."

A secondary, though no less interesting, advantage to be gained by fire-telegraphs has been pointed out to me by Mr. Frobeen, chief of the Memel Brigade, who says:—"After forty years' experience as chief of the brigade, I can assure you that since the establishment of the fire-telegraphs there are not only very few serious fires but there are no cases of incendiarism, so little chance of success being left to the incendiary in a place where most of the fires are quenched in their infancy."

From a table of Stettin fires, from 1865 to 1875, it appears by far the greater number were extinguished in their infancy, and they furnish good testimony of the efficiency of the fire telegraphs, and go far to corroborate Mr. Frobeen's opinion. The truth of it must, however appear evident to all, upon the meanest consideration, for it stands to reason that the incendiary will be far less likely to carry out any of his nefarious schemes when the certainty exists that in the course of a few minutes a policeman, or other officer connected with the fire-brigade, will be on the spot, and so able to detect him. I need not, therefore, waste more of your time in discussing the point.

I am well aware that the statistics I have laid before you are far from complete, but any addition to them cannot materially alter the conclusions to which they all point. These conclusions briefly summed up are:—

(1) That the towns without fire-telegraphs are liable to a very high percentage of serious fires, the cause of this being unquestionably the time lost in calling out the fire-brigade.

(2) That the employment of fire-telegraphs in all cases leads to a decrease in the percentage of serious fires, and that the more perfect the fire-telegraph is the greater the reduction effected in the percentage of serious fires.

The principles of construction claimed by a perfect fire-telegraph system are shortly these:—

(*a*) Entire control and management of the line by the fire-brigade department.

(*b*) Underground cables.

(*c*) A system of circles or radii, with a suitable number of speaking stations and automatic fire-annunciators, all terminating in one or more central stations, from which commands are issued to the entire system.

(*d*) That the stations and annunciators be so chosen that each part of the town be as near as possible to a point of alarm; that the closed-circuit system be preferably adopted, and the Morse in preference to other speaking instruments.

These points might be modified as local circumstances require.

THE NEW NOMENCLATURE IN GERMANY.

THE following letter bearing on this question has just been published:—

"Berlin, Germany, January 5th, 1877.

"*To the Secretary of the American Iron and Steel Association:*

"Sir,—Every system has its defects; hence, every nomenclature also. The settlement of a system can therefore only be founded upon a compromise, and a system so made is the better the more its nomenclature covers the principal abstracts, and leaves the uncertainties to the lowest divisions. That was my opinion as I put my name under the International Committee's report.

"Our ancestors made by the ways of the direct process, or of the charcoal finery, two kinds of forgeable iron, which always differed essentially in the amount of carbon, had, in consequence, essentially different physical properties, and were used for essentially different purposes. The intermediate kinds of iron were not in use, and were therefore not purposely produced. The puddling process originated at first an intermediate product, the so-called 'fine-grained iron.'

"All these products were obtained in a pasty state. Now comes the Bessemer process and produces a fluid, forgeable metal, and several adjoining processes do the same. Fluid irons are now easily made of different amounts of carbon, and every intermediate product is blown without difficulty. From this time the property of hardening no more stands in the foreground; it goes back, and the properties which are a consequence of the fluid state take the leading place. At the same time arises the necessity of a new nomenclature.

"The nomenclature of the International Committee is known. Let me show the system:—

Iron.
- Forgeable; difficult to melt: Forgeable iron. I.
  - Obtained in a fluid state: A. Ingot iron.
    - Hardening: 1. Ingot steel.
    - Not hardening: 2. Ingot iron.
  - Obtained in a non-fluid state: B. Weld iron.
    - Hardening: 3. Weld steel.
    - Not hardening: 4. Weld iron.
- Not forgeable; easy to melt: Pig-iron. II.
  - With amorphic carbon only: C. White pig.
  - With graphite: D. Gray pig.

There may be added, called as before: *remelted* pig-iron—cast iron; *remelted* steel of every description—cast steel. Here the division following the fluid or non-fluid state keeps the principal place; the hardening only the second. Therefore, all the members of the committee, differing in some points (Mr. Akerman and myself wishing a more detailed subdivision), agreed to this compromise without hesitation.

"It is asserted that such a compromise, comprising the languages of the principal iron-producing peoples, has not been necessary, and that each country may keep its own expressions without caring about others. But how can that be good and useful? I think every one, protectionist or free-trader, must be a friend of clear and distinct definitions, whether in treaties of commerce or in simple tariffs. And even besides this international question, is it not necessary for the public trade to have accurate definitions for every kind of ware, giving no room for intentional or unintentional deceptions?

"By the new nomenclature accepted and introduced, every tradesman and every customs officer who knows nothing about iron metallurgy easily distinguish:—I and II by the forgeability; C and D by the colour; A and B by the fracture—if necessary, by an easily made etching with acid; 1, 2, 3 and 4, by the hardening. Also, those ought to be satisfied who desire to examine the chemical properties, viz.:—

Iron.
- I. contains O 2, 3⁰⁰ C.
  - 2 and 4; O·O, 6⁰⁰ C.
  - 1 and 3; O, 6·2, 3⁰⁰ C.
- II. contains 2, 3·5 ° C.
  - Amorphic C.
  - Graphitic and amorphic.

"But it is not necessary to make analyses and to dwell upon differences growing from the presence of other matters, which would be the case if you classify according to the amount of carbon.

"After having read all that has appeared in your *Bulletin* and the *Engineering and Mining Journal*, I have no hope that our nomenclature will be accepted in America. But, let me tell you, we are happier. It may be the interior value of the nomenclature, or it may be the authority of the names of the international committee that has accomplished this result, but what long discussion could not do is done. The nomenclature is accepted in Germany.

"The professors of iron metallurgy in Germany, Austria and Hungary have accepted it; the most widely circulated journal of mining and metallurgy and the official journal of the ministry of trade and commerce have accepted it; the Association for the Progress of Industry at Berlin and the Association of Miners and Smelters at Karntnen have accepted it. It will be introduced very probably in all official statistics. So we are certain that at least our rising generation will unanimously use the nomenclature proposed by the international committee.

"Well, you Americans will of course do what you think best, but please accept our German thanks, added to many thanks for the kind and amiable reception given us in your wonderful country, that you again have been the best help to a uniform nomenclature of iron in Germany.

"Very truly, Dr. Hermann Wedding."

SCIENCE

HOMOGENEOUS IRON,

And the Degree of Homogeneity to be expected in Iron produced by Various Systems of Puddling and Subsequent Working.*

MANUFACTURERS of finished iron are frequently blamed by engineers for not giving them the exact qualities required, and they excuse themselves by saying that the pig-iron supplied to them under the same name varies very much in its composition, and that they cannot make an invariable product from it. Smelters affect to regard complaints of the quality of pig-iron as purely imaginary, but they themselves find fault with the minerals supplied to them, and mine-owners are very ready to tell them that they can only give such materials as the mines yield. Thus every one exonerates himself, yet the truth is that no one of the departments is without its difficulties; and if each, instead of ignoring those of the others, would patiently examine them, and endeavour to remove, mitigate or neutralise them, in the end all would be gainers. It is from such considerations that this paper is brought forward, in which it is the writer's intention to present some facts and offer some remarks from an ironmaker's point of view.

Words sometimes alter their signification so much in course of time that it is occasionally difficult, during the period of transition, to embrace all the shades of meaning current in any short definition; and if the title of this paper had been confined to "Homogeneous Iron," numerous precedents might have been found for a departure from the strict original sense of the term "homogeneous." But it is contended that many such departures give rise to ambiguity and confusion, and to a loss of valuable time which ought to be avoided. Thus the word "puddling" was originally restricted to the working of refined iron, which never became thoroughly liquid, but was in a "puddle" or pasty state throughout; and when unrefined pig began to be worked, and was found to melt thin and boil up freely from the rapid escape of carbon, the process was termed "boiling." But as the puddled iron was better than the boiled, there was the temptation to sink the word boiling altogether, and this has been done so completely that now, when we want to speak of the old puddling process—which is still carried on at all the best Yorkshire works and at many others where the very highest quality of iron is made—it requires a lengthy description to convey the intended meaning.

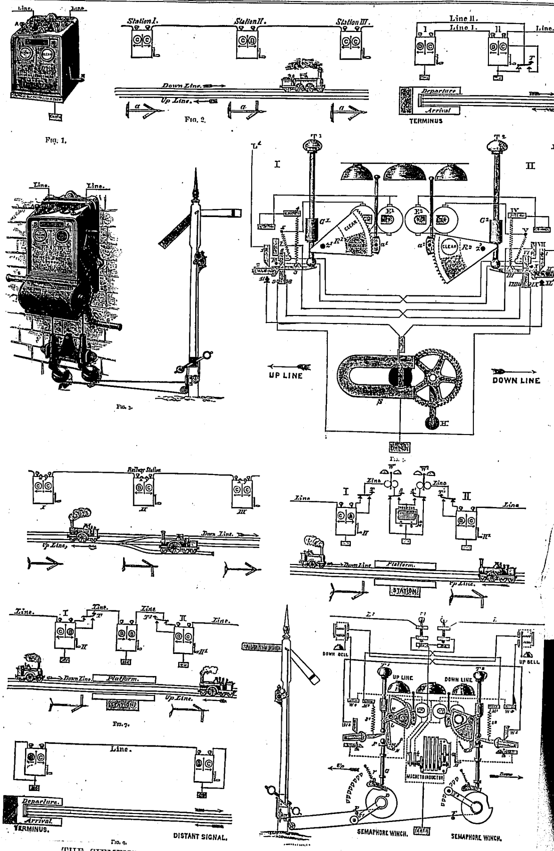
The term homogeneous seems to have been first applied to iron about twenty years ago, and it meant a comparatively pure iron manufactured by melting, too low in carbon to be called steel—in fact, presenting none of its characteristics. But within the last ten years makers of homogeneous iron have appropriated the term steel, steel being something better than iron; and now there appears in some quarters a disposition to adapt the word homogeneous to iron produced by puddling, whereas puddled iron is not, and perhaps cannot be made, truly homogeneous. It is highly probable that the use of the term steel has very much hindered the employment of true homogeneous iron in works of construction, for which it appears to be eminently fitted, by creating false impressions as to its hardness and the expense of working it, and it is a question whether the appropriation of the term homogeneous will help iron manufacturers nearly so much as the closest approximation to its most valuable properties which it is in their power to make. But here arises a difficulty: the finely crystalline appearance of such iron, when cut round with a chisel and broken suddenly off, finds little favour with engineers and consumers, while the fact of its being remarkably strong in its hot as well as in its cold state, and requiring a good deal of fire to heat and muscular force to work, excites prejudice on the part of those who have to expend their labour upon it.

The writer will now endeavour to show, first, what homogeneous iron is, and what are its properties; next, how far the conditions of various modes of puddling are compatible with the production of similar iron; and, lastly, how homogeneity is affected by the subsequent operations of hammering, rolling, heating, piling, &c.

Homogeneous iron will be considered herein as iron of the same kind or nature throughout, and consisting of similar parts. Thus iron may be homogeneous and yet contain all the elements usually associated with it, such as carbon, silicon, sulphur, phosphorus and manganese; but iron containing cinder cannot be truly homogeneous, because the nature of cinder is altogether different from that of iron, and in fact cinder does not combine with it at all, but only remains diffused throughout the mass. Iron produced by melting and casting into solid ingots, carefully heated and well worked, may properly be called homogeneous. Such iron has no right to the term steel when the carbon is not above 0·30 per cent., which is an amount sometimes exceeded in the very best brands of wrought-iron; for instance, an analysis of Swedish iron is given by Percy with 0·386 per cent. of carbon, and one of Russian with 0·34 per cent.

Homogeneous iron—or mild steel as it is now called—is remarkable, as compared with puddled iron, for its high degree of strength and ductility combined. This is well exemplified in the samples of mild steel and iron hoops of which tests are given in Table A. The pieces were about

* Prepared for the last General Meeting of the Society of Mechanical Engineers, at Birmingham, by Henry Kirk, Workington, and taken as read.



THE SIEMENS AND HALSKE SYSTEM OF ELECTRICAL RAILWAY SIGNALS.

and on the voyage home 84 tons, the latter being Australian Bull-eye coal. Altogether the performance is an admirable one. The St. Osyth was built in 1874 by Messrs. C. Mitchell & Co., of Low Walker; she carries 4,000 tons dead weight, and her engines are 500 horse power nominal.

SIEMENS AND HALSKE'S ELECTRICAL RAILWAY SIGNALS.

In the improved form of block apparatus, a perspective view of which is shown at Fig. 1, the protecting case is entirely of iron, and may be put in communication with the earth for preventing any danger from lightning to the man working the apparatus. The handle, H, of the indicator is at the right hand side, and the two plungers, A and B, are at the top of the case. These plungers, or transmitting keys, serve as line-circuit closers, and when pressed down, produce the signal "line blocked" at the apparatus itself, thus sending the induction current to the preceding block station; the direction of the trains is marked by arrows. If the handle, H, of the instrument be turned, and at the same time the plunger A, on the left side of the instrument, be pressed down, the word "clear" becomes changed to "blocked," thus showing that the up-line is closed; and in the same way, if the plunger B were depressed, the right hand aperture would show that the down-line was blocked.

The signals given by electricity must be transferred to a standard signal visible to the engine driver, so that the signalman has not only to give the electrical signal, but also to work the visible standard signals. Let a a a (Fig. 2) represent these signals; when a train is proceeding on the down-line from station II. to station III., the signals should stand as shown in the engraving. If the apparatus were so constructed that a negligent signalman could omit to put his standard signal at "line blocked" after having given the electric signal, thereby clearing the preceding station, a collision might take place on the arrival of the succeeding train; but, as the man is unable to give the electric signal until he has put his semaphore at "danger," an accident is impossible, and delay only can ensue. The arrangement whereby a signalman is prevented from clearing the preceding block station before he has blocked the line with his semaphore, is shown at Fig. 3. In this case a winch is added to the bottom of the block apparatus, which may be placed in any convenient position inside the signal box, and this winch is so connected mechanically with the semaphore that, while the latter stands at "clear," it is impossible to give an electrical signal. By turning the handles S S, corresponding with the up and down lines, the semaphore arms are raised or lowered. In order to send an electrical signal to the preceding station (which is always the "clear" signal) it is necessary that the standard signal be first put to "danger," and an electrical "clear" signal sent to the preceding station during this "line blocked" position of the semaphore, not only blocks the electrical apparatus, but also interlocks the standard "blocked" signal, so that the standard "clear" signal can only be given after the electrical "blocked" signal has been changed into "clear" by the forward station.

The working of the electrical block apparatus is shown at Fig. 4, which represents two indices, identically the same for up and down lines, constituting one of the signalling instruments. To take No. 1, or that for the up-line, R_1, is a movable arm pivoted at 2_1, and provided with teeth on its periphery. The movement of this index up or down brings the words "blocked" or "clear" opposite the aperture in the case. The pallets of an escapement, a_1, similar to that used in clocks, engage in the teeth of the arm R_1. This escapement is attached to and worked by the polarized armature of an electro-magnet, E^1, and is caused to oscillate by a number of successive alternating positive and negative electrical currents. The arm, R^1, has, by its own weight, a tendency to fall, but, being held by the pallets of the escapement when they are at rest, it can only fall tooth by tooth when these pallets oscillate. As several alternating positive and negative currents in succession are required to give a number of oscillations sufficient to change the signal, an accidental current, a succession of currents of the same direction, or a discharge of atmospheric electricity, cannot change the signal. The armature connected to the escapement a^1 is polarized, so that the alternating positive and negative currents transmitted through the coils of the magnet E^1, cause it to oscillate. This oscillation, besides working the escapement, causes a hammer attached to the armature to strike the bells placed near it. To move the arm R^1 up again, a plunger, T^1, with a sliding weight, G^1, bearing upon the tail of the arm, is pressed down, thus giving the arm a tendency to rise as soon as the armature, a^1, oscillates. The plunger, T^1, also acts upon a commutator and determines the course the electrical currents have then to take.

The following example will serve to show the reciprocal operation between the block apparatus of two neighboring stations. In Fig. 4, the up-line is blocked, a train having just passed. As soon as that train passes the next station, the signalman then presses down his up line plunger, at the same time turning the handle of his magneto-inductor. By these two operations he blocks his up-line apparatus, and also sends alternate positive and negative currents along the line wire, L^1, and through the conducting parts marked 1, 2, 3, 4, to the coils of E^1, and thence through 5, 6, 7, *VIII.* and *IX.* to earth, thus causing the escapement, a^1, to oscillate. During this oscillation the arm R^1 descends, tooth by tooth, and brings before the aperture in the cover of the instrument the word "clear," while the word "blocked" becomes hidden behind the cover. A similar action takes place for the down-line indicator, marked II., when the currents are transmitted to L^2.

The apparatus above described, always interlocks with the standard signal, serves for block stations between railway stations where there are no points or sidings; it is also sufficient for small railway stations, but will require a few more manipulations for the blocking and clearing of the line when a goods or slow train has to be shunted, to allow an express or fast train to pass. At Fig. 5, *II.* shows a siding at a railway station, into which it is necessary to shunt a goods train to allow an express, one stage behind, to pass. When the goods train is shunted, the signalman at station *II.* blocks his up-line, thereby clearing station *III.* Before the express could pass station *III.*, its apparatus should show the signal "line clear." As this effect, when produced in the ordinary way, by turning the handle of the magneto-inductor and pressing down the corresponding plunger to "danger" at station *II.*, would involve the signal "line clear" at station *III.*, and so forbid the express to pass station *II.*, it becomes necessary to open the aperture at the top of the apparatus at station *II.*, and to change with the finger (without sending currents to station *III.*) the signal "blocked" to "clear." The block section between stations *II.* and *III.* still remain blocked; but, as soon as the express has passed station *I.*, this station, by blocking itself, electrically unblocks station *II.*, and allows the shunted goods train to proceed towards station *I.*, when the usual electrical connection between the three stations is again established.

If it be necessary for trains entering a station to receive a permissive signal at the entrance block station from the platform, the arrangement is adopted as shown at Fig. 6, where two trains are awaiting the "clear" signals which are to be sent from the platform to the entrance block station. In this case there is a magneto-inductor at the platform, and the two block stations, *I.* and *II.*, at either end; the block apparatus is of the usual construction, but has, in addition, the transmitting key, T, which, when pressed down while the handle, H, is turned at the same time, causes an alarm bell, W, to ring at the station-platform, announcing the approach of a train. In order to answer the signal, the magneto-inductor at the platform is also provided with a transmitting key, S, the pressing down of which, while the handle, M, of the inductor is turned, clears the entrance block station, and allows the train to enter. As soon as the train has passed the entrance block station, the signal is again set to "blocked."

Should it be desired that the entering train be announced by a visible signal, as well as by the bell-signal, a block-signal apparatus is placed at the platform. In Fig. 7, which shows an arrangement for this purpose, the platform and both the entrance-instruments show "blocked." Let it be supposed that a train approaches the entrance block station *I.*, the signalman presses down the key, T, simultaneously turning the handle of his inductor, H, and thus rings a bell in the platform apparatus, thereby inquiring whether the down train may enter that station. If the platform is clear, a signal is sent back, ringing a bell at *I.*, and also changing the block signals at the entrance block station and at his own platform into "clear." As soon as the train has passed the entrance block station, *I.*, the signalman puts his standard signal at "danger," produces at his own apparatus the electric signal "line blocked," and at the same time clears the preceding station as usual, thus blocking his own again, and, as a proof for the station master that a train has passed the entrance block station, changing the "clear" signal into "blocked" at the station-master's instrument. Both signals are thus placed at "blocked" again, and remain so until another train approaches that entrance block station.

Fig. 8 shows an arrangement where the block signals begin at the platform of a terminus instead of at the entrance block station. In this case the entrance apparatus is connected with the season block apparatus by two line wires, the second wire leading to a key, T, at the entrance apparatus. All trains leaving the terminus are signalled as usual, and those entering are signalled as in the last case, an arrangement which gives the station-master entire control over the traffic. Block-signal apparatus may also be conveniently used as distant signals between platform and entrance block station, as shown at Fig. 9.

As the use of alternate magneto-electric currents for the production of the simultaneous audible and visible signals, "line clear" and "line blocked," is the important point as regards safety of Messrs. Siemens and Halske's block system, it may be mentioned incidentally that currents of this nature, uninfluenced by atmospheric electricity, are sent from one signal-box to another in a direction opposite to that in which the train is traveling; but it must not be forgotten that there is an accessory part of that block system which, whether working or not working, could not interfere with the safety, and which is actuated by the same induction machines which give the block signals, though independently. Experience has shown it to be useful to warn signalmen when a train has left the preceding block station and is traveling towards them. This information, though produced by the turning of the same induction-coil handle as that for blocking and unblocking the signals, is obtained by the lowering of a separate key, and its working might possibly be interfered with by strong atmospheric currents.

The arrangement for sending warning signals in a forward direction is shown at Fig. 10. P^1 and P^2 are the plungers or contact makers, the depression of which cuts either the up or the down index out of circuit and brings the line wire of either side into direct communication with the magneto-inductor. The latter is so constructed that, of the two currents produced at each revolution of the coil, only one is permitted to enter the line to obtain this result. The spindle of the revolving coil is for a short distance cut in half, one half being taken away and replaced by a piece of insulating material. One contact spring, x, is in communication with either terminal, p^1 or p^2, and receives the current produced during half the revolutions of the coil: that is, when the spring, x, bears against the metallic part of the spindle. The contact spring, x, is, however, in constant metallic contact with either line *via* the springs, s^1 or s^2, when the plungers, T^1 or T^2, are pressed down. The latter contact spring, x, therefore, communicates both currents to either line. The currents of like kind passing by the spring, x, cause a bell to sound at the forward block station, thereby warning the signalman of the approach of a train. By pressing down the plunger, P^1, these currents pass from the magneto-inductor into the up-line, L^1, and, by pressing down P^2, into the down-line, L^2. The course of the single currents being from earth through the magneto-inductor, x, p^1, P^1, L^1, to the forward stations into P^2, M^2, s^1, W^2, through coils of up-bell, W^2, through bobbin of down-line index to earth, the index will not be affected, but the bell will give any number of vibrations corresponding to the manipulation of the magneto-inductor.

As railway telegraph posts are, as a rule, already overloaded with wires, it is a matter of importance not to still further increase their burden; and in this respect, again, Messrs. Siemens & Halske's compares favorably with other systems, as the whole of the block signals for a double line, together with those for giving the intimation that a train has left the preceding block station, are worked by means of a single wire.—*Iron.*

[27080.]—**Electric Bell.**—In Vol. XXII. which you have, there are two separate ways how to make a telegraph instrument, and as for the bell, what could you want more than the article by Mr. Voll in the same Vol., Nos. 558 and 565? If the bell is only to ring once the wire will go to the magnet and back to battery. No platinum brake, &c., will be needed.—BLACKHEATH. 4/7

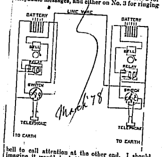
Improved District Telegraph Signal Box.

MR. S. D. FIELD, electrical engineer to the Electrical Construction and Maintenance Company, of San Francisco, Cal., has perfected and patented an improved signal box for District Telegraphs, which has been successfully introduced upon the District Telegraphs in California. June 77

Mr. Field's improvements, for which he has obtained letters patent, consist in providing the apparatus with an answering back signal, for the purpose of enabling the central office to indicate to the sender the receipt and understanding of the call. In each signal box there is a continuation of an alarm or sounding apparatus, consisting of a series of tripping levers, a trigger, and an alarm device, which are so arranged that the alarm can either be set by the act of transmitting a signal, or by an independent action, and afterwards be released by the operator at the central station by shunting a portion of the resistance in a line circuit, increasing the battery power, or reversing the line battery, so as to sound an alarm or signal at the particular box from which a signal has been received. The alarm is connected with the same wire over which is transmitted the signal from the signal box to the central station, but the inventor interposes in the same circuit an electromagnet of low resistance that will not be affected by the electric current in ordinary use upon the line, so that signals can be transmitted over the line after the alarm is set without affecting the electromagnet or alarm mechanism

Another improvement made by Mr. Field is a means of correcting any mistake of the sender of the message, in case the pointer is turned to the wrong call. By a simple contrivance operated by a button, over the box, it is so arranged that in case the pointer is set at the wrong call, the sender, before sending the message, can press on the buttons and bring the pointer back to its place and then reset it properly before putting down the lever which sends the message.

[32312.]—**Electric Bells.**—I send an illustration showing "X. X." how he can connect his bells and telephones by one wire. He must use a relay, as shown. The switch has 3 knobs—Nos. 1, 2, and 3. The handles of both switches must be turned on No. 1 when not in use, waiting calls, both on No. 2 for telephonic messages, and either on No. 3 for ringing



bell to call attention at the other end. I should imagine it would be better to alter your bell to single stroke (the connections make the difference), and the relay will make it continuous. I should make the relay of small size, and to fit in at the back of the switch. If you should not understand the relay, its action is thus:—When handle is turned on No. 3 right-hand switch a current of electricity is sent through wire to the other end, through No. 1 knob to electro-magnet in relay, which draws down the spring until it touches the other wire, which sends a current through the battery, and strikes the bell. I trust the other connections will explain themselves.—C. O. G.

THE AUTOMATIC FIRE BELL.—A correspondent of the *Globe* says that the automatic fire bell is by no means a new idea, as above twelve years ago an electrician fitted one up in his warehouse, which was so sensitive that an unusually hot afternoon was found to set it going. Sept 74

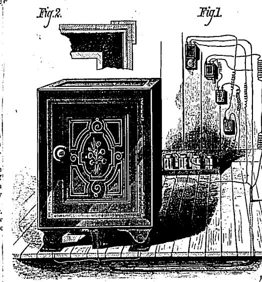
ELECTRO-MAGNETIC BURGLAR ALARM SAFE.

This invention, which is shown in the accompanying engraving, consists in a certain construction and arrangement of safes in connection with magnetic or electric wires, a battery and an alarm apparatus, by which the drilling, forcible breaking or opening as well as removal of safes is prevented.

The safe is constructed in such a way that it is impossible to tamper with it without it gives an alarm, either by drilling, forcible breaking, insertion of key, or by turning the knob of a combination lock, through which the c[illegible] the safe is connected with an inner insulating plate running on all sides and door thereof, or by moving the safe, which stands on plates inserted in the floor; the safe being moved from it will break the circuit of the current, connected with a relay, provided with an anchor, which will fall off, giving an alarm, as soon as the safe is moved, the same being the case if the wires should be cut connecting with the safe. The alarm thus brought into motion will keep on ringing until released, the alarm being provided with circuit breakers, which may be put to rest during the day. The alarm apparatus can be placed in any suitable place about the house, police station, night watchman's room, etc. The safe does not differ in appearance from any other. We are informed that this alarm can also be affixed to old safes.

The wires, which for convenience in the present case are connected with the front of the safe, will, in practice, be connected with the back, where they will be out of the way and out of sight.

This invention was recently patented by Mr. Max Koloseus, 123 East Houston street, New York, from whom furthur particulars may be obtained.



ELECTRO-MAGNETIC BURGLAR ALARM SAFE.

ELECTRIC FIRE ALARM.

Close to the stall of M. D'Arlingcourt is that of M. Leblan, who shows one of the neatest automatic fire indicators we have ever seen. Before describing it, we may remind our readers that quite recently the system of fire alarms so successfully and so extensively adopted in America and in some parts of the Continent has been imported into London. The Exchange Telegraph Company in Cornhill shows some very good fire indicators, so sensitive that the change of temperature caused by the warm breath impinging on the instrument will set the bell ringing in connection with it. The apparatus which M. Leblan has devised is based upon the property which certain bodies, such as felt and wool, possess of acting as good conductors of heat when the heat rays vary by insensible degrees, while offering resistance to quick changes of temperature, as those caused by instantaneous combustion. M. Leblan is in fact the inventor of a new differential thermometer. In its construction he employs zinc, which is a metal having a high coefficient of expansion. The instrument consists of two strong plates of zinc cut from the same sheet and identical as to size, 0·6 meter long by 0·05 meter wide, placed parallel on a wooden pedestal; the ends on one side are firmly fixed, but on the other capable of moving freely. One of the plates is uncovered, and its end free to carry a platinum spring. A binding screw is placed opposite, fixed by an insulated body to the second bar, which is covered throughout its length with a sheath of cloth or felt.

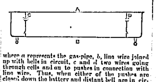
The screw is connected with one of the poles of a battery; the two plates are connected to the other pole, and in the circuit is placed a bell at some point where its sound can easily be heard by the inmates whenever it happens to be sounded. The action of this apparatus is easily seen. If the amount of heat received by the plates is gradual, the expansion of each is equal and the relative position of the platinum spring and contact screw is maintained; but should the development of heat be sudden, the uncovered plate expands at a greater rate than the other, forcing the spring against the screw, thus completing the circuit, when a current at once actuates the bell and gives the alarm.

[36127.]—**Electric Bells.**—Wind on each bobbin as much wire as will make it as thick a layer as the diameter of the core; this will give you a maximum of power. To lacquer the bells heat them so hot as to be too hot to hold, then chuck them and lacquer from centre to edge; binding screws are lacquered in the same manner. For the standard carrying bell either iron or brass will do; brass is the easiest to work. The wire can be wound from a bobbin fixed to back of lathe, and kept rather tight by means of a spring, so that the wire is pulled tight when being wound on, then close up to T have a rod hinged at the bottom with a fork, same height as bobbin, the rod being continued for about 4in., pass the wire through this into bobbin, and you will be able to wind any number of layers quite evenly. Electric bells may be made for any price. We make bells from 6s. 6d. to 60s. each, but of course, so much depends upon quality, that they could be made even at 3s. to 4s. each. I would not advise you to make common stuff. Vendors of rubbish have but a little day.—W. J. LANCASTER.

[36127.]—**Electric Bells.**—(1.) The amounts and sizes of silk covered wire to be used for making coils for electric bells are as follows:—The number of inches indicating the diameters of the respective gongs: for a 2in. gong, 8 yards of No. 26; 2½in., 9 yards No. 26; 3in., 10 yards No. 26; 3½in., 10 yards No. 26; 4in., 11 yards No. 24; 5in., 12 yards No. 22; 6in., 13 yards No. 20. (2.) The bells after being turned and polished receive an electro deposit of nickel or silver, or they may be warmed and lacquered with gold-lacquer in the lathe, screws and other brass fittings are done the same way. (3.) It is immaterial whether the bell support be of iron or brass. (4.) For winding the bobbins quickly and neatly have a steel spindle about ¼in. diameter, fixed in two bearings on uprights on a stand. Cut two pieces of stout brass tube (¼in. common tube) each one inch long, turn each one down taper to one end and put a set-screw in each. Then slide them over the ¼in. spindle so that their thin ends are nearest together. Reels with holes of many different sizes can thus easily be fixed true and wound very easily either in the lathe or by hand by means of a small crank.—WIESENDANGER. Jan 79

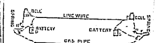
[35202.]—**Electric Bells.**—It is possible to ring two bells with only one wire by having two series of cells, but as this would involve much more expense and trouble than laying a double wire I should advise you to have the double wire and one series of cells.

You can work with one wire if you allow both bells to ring at the same time, and have a battery at each end, or you can so arrange the batteries and bells as to throw battery of one end in circuit with the bell of the other end, and so on, as per rough sketch,



where a represents the gas-pipe, b, line wire joined up with bells in circuit, c and d two wires going through cells and on to pushes in connection with line wire. Thus, when either of the pushes are closed down the battery and distant bell are in circuit, and vice versâ. But as I said before you would require two series of cells.—W. J. LANCASTER.

[35202.]—**Electric Bells.**—I think the subjoined arrangement is simple, and will meet "Edward's" requirements:—Let A and B be the bells at shop and house respectively—connect the line wire with

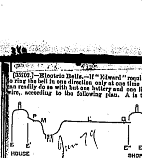


a binding-screw of each bell, as shown. Have a battery at shop and another at house, C and D; connect line-wire also with one pole of each battery; connect the remaining binding screw of each bell with a metallic plate, P and N; connect the remaining poles of batteries, each with metallic plate, R and S. Instead of the ordinary "push" arrange metallic springs at shop and house, as shown at H and K, each permanently connected with gas-pipe, and so placed that when at rest they are in contact with the plates, P and N, respectively. Let the plates, R and S, be so placed that the springs, H and K, when pressed, come into contact with them. It will readily be seen that on pressing the spring, K, the bell, B, is thrown out of circuit, and the battery, C, is thrown into action, ringing the bell, A. Similarly pressure upon the spring, H, throws A out of connection, and by means of the battery D rings B. I have not had much experience with the telephone or electric light, but for electric bells I have been well pleased with No. 20 copper wire, covered with cotton and saturated with paraffin wax. For bells I have been most satisfied with the Léclanché battery.—AMPHIBIAN.

IMPROVED ELECTRIC BELLS.

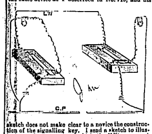
WE have had our attention directed by Messrs. F. Darton & Co., 48, St. John Street, West Smithfield, to their new improved continuous-action bell. The advantage of this over the ordinary bell is that it continues ringing after the door or window is closed, and even when the wires themselves are cut. This appears a great advantage over the old form, as in many cases burglars cut the wires, and so prevent an alarm being effective. In this bell the electric current, passing through the wire, causes a spring to be detached, and thereby places it in short circuit, thus preventing the cutting of the main wire from interfering with the action of the bell. April 78

[35202.]—**Electric Bells.**—If "Edward" requires to ring the bell in one direction only at one time he can readily do so with but one battery and one line wire, according to the following plan. A is the



battery, placed, say, in the house. At P and Q are two small levers, which can be moved so as to put the line wire, L, and the short wire, M, which constitute the poles of the battery, in connection with the earth in two sets of ways. The figure shows the connection in case "Edward" wishes to ring the house bell from the shop. Before leaving the house he brings the lever, P, in connection with the wire which traverses the electro-magnet of the house bell; thus M is brought into connection with the earth at E. Whenever, then, in the shop he presses down the lever, Q, in direction of the arrow he completes the circuit, and the house bell rings. Before leaving the shop he must raise the lever, Q, so as to bring the shop bell into the circuit, and when he returns to the house he can complete the circuit, and cause the shop bell to ring every time he presses down the lever, P.—W. P. H.

[35202.]—**Electric Bells.**—I think something must be wrong with Mr. Lancaster's sketch on page 452, January 10, No. 720. As shewn, when contact is made, both bells are in circuit, and most of the current would go through the near bell, and a portion only (inversely proportional to resistance) through the far bell. "Amphibian" has illustrated the same device as I described in No. 710, and his



sketch does not make clear to a novice the construction of the signalling key. I send a sketch to illustrate my former answer, which the Editor can put in if he thinks enough has not been said.—PLONI ALMONI.

LE BLANC'S FIRE TELL-TALE.—This ingenious fire alarm (for an account of which we are indebted to *Engineering*) is designed to indicate outbreaks of fire on premises. It is so constructed as to be sensitive to sudden rises of temperature, while it is unaffected by slow variations of the same. The sensitive part consists of two expansible plates of sheet zinc about 60 centimetres long and 0·05 centimetres thick, cut from the same piece so as to be isometric, or having an equal expansion. They are doubled into a gutter shape, so as to be more rigid, and are fixed at one end, while being free to expand at the other. One of these is swathed in flannel, and the other is bare to the atmosphere. When the variations of the temperature in the apartment where the tell-tale is placed are sluggish, the flannel round the covered plate will not interfere with its expansion; and both plates, naked and clothed, will expand equally. But when there is a sudden rise of temperature the bared plate will expand the faster. The effect of this is to make it bring a contact screw which it carries into contact with a spring contact carried by the plate, and the circuit being closed an alarm bell is rung. Jan 79

ELECTRICITY IN CHINA.—On Tuesday, 1st Oct., we were entertained with a grand display of torpedoes at "Hsiku," near Tientsin, being the annual inspection of the students of the Imperial Torpedo College by H. E. Li Hung-chang. A straight reach of the main river was selected, about a mile in length, and all boat traffic stopped for the day. The students had been busy for two or three previous days laying down cables, joining up torpedoes, &c; and when H. E. arrived at the appointed time many thousands of spectators had assembled on the banks and house tops commanding a view of the situation. The work carried out was a representation on a minor scale of the defence of the channel at Taku. A chart was drawn out, showing the position of each torpedo, and they were fired in the order given by H. E., at the sounding of a bugle. As the last notes of the bugle died away the first charge exploded, throwing up an immense column of water in the air, to the height of three or four hundred feet; this was immediately followed by five other explosions, forming the outer line of defence. On the next word of command, seven torpedoes were simultaneously fired, throwing up a tremendous body of water and shaking the place as by an earthquake; these were followed by seven torpedoes fired singly; after which contact torpedoes were shown, in which heavy charges of powder were exploded, by a steam-launch striking the circuit-closer moored in mid-stream. The experiments were concluded by an array of five torpedo boats advancing in line, each armed with two fifty-pound spar torpedoes, which wheeling round a flag representing an imaginary enemy's ship, launched their torpedoes and fired at a given signal. The boats rose with the upheaving

stream, and were instantly hidden from view by the large volume of water thrown up.

H. E. the Viceroy congratulated Mr. Betts warmly upon the success of the experiments; and calling up the students of the college awarded official rank to several of them and prizes to all, but as each one of the forty-nine torpedoes fired was the work of one individual student, it was difficult to draw a distinction where all were alike successful. H. E. returned to the Yamên at 6 p.m. Now that the inspection is over, the students will at once commence the erection of the Tientsin-Taku telegraph, and the survey for the Tientsin-Paouting-foo-Peking line will be carried out.—*North China Daily News*, Oct. 9, 1878.

WE have to record the death of Sarah Faraday, widow of Michael Faraday.

FLOOD TELL-TALE.—We learn from the *Moniteur Scientifique* that a new contrivance, invented by U. Camille Gras, for warning towns on the lower reaches of a river of the water level of its upper stream, has recently been tried with success between Laroque-Bouillac and Capdenac, on the river Lot. It consists of a float moored on the surface of the river, and an electric indicator, actuated by the float in such a manner that the needle follows the level of the stream. Indicators may be placed at distant towns, and connected to the float by telegraph. When the river reaches a certain flood level, an alarm bell is rung at these towns, and preparations may be taken against the coming flood. Jan 79

A SIMPLE ELECTRIC ALARUM.

[15138.]—LETTER 15336, p. 564, rather amused me. May I be permitted to point out to Mr. G. H. Mason that in the MECHANIC of Dec. 6th, 1878, p. 327, Letter 34122, I gave a sketch of an electric alarum, making the very same connections as he has, to place the clock in circuit with the bell and battery? Besides which, my arrangement is much more simple than his, as, in mine, all that is necessary is a simple piece of wire, which is bent and placed against the clock dial, at whatever time the hour hand of the clock is required to come in contact with it, and the hand *carries the wire round with it*; whereas, in Mr. Mason's adaptation, without the pointer, B, is released directly the bell begins to ring, it will either spoil, or at least stop, the clock. Besides all this, in my plan it is not necessary to shorten the minute hand of the clock, a process of mutilation which I should think few people would approve. Mechanician.

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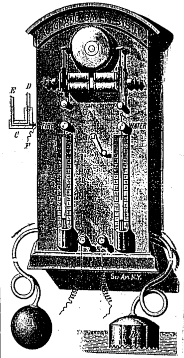
FIRE AND WATER INDICATOR.

We illustrate herewith a novel fire and water indicator and alarm, which is the invention of Col. A. Gerard. It was



AUTOMATIC SAFETY APPARATUS.

recently patented in this country, also in Canada and Europe, and is controlled by the Automatic Safety Company, of No. 40 Charles St., New Orleans, La.

The invention consists in a simple arrangement of devices, by means of which the presence of fire or undue heat or any change of temperature may be indicated or recorded at any distant point. The instrument illustrated is also designed for the detection of the presence of water in the holds of vessels.

The two vertical glass tubes shown below the alarm apparatus, and marked "Fire" and "Water," are similar in their construction. The glass tube, D, is inserted in a metallic piece, C, which extends through the support, and has a passage, E, that communicates, in the case of the fire alarm, with the receiver hollow sphere, A, and in case of the water alarm with the bell or receiver, B, which is inverted upon the floor or surface liable to the incursions of water. Needles enter the tops of the glass tubes and extend downward toward the mercury contained in the lower part of the tubes. These needles are in electrical communication with the alarm bell at the top of the apparatus, and the mercury is in communication with the battery wires, the whole being arranged so that the rising of the mercury beyond the prescribed distance in either tube will complete an electrical circuit and operate the alarm apparatus.

The hollow sphere, A, being placed in any distant apartment, a rise of temperature in the vicinity of the sphere expands the air contained by it, creating a pressure which displaces the mercury in the tubes of the apparatus and gives the alarm. Similarly, when the water rises upon the surface on which rests the bell, B, the air in the bell is displaced, and the mercury in the tube marked "water" rises and completes the electrical circuit and gives the alarm.

The necessity of an invention that will with certainty report leakages or fires on shipboard will be recognized by any one having even a cursory knowledge of shipping, and the simplicity and adaptability of the Gerard system will be apparent to our readers.

This apparatus is applicable to buildings as an indicator of high temperatures or fire, and, placed in a cellar liable to flooding, it indicates the presence of water. It is capable of many other applications, which our space will not permit us to enumerate.

A SIMPLE ELECTRIC ALARUM.

[15396.]—ALTHOUGH electric alarums are not strangers to your pages, I am not aware of having seen so simple an arrangement as that which I venture to introduce to your readers. All that is necessary to transform any common clock into an alarum in connection with an electric bell is, to connect one pole of the battery with the works of the clock (by attaching the wire to one of the screws connected therewith), and the wire from the other pole (having the bell attached) to a movable pointer, whose extremity is capable of different positions on the dial. The first point is easy enough. To accomplish the second: take a flat piece of mahogany or deal, the size of the top of your clock and about ½in. thick; into the side of this piece of wood, A, fix a binding screw, B. To the base of the binding screw (B) attach the wire from your bell, and fasten it to block A. The block may now be placed on the top of the clock and kept in

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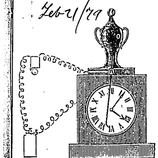

position by an ornament, O. For the pointer bend a knitting-needle (or, better still, a piece of stout brass wire) into the shape represented by P (Fig. 3). Clamp this in the binding screw, B (shown in position).

Now cut the minute hand of the clock, so as to make it shorter than the hour hand.

If you wish to wake at six, clamp the pointer so that the point will be touched as the *hour* hand comes round to six o'clock. Communication between the poles will thus be effected, and the bell will ring until you unclamp the pointer. This, at any rate, insures your getting up, and lessens the risk of taking a second "nap," as often happens with some kinds of alarum. Of course, I am supposing the dial to be a non-conductor, such as enamel or paint.

If the clock be not flat at the top, the block and pointer could be placed beneath the clock.

Geo. H. Mason.

25

BRIGHT'S ELECTRICAL FIRE INDICATOR.

THE electrical fire alarm systems so common in American towns, have never been received with much favour in England. Whether this arises from mere apathy or from the conservatism, for which

Local Government Boards are notorious, it is difficult to say, but the fact remains that although many attempts have been made, but very little, if any, progress has resulted towards introducing any system of electrical or other fire alarms. It is not that such systems have not been shown to be practicable, for many have been exhibited and partially worked with success, but unfortunately, we believe, in no case, where the apparatus has been fitted, has an opportunity arisen for practically demonstrating the utility of the inventions, and for this reason possibly the schemes have been allowed to fall into oblivion.

One of the most recent inventions for effecting the object in view, is that of Mr. E. B. Bright, whose system has recently been fitted up, and had a practical trial, in Glasgow. As this system possesses some decided points of novelty over those hitherto invented, it merits a description.

The chief point of novelty in the apparatus consists in the employment of artificial electrical measures of resistance (or rheostats) for the purpose of making known the locality of the fire; such artificial measures of electrical resistance being used in combination with thermostats or appliances for closing or opening or making a variation in an electrical circuit or circuits by such fire.

The following is a description of the apparatus:—

Fig. 1 is a section, and fig. 2 a side view of a thermostat, consisting of a metallic box inside of which is fixed a curved band *c*, formed of two metals, such as platinum and brass, which expand unequally under the influence of heat. Opposite the end of the band *c*, is an insulated screw *d*, which can be so adjusted that the addition of any given amount of heat will, by its effect upon the band, bring the end of the band *c* into contact with the end of the screw terminal *d*. The terminal *e* is connected with the metallic box, and therefore with the curved band *c*.

Fig. 3 is a general plan, shewing the apparatus employed at the fire brigade station or other place to which a warning is to be given, and also a diagram of the electrical circuits in connection with the thermostats and rheostats by which the locality whence the warning proceeds is indicated.

Fig. 4 is a side view of the indicating apparatus at the fire brigade station or other place to which a warning is to be given.

The series of circles marked with numbers varying from 5 to 15 included by the bracket *f*, represents a number of rheostats placed in the various buildings or places from which an alarm may be given. They are connected together by a line wire *g*, extending to the fire brigade station, as shewn by the diagram, which wire is there joined to one side of the differential coil *h*, and thence through the alarum *i* to one pole of the battery *j*. The same pole of the battery *j* is also connected through the alarum, to the other side of the differential coil *h*, and thence to the end of a series of rheostats fixed round a circle in the indicating apparatus at the station, which are also marked on the plan, with numbers varying from 5 to 15, indicating electrical resistances corresponding with those of the rheostats included in the bracket *f*, before described.

By means of the handle *k* the arm *l* with a spring *m* can be moved over a series of metallic plates *n*, *n*,

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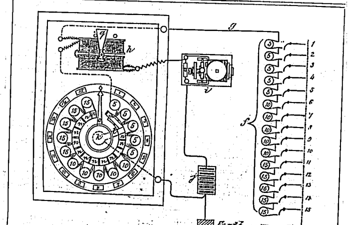


FIG. 3.

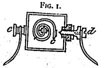


FIG. 1.

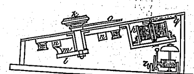


Fig. 4.

FIG. 2.

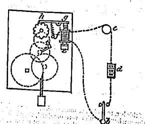


FIG. 5.

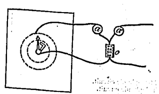


FIG. 6.

27

which are insulated from each other, and connected consecutively with the rheostats, as shown on the plan. The arm *l* and spring *m* are connected with the other pole of the battery *j*, which is also connected to the earth. To the handle *k* is attached a pointer *o*, moving outside the dial of the instrument over a circle of figures corresponding to the number of rheostats in the circuit.

Connected to one end of each of the rheostats included in bracket *f*, is a thermostat, the insulated screw of which *d* (figs. 1 and 2), is connected to the earth. On an undue increase of heat taking place, the band *c* (figs. 1 and 2) of the thermostat makes contact with the insulated screw *d* (figs. 1 and 2), and thus completes the circuit with the battery *j*, as shewn by the dotted line *p*.

The electric current from the battery *j* passing thus through the alarum *i* rings it, and also passing through one side of the differential coil *h*, deflects the disc *g*, which is fixed to the axle of a permanent magnet contained within the coil *h*. On the alarm being thus given, the person summoned moves the handle *k* round the dial of the instrument, and as soon as the spring *m* comes into contact with the particular plate *n* connected with the rheostat that corresponds with the line rheostat which has been put to earth by the thermostat at the point from which the alarm is given, the electrical balance of the differential coil *h* is re-established, and the disc *g* returns to zero.

The pointer *o* indicates the number on the dial of the station instrument which corresponds with the number of the place on the station list from which the alarm emanates.

In the plan of the apparatus, as drawn in figs. 3, 4, and 5, only fifteen protected places are shewn, but a larger or smaller number can, of course, be connected.

Figs. 5 and 6 shew a train of clockwork brought into action by a differential relay, which moves round the contact maker in connection with the station rheostats in case of fire, until the balance between the station rheostats and the line rheostats is re-established, when the indicating hand attached to the axle of the contact maker (as in the apparatus worked by hand shown at fig. 3) points to the number showing the locality of the fire. In this figure *a*, a^1, are the differential coils of the relay; *b* is the contact maker influenced by them; *c* is the battery of the line and station circuit, and *d* the battery of the local relay circuit; *e* is the coil of the alarum, and *f* is an electro-magnet actuating an armature *g*, and thus releasing the escapement or detent h^1.

ap. 79

FIELD TELEGRAPHS.—Lord Chelmsford has asked for a field telegraph to be sent out to him; also electric lights for his encampments. The Ordnance Department at Woolwich have accordingly forwarded a fully equipped wire-waggon-and-barrow apparatus to the *Loanda*, now taking in cargo at the Royal Arsenal. The waggon consists of a strong but simple framework on ordinary wheels, supporting on revolving spindles six drums or reels of telegraphic wire, the movement of a lever and clutch causing the vehicle either to lay or pick up the wire as it passes over the ground. The barrow carries a single drum, and is mounted on wheels only 2 ft. high, with a 2 ft. track. It resembles an ordinary hose-reel, and is so light that it can be run over the field by one or two men, and can, therefore be of use during an action. Each drum carries 133 lbs. of wire. The waggon carries telegraph poles, a ladder and tools for constructing an "air line." The poles consist of iron tubes, in lengths of about ten feet, uniting by a bayonet joint and secured by three guy lines. A few sets of electric lighting apparatus and portable engines will also be sent out. The force under his command does not seem even to have been provided with Mance heliographs.

[37215.]—Electric Bells.—The bells may be turned in the usual way, and faced as true as the turning tool will leave them, then with a smooth file followed by emery paper a good surface is obtained; and if you like you may use the burnisher, but this makes the work common in appearance; the better way is to polish with a piece of thick cloth, oil, and rottenstone, then lacquer with either pale gold or gold lacquer, or if you silver the bells the lacquer should be quite colourless. The bronzed work should be done with bichloride of platinum for good work, then blackleaded and lacquered with colourless lacquer.—W. J. LANCASTER.

[37216.]—Science Examination.—

78

The Underground Telegraphs in Germany.

[*Berlin correspondence of the London Times.*]

The Reichstag has voted the sum of 1,830,000 marks for the further construction of subterranean telegraph wires. Germany will soon be intersected with a complete net-work of this invisible and inaccessible means of communication, which no thunderstorm can destroy and no roving enemy can readily cut. In 1875 it was first proposed to connect by underground cables all the chief centers of commerce and industry in the Empire, all the fortresses and places of arms, the cost being reckoned at about 31,000,000 marks (£1,700,000). The first experiment of the kind was made by the sinking of a wire between Berlin and Halle, which has been subjected to the strictest scientific tests, and yielded highly satisfactory results, not a single interruption being recorded. When the whole work is ended the German Empire will be crossed by two great main cables, stretching from Königsberg, in the north, to Strasburg, in the south, and from Hamburg, in the northwest, to Ratisbon, in the southeast, intersecting at Berlin. Strasburg will also be connected with Metz. In addition, another sunken wire will curve away up from Strasburg through Cologne to Hamburg, while Ratisbon and Königsberg will similarly be connected. An underground wire will also bind together Berlin, Dresden, Stuttgart and Munich, communicating with a fifth main cable passing through South Germany. In three years, it is said, the whole network thus planned by Dr. Stephan, the Postmaster General, will be completed. The half is already finished. An underground cable now connects Berlin, Halle, Leipsic, Cassel, Frankfort, Mayence, Mannheim, Carlsruhe, Rastadt and Strasburg; another line runs from Berlin, through Magdeburg, Brunswick, Hanover, Münster, Düsseldorf and Barmen-Elberfeld to Cologne, while Berlin and Hamburg are also connected, throwing out branch lines to Kiel and Cuxhaven, to Bremen and Emden, thus joining the North Sea cable communicating with England and America. A sum of 18,030,000 marks (£900,000) has already been spent on this subterranean enterprise, and the money now voted will be employed in connecting the towns and harbors along the Baltic shore for the furtherance of commerce and coast defense—a work, said the Postmaster General, which should be proceeded with as speedily as possible.

A fire-telegraph system, with fifty-eight kilometres of line, is now established at Munich. The wire used is patent cast steel from Cologne, mostly 3·1 mm. in diameter, and stretched over the houses in spans of not more than 200 metres. The lines over the houses are found much less liable to disturbance than those fixed to the fronts of houses. A thoroughly organised system of

May 79

MECHANIC AND WORLD OF SCIEN[CE]

defence against fire is in operation at the extensive steel works of Krupp, at Essen.

Thomas Alvah Edison and George Harrington against the Western Union Telegraph Company.

This case, which is an application on the part of the plaintiffs for an injunction against the Western Union Telegraph Company, restraining the latter from the use of the duplex and quadruplex telegraph transmitters, which Edison invented in 1875, was argued in the District Supreme Court, at Washington, before Judge James, on the plea of the defendants, Feb. 27th. Messrs. J. H. Ashford and Matt. H. Carpenter appeared in support of the plea, and Messrs. J. H. B. Latrobe and R. D. Mussey for the bill. The former argued that the pendency of a similar suit in the United States Circuit Court at New York barred the one at Washington, and counsel for Edison that the two suits were compatible, being for infringements of his patents in different places. The suit arises from Edison's having contracted to sell the patent for $25,000 and $233 royalty on each circuit to the company, on which he received $5,000 on account, and afterward, discovering that, in a partnership which he had concluded with Harrington, in 1870, he had agreed not to sell his inventions without the latter's consent. The company had, in the mean time, put the transmitters into use, and retained them, announcing their readiness to perform the contract. The Court took the papers and reserved its decision, after giving the defendants leave to file the record of the New York suit in this case.

THE HALL AUTOMATIC ELECTRIC RAILROAD SIGNALS.*

The "block system" has been generally acknowledged by competent authorities as the safest system for working railroad signals and conducting traffic. Notwithstanding this fact, it is used to only a very limited extent on even our busiest railroads.

If we inquire into the reason for this, we shall find that it is largely due to the imperfection of most of the appliances which are used in operating this system, and that they do not completely eliminate errors and thus make it practically infallible. Late improvements in these appliances—such as the apparatus of Messrs. Saxby and Farmer, known as the "union of the block and interlocking systems" and the "electro-semaphores" used on some of the French railroads, have contributed greatly toward perfection, and thus, it is thought, should have overcome the objection to the introduction of the block system.

There is, however, still another and probably even stronger objection, which is purely economical. New appliances require an outlay of capital; and the cost of maintaining and operating them would swell considerably the working expenses of a railroad. It is this last expense to which the managers of our roads are mostly averse. In Europe the great number of watchmen employed on railroads—as, for instance, in France, in connection with electro-semaphores—are advantageously used to attend to the signals also; but the small number of *employés* of this class on our roads would make it necessary to engage new men for this work.

We will not discuss here whether this extra expense would be repaid in the end, but attention will be called to the efforts of American inventors to annul this obstacle in the progress of the system by devising such appliances as will act automatically without the intervention of attendants.

Such automatic signals, invented by Mr. Thos. S. Hall, are already in operation on some of the New England railroads. They combine the block with the interlocking system, and have been worked out with remarkable inventive skill.

The manner in which they are operated being different from that of other signals purporting to have the same object, it needs to be understood before the mechanism of the apparatus can be clearly comprehended. Each line is divided into sections, at the entrance of which are erected two signals, one called the "danger signal," and the other the "safety signal." These signals are of the disc form, visible when displayed through circular openings made in boxes in which they are enclosed. They are placed on posts of sufficient height to be conspicuous. The "danger signal" is placed immediately at the entrance to a section, and the "safety signal" some 1,000 feet further. The disc of the first is red, and that of the second is blue; but this difference is not essential to the system, and both of them can be of the same colour. From the difference in names of the two signals, it should not be concluded that the one when displayed means *danger*, while the other when displayed means *safety*, as either of them in this position is the signal of danger, and thus stops the advance of a train. The name of "safety signal" was given to the one because it gives the means of a constant control of the working order of the apparatus, which must be observed by the locomotive driver. Any derangement of the signals, being thus easily discovered by the first train passing, would be reported at the nearest station—the train having passed over the section cautiously—and the damage could be speedily repaired.

The signals are acted on by electric currents, being connected by wires with a battery. At all times, when one of the two signals is displayed, the other is hidden from view—the change of the position of one of the signals causing the reversal of the other. The way in which this is effected will be described below.

An examination of the system will show that the signals, say, at C and D on the "up line," and at M and N on the "down line," have their "danger signals" hidden, and the "safety signals" displayed. This position of the signals indicates that the corresponding sections are not occupied, and that trains may therefore run over them. The signals at B have just the reverse position, in consequence of the section B C being occupied by a train. If a train on the section A B were now to arrive at B, it would find that the "danger signal"—which is the first which would be seen—was displayed, and thus the section B C would be blocked. But the first train, which then occupies the section B C, arriving at C, finds the "danger signal" hidden from view; it therefore advances and enters the section C D. At the moment when the train enters this new section, the following action occurs: The "danger signal" at C displays itself, and the change of its position causes a change of position of the "safety signal." The train arriving next in sight of the "safety signal," and finding it hidden from view, does not stop, but proceeds further. This position of the "safety signal" indicates to the engineman that the "danger signal" behind him has been displayed to protect his train. Should he, however, find the "safety signal" displayed on his approach to it, he would know that something was wrong with the apparatus, and would proceed cautiously over this section, reporting the derangement at the nearest station.

This reversal of the signals is effected by means of an electric current, closed by the action of a wheel of the passing train which depresses a lever of a "track-instrument." This track-instrument is placed in close proximity to the "danger-signal." Although the train has entered the section C D the section B C remains still closed by the undisturbed position of the signals at B, and it is not until the train reaches a second track-instrument, which is placed about 1,600 feet from C, that a circuit acting on the signals at B reverses their position, and thus opens the section B C for traffic.

It will be noted here that the train is already well protected by the signals from the rear, when the section behind is opened for a succeeding train.

The same operation continues along the whole line as the train proceeds from section to section.

Hall's signals can easily be applied to a depôt which possesses several switches, side and cross-over tracks, and a roadway crossing. On either track, about a mile each way from the station, is seen a track instrument marked "Strikes bell at road crossing." A train passing over one of these instruments closes a circuit which strikes an electric bell at the watchman's house at the road crossing, notifying the watchman of the approach of a train, and he then closes the roadway against ordinary traffic. The use of the locomotive steam whistle is thus replaced by an electric bell. The approach to the depôt is protected by two distant signals, the "danger" and the "safety signals," in exactly the same manner as the entrance to a block section on the open road, as described above. But, it being advisable that the station agent and the passengers be notified in time of the approach of a train, the reversal of the signals from *safety* to *danger* causes an electric bell, placed at the station, to strike. Each line has a separate bell. These bells, being of distinctive tones, indicate also the directions from which the trains approach. This is another instance of the suppression of the use of the steam whistle.

The track instruments which open the way to the depôt are, placed at the other extremities of the depôt, as shown in the plan.

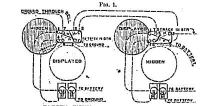
To enable the station agent to operate the distant signals from the station—the necessity of which may sometimes arise, as, for instance, when the passengers are crossing the "up line" to take the "down line" train, in which case the "up line" should be closed—a hand instrument is placed there, with which the signals can be set either at *danger* or *safety*. The instrument is locked, and the key of it is in the possession of the agent.

The switches are interlocked with the distant signals, by means of "switch instruments," in such manner that whenever a switch is set wrong to one of the main lines, the respective signals will display *danger*—if they were not previously in that position—and remain so, unaffected either by the track or the hand instrument, until the switch is set back for the main line, when the signals will be set automatically to safety. Should a switch be placed at a long distance behind the station, in order not to prevent a train from approaching the station, a special switch signal, operated by the instrument of this distant switch, may be erected.

The diagram shows the connection of wires of the two signals, "safety" and "danger," which constitute one signal post. The disc of the "danger" signal is shown displayed, while the disc of the "safety" signal is hidden (both being, however, in the raised position). Such position of the signals indicates that the section of the road which is guarded by them, is occupied by a train. The signals remain in this position until the train passes over a track instrument.

Every track instrument connects the "ground wire" with the signal apparatus; but that track instrument which *opens* a section connects with the "safety signal" apparatus—namely, with its connector, 2 (see Fig. 1), and that track instrument which *closes* a section connects with the "danger signal" apparatus—namely, with its connector.

Fig. 1.



If, therefore, in the position of signals shown in the diagram, the train passes over a track instrument that *opens* a section, an electric current is closed which runs from the ground through the track instrument, the safety signal—namely, its connector 2, circuit-closer H, connector 1, electro-magnet N N, and hence through the battery to the ground again, or *vice versâ*. (The connection of wires is indicated in the diagram with dotted lines.) As the electro-magnet, N N, becomes magnetised, it produces a fall of the "safety signal" discs which will then take the displayed position shown in dotted lines. At the same time the circuit-closer, H, will swing, or switch off, from the position indicated by a full line into the position H', shown by a broken line, which change of position will break the circuit between the connectors 2 and 1, destroying the vitality of the electro-magnet N N. The action of the electro-magnet is thus momentary, and as soon as the stroke of one wheel of a train on the "track instrument" has produced the change, all subsequent strokes are without effect; hence, that portion of the apparatus which contains the circuit-closer H has been called by the inventor the "cut-out." At the same time that this is accomplished, the spring circuit-closer, T, of the "safety-signal," by the action of a finger, P, closes another current, which runs from the ground through connector 6, the circuit-closer T, connector 5, to the danger signal, namely, through its connector 2, circuit-closer H, connector 1, to the electro-magnet N N, and thence through the battery to the ground again, or *vice versâ*. This circuit causes the fall of the disc of the "danger" signal, in which position it is hidden. The circuit-closer H of the "danger" signal will then take the position shown by the dotted line, breaking the circuit, but producing no other effect. The position of both the signals will thus be reversed and the section will be opened for traffic. If a train should now enter upon this section, the track instrument which *closes* the section would be struck by the wheel, and cause a current to pass from the ground through the track instrument to the "danger signal," namely, through its connector 3, the circuit-closer in the position H', connector 4, to the electro-magnet M M, and thence through the battery to the ground again, or *vice versâ*. This would cause the disc of the danger-signal to rise again in the displayed position, and the circuit-closer to take the position shown at H. As soon as this is accomplished the spring-circuit-closer T of the "danger signal" would close momentarily, completing a circuit that passes from the battery through connector 6, circuit-closer T, connector 5, to the connector 3 of the "safety signal," then through its circuit-closer in the position H' to connector 4, then to the electro-magnet M M, and thence through the ground to the battery again. The disc of the "safety" signal will rise, therefore, into its hidden position. The section of the road will thus be closed again for traffic until the operation described at first is repeated.

If the signals belong to a depôt section, the apparatus of the safety signal is provided with another spring circuit-closer, T', which, when the disc rises, is closed and completes a circuit passing from battery through connector 8, circuit-closer T', connector 7, and thence through a bell (placed at the station) and the ground to the battery again, or *vice versâ*. Thus the approach of a train is announced at the station. In this manner the signals are operated by the movements of the trains themselves.

The switch interlocking instrument consists of a lever, L, pivoted at P P in a casting, G, the lower portion of which is shown broken off, but which resembles the casting of the track instrument, and is likewise bolted to a cross-tie of the road. The lower end of the lever is connected with the switch-rails by a rod in such manner that when the switch is being moved the lever L swings on its pivot, taking a position indicated by the centre-lines *l l* or *l' l'*, Fig. 2. While the switch is set for the main line the lever L has the vertical position, as shown in the engraving. The upper end of the lever is provided with two cams, *b* and *b'* (Fig. 2). The casting G has on its top a cover, C, on which are attached two insulating wooden blocks, A and B, carrying six metallic plates with connectors, marked 1 to 6. Three spring circuit-closers, *a*, *c*, *e*, serve to effect closures, or a breaking-off of the electric currents between the connectors; the circuit-closer *a*, between connectors 1 and 2, the circuit-closer *c*, between connectors 3 and 4, and the circuit-closer *e*, between connectors 5 and 6. They are operated by means of the following mechanism, and in the following manner:—

Fig. 2.

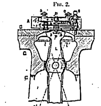
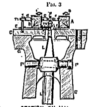


Fig. 3



Between the circuit-closers *c* and *e*, in the centre of the machine, is a pin, *p*, which is held by one end of the rocking-arm, *k*, the other end of which is pivoted by a stud, *o*, around which

* Abstracted from the *American Railroad Gazette*.

THE RAILROAD SIGNALS NOW USED.

[From the Eleventh Annual Report of the Massachusetts Railroad Commissioners.]

RESOLVE IN RELATION TO THE USE OF SIGNALS ON RAILROADS.

Resolved, That the Board of Railroad Commissioners be instructed to investigate the subject of railroad signals, and to report the result of their investigation to the several railroad corporations in this Commonwealth, and to the next General Court. (Resolves, 1879, chap. 24.)

In conformity with this resolve, the Board gave extensive notice of public hearings, and have examined many models, and a greater number of working signals, on the railroads of this and other States. The great importance of the subject, and the attention given to it by railroad managers, together with its relation to other matters now under consideration, have induced the board to place their views, in the body of the report.

BLOCK AND INTERLOCKING SYSTEM.

There can be no doubt that, for security from rear collisions, and from accidents occurring by reason of misplaced switches or open draw-bridges, the block system carried out by interlocking switches and signals comes nearer to insuring immunity from accident than any other known device. The block system, long used in England, and now brought almost to perfection by interlocking devices, is so called because under it each section of road is "blocked" by signals against the entrance of a train while that section is occupied by another train. Improving on the former system, which only provided for an interval of time between successive trains, the block system secured an interval of space. Under it a railroad was divided into telegraphic sections. Before a train could start from the first station, a signal was sent from the first to the second, and a favorable reply was received; then a signal was made for the train to leave station one, and at the same time station two was notified of the fact; this notification was acknowledged, and the section was "blocked" by a signal showing that it was occupied. When the train reached station two, a signal was sent to station one that the line was clear, and the "block" was taken off. Of course, if the train met with an accident, or if it was delayed in reaching the second station, the section continued to be blocked, and no other train entered it until a signal from the second station gave notice that the danger had ceased. And the same precautions guarded every section throughout the line.

THE INTERLOCKING OF SWITCHES AND SIGNALS,

combined with the block system, not only secures each section from the entrance of a train while it is already occupied, but also blocks the section for any train while the track is broken by the throwing of a switch, or by the opening of a draw-bridge, thus removing these causes of numerous disasters, while it allows a vast increase in the number of trains.

The method, in brief, is by the use of levers, operating switches and signals, so interlocked that a signal of safety cannot be given while danger exists, and a danger cannot exist until after it has been signaled. In other words, the operator cannot, by negligence or forgetfulness, or even from malice, create a danger or suffer it to exist until he has signaled it afar off to any approaching train. He cannot open a switch before setting a signal at danger; having opened a switch, he cannot leave a signal at safety; he cannot set the signal at safety before closing the switch; he cannot leave the switch half closed without giving a signal of danger. All these four errors, each of which has cost many lives, are made impossible in a section of road guarded by this system. And the boast is not extravagant that, for this purpose, the working of signals is not trusted to the intelligence or to the fidelity of a man, but that each man becomes part of an unerring machine in which his will ceases to operate, and he must act in accordance with the principles of its mechanism.

Mr. Barry, in his work on railway appliances, gives a strong illustration of the perfection to which mechanical provisions for safety have been carried. At Cannon street station in London 70 switch and signal levers are placed in one signal house, making millions of combinations possible, if they were not interlocked. Of these combinations only 808 are safe. Yet a stranger blindfolded or blind, handling these levers at random, cannot produce a condition of danger. He could stop trains and hinder business, but he could not create a possibility of danger without signaling it in advance.

More than this—because the pulling of the wrong levers, although not causing immediate accidents, does strain the machine and thus might lead to the unlocking of the levers, with consequent disaster; therefore, the attempt and bare idea of pulling the wrong lever is checked by mechanical means, and the uncertain will of man is subordinated to the perfect mechanism of this device.

In operating this apparatus two systems of signals are used, one near the cabin or tower of the operator, and one at a distance sufficient to enable a train to be stopped after the signal is seen and before entering on the blocked section. The semaphore is used by day for a signal, as being the one distinguishable at a greater distance than any other form. At night colored lights are used. Mechanical means may be employed for short distances; electricity serves for long distances. To supplement the signal, if it should be obscured by fog or darkness, a "contact bar" is sometimes used which, with the danger signal, assumes a horizontal position, and, by striking the cab of the locomotive, gives a warning somewhat like that given by the bridge guards, which strike the person who is exposed on a freight car.

The working of this system for draw-bridges is the same as for switches. The draw cannot be opened until the signal for danger has been set. The signal of safety cannot be given until the draw has been closed and actually locked.

By uniting the interlocking device with the block system it becomes impossible to telegraph safety from one signal station to the station next in the rear until all the switches are in a safe position for a coming train. It is impossible to move switches so as to allow access from a siding to a track which has been telegraphed as safe for a coming train. It is impossible to so move the switches, or any of them, after the line has been telegraphed to be blocked. It is impossible for a train to enter a section until its coming has been announced by telegraph, for the signal to enter cannot be given until a signal announcing its approach has been received. The signal which permits entrance into a section cannot be given without the concurrence of signal men at both ends of the section. The starting signal is reset at danger by machinery behind every train. The signal that the line is blocked must be given from the station in advance to the station in the rear.

This summary, in substance, is borrowed from a description of the combination of the Toucey and Buchanan with the Saxby and Farmer devices, which, aided by some subsidiary inventions, are now in use on a portion of the Pennsylvania Railroad and on the Metropolitan Elevated Railroad in New York, as well as elsewhere.

The ingenious device of David Rousseau, involving the same principles and accomplishing the same end, may be seen at the New York Grand Central depot. The members of the board have seen the operation of these inventions at these points, and their daily working vindicates the high claim made on their behalf. It will be a happy day for travelers when this system, in all its completeness, has been universally adopted on American railroads.

But the block system, as operated with interlocking devices in England and France, and as used with additional improvements on portions of American roads, requires a large body of skilled and well-paid men. For an unskilled operator, although he could not cause danger, would cause delay and difficulty. Our inventors, therefore, have tried to supply its place by automatic signals, guarding a road and giving warning of danger without the constant intervention of man. And it is claimed by some of them that their inventions are not only more economical than the English system, but that they are safer. In the language of one of these inventors: "My device is better than a man, for it is always on hand; it never sleeps and it never drinks."

As a preliminary remark to a discussion of automatic signals, it may be observed that it is a requisite of any system that the normal conditions of its signals should indicate danger, so that in case of any derangement of apparatus, accidental or intentional, warning will be given. Thus, failure to act will at most stop or check the movement of a train. It will never cause a disaster. A device that fails in this particular fails at the outset. It is also absolutely requisite that the danger signal should be given far in advance of the point of danger. A signal displayed at or near the point of danger is utterly insufficient and unsatisfactory.

HALL'S ELECTRIC SIGNAL

is the best known and most widely used. He employs an open circuit, and the current which keeps his signals set at safety is transmitted over wires. This current, being broken by an engine entering a section and touching a circuit closer, sets the signal at danger.

1. As a safeguard from rear collisions, theoretically at least, it approaches perfection. The danger signals are set a mile or less apart, and a red disk shows that a section is occupied. A secondary signal, sometimes called a tell-tale, is placed a thousand feet in advance of the danger signal, and informs the engineer whether the danger signal behind him has been set. When the engine passes out of a section, it sets the signal of safety for that section. If the current ceases to work from any cause, a signal of danger will be given. But absolute perfection has not yet been obtained in the construction of the apparatus; and the passage of a train sometimes fails to set the signal of danger; yet, in that case, the tell-tale will indicate danger. And so it cannot happen that both signals belonging to a pair will indicate safety when danger ought to be announced.

2. Station agents, by a separate device, can arrest the progress of a train at a distance of half a mile by a signal of danger.

3. The connection of switches with this system makes it impossible to open a switch so connected without blocking the track by a signal. This occurs at a distance of two thousand feet, more or less; and at the same time a bell rings at the switch, and continues to ring until the switch is closed.

4. The application of this system to draw-bridges appears to secure perfect safety. It is impossible to open a draw-bridge without blocking the track by a distant signal; and, if the engineer fails to see or recklessly disregards the blocking signal, then another signal will arrest his progress—a mechanical drop, constructed of heavy plank, placed 2,000 ft. from the draw, and so arranged that it falls by gravity when the draw is opened; and, if the engineer still presses on, his locomotive is sure to lose its smoke-stack, and he yet has time to check his train and escape disaster. The working of this device was curiously illustrated when it was first used on a road in New York; for the train men, having a prejudice against it as a novelty, determined to disregard it; and more than one engineer, bringing in his locomotive without a smoke-stack, gave the best evidence of his own recklessness and of the merits of the invention. Now that draw is opened 130 times a day, and it is approached without fear of accident. Two other adjuncts furnish additional safeguards in approaching a draw-bridge guarded by Hall's signals—a bell ringing at the distance of a mile when the draw-bridge is opened, and a signal given to the bridge-tender if the train enters the blocked section.

5. The notice given to passengers and agents at stations, by bells differing in tone for "up" and "down" trains, announcing the approach of a train, is convenient, and tends to prevent accidents. For its purpose it is a perfect device, while it saves the great annoyance of whistling.

6. Highway crossings at grade are guarded by a bell or gong placed at the crossing, which begins to ring when a train approaches within half a mile, and continues to sound until the train has passed. This calls the attention of the flagman or gate-keeper to his duty. And if the sound were loud enough, it would arrest the attention of travelers and warn them of the coming danger. Some device of this kind has been heretofore urged by this board, and their views are repeated in their report on the Lincoln accident (Appendix E). With such an appliance, giving an alarm sufficient to command attention and always in working order, there would be absolutely no excuse for an accident at a crossing, unless it happened to be a man blind as well as deaf; for not only does the bell sound, but a signal to stop is displayed to the eye automatically while the danger continues.

But such a device, in order to be depended upon, must be without the possibility of failure, and neither in theory nor in practice can this be said of Mr. Hall's crossing-signal. The ringing is done by the positive action of electricity put in operation by the passing of a train. If the apparatus is out of order, no current is produced and no warning is given. The principle that danger should be indicated, unless something positive happens to prevent it, is not carried out in this part of Mr. Hall's invention. And in fact we learn that such an apparatus, placed within the limits of Boston, does occasionally fail to announce a coming train. Its use, therefore, is only auxiliary, and it will not, as it now exists, allow railroad managers to dispense with other safeguards at highway crossings.

The objections urged against Mr. Hall's block or track and switch signals, apart from their cost, are mainly these:

(1.) It is said that they are so delicate and complicated that they often fail. This, to be sure, when the failure is of electric current, does not directly result in an accident. It only delays a train. Each double-track road has orders directing the time of delay on seeing the signal of danger—a time necessarily brief, say one minute—and after this the train pro-

sufficient to make it understood how this new distilling furnace works. An iron plate reservoir, closed by a hydraulic jointed cover, receives a charge of coal sufficient for several hours' distillation. This reservoir ends at its lower part in a conical orifice, which empties into a rectangular chamber. When the coal reaches the latter, it is carried up in a very regular and uniform manner into the distilling apparatus by means of a chain and buckets. The distilling apparatus consists of a vessel made of cast iron or refractory clay, closed by a cover, which is provided with an opening. Within the interior of this vessel there revolves very slowly a circular plate mounted on a vertical axis. The coal brought up by the chain and buckets falls upon the plate through the upper orifice and is carried along with it until it meets a partition, which stops it and directs it toward the aperture, through which it falls into the receiver. The vessel which serves as a retort is heated by a coke or coal fire

pled car remained on the main track. A passenger train afterward left the station and came in collision with this car. Fortunately, the result was not serious; but it illustrates a danger against which Mr. Hall's signals do not profess to guard.

(4.) So it is said that a train on a guarded section, followed by another train proceeding with caution, would, on passing off, set the signal of safety. The second train breaking down from some defect of wheel or like cause, would remain as an obstacle and possible cause of collision with a third train coming on the section with the assurance of a clear track given by the signal. This, however, could never occur unless the second train were allowed to enter a blocked section, nor without gross carelessness on the part of those in charge of that train in neglecting to flag the section.

THE UNION ELECTRIC SIGNAL,

hitherto little tried in actual working, professes to do away with all these objections and to guard against all the dangers which Mr. Hall leaves unguarded. Its fundamental difference from his system is that it uses a closed circuit, with an electric current moving through the rails; and this current holds the signal at safety, from which it is moved to danger by mechanical means whenever the current is checked, whether by the dangers intended to be guarded against or by some accident to the apparatus. Thus, in all its operations (as in most of Mr. Hall's) a failure to work gives warning of danger, but no failure can entice a train into peril. The circuit through the rails is made more effective by wires connecting each rail with the next, and firmly fastened at every joint. This was found necessary because the oxidization of the rails interrupted their conducting power. Each section is insulated by the use of vulcanized fiber. This seems to be effectual. The mechanical means by which the signal is given in case of a broken current is a simple clockweight, so arranged that it runs for several days, giving passage for 600 trains before it runs down. The current is produced by a battery, and in cold weather a kerosene lamp, burning for a week at a time, is used to keep the liquid from freezing.

When a section of road is guarded by this device, the entrance of a locomotive breaks the current simply by placing its wheels upon the conducting rails, and thereupon visible signals of danger are given, and when the train approaches a station or crossing a warning bell is rung. So excellent is its working that a piece of wire laid across the rails breaks the current and sets the signal of danger; and a stray goat, dragging his chain after him across the track of the Providence Railroad, recently gave the alarm as of a coming train to the gateman at Forest Hill crossing. A secondary or tell-tale signal, in this system, informs the engineer at once whether or not his train has given warning. And station agents have the means of warning a train that is entering on a blocked track. This device is considerably cheaper than Mr. Hall's, and it is claimed that, being simpler, it is less likely to be out of order. But it certainly has these more important advantages:

(1.) As a crossing signal it indicates danger in case of any accident to the apparatus. The failure of a battery, the breaking of the apparatus by accident or design, would of itself give an alarm, while in such case, as has been said, the Hall device would cease to work and trains would pass without warning. It is claimed also that it has this incidental advantage: Under it the bell is sounded by mechanical means, which are released by breaking the electrical current. And so the ringing may be done more powerfully than when it is effected by the direct power of electricity, which is variable, and which, as practically used, is supposed to be feebler than the cheap mechanical power applied by clock motion. But the soundness of this claim has not been demonstrated by any exhibition made to this board. And no crossing signal of this system has yet been exhibited which seems calculated to arrest the traveler's attention as thoroughly and certainly as it should.

(2.) The breaking or displacement of a rail, by interrupting the current of electricity, gives a signal of danger, provided the displacement of the portions of the rail is sufficient to cause such interruption.

(3.) It indicates the presence of a car on the track by whatever means it came there.

The invention has not been used nearly as much as Mr. Hall's. Its proprietors, therefore, cannot refer to so many witnesses as to its working. Probably it is just to add that, for the same reason, there may have been fewer criticisms on its defects. As has been suggested before, there seems to be this advantage in using a closed circuit, that it requires less from electricity. The labor of this system is done by gravitation, and electric force is only used to control it. Electricians are accustomed to say: "The less you ask of electricity the more sure you are to get what you want." In the present state of science this is no doubt true.

Among the possibilities of failure with this signal is neglect to wind up the weight, which would prevent any signal from being given. Some, also, object to the need of lighted lamps in cold weather; but failure of a lamp, resulting in the failure of a battery, would set a signal of danger. On one road,

32

where a few of these signals are used, frequent breaking of the wires is complained of as giving needless signals of danger. The Fitchburg Railroad Company has had the signal on five miles of its road for more than a year, including the whole of last winter. Since May it has been in charge of the officials of the road, and their report is highly favorable. If it works well through the winter, it will have had that full and continued testing which such inventions need before they can be commended with entire confidence.

ROUSSEAU'S SAFETY RAILWAY SIGNAL.

This signal has already been referred to as used in blocking the New York Central and Hudson River, where it has been in successful operation for nearly four years. It resembles Hall's system in many points—among others, in using an open circuit. It resembles the Union electric signal in using gravitation as the power which actually gives the signals, thus requiring a less powerful battery than the devices where electricity does the direct work. The signal is set by a clock weight, and when wound up it signals 350 trains before it needs winding again. By an ingenious device the lamp on these signals cannot be removed for trimming without winding up the weight.

As in the inventions described before, the engine, when it enters a section, sets the signal at red, meaning danger, and it so continues till the train has passed off, when it sets it at clear, meaning safety. Each of these effects is produced by a "commutator," over which the wheels pass. In places of extra-hazard, two danger signals are used—one, called a distance or cautionary signal, 1,000 feet in advance of the signal within the section that is to be entered. If this distance signal shows green (or any color selected for the purpose) it indicates that the second signal is red; and the engineer must stop before entering on that blocked section. This system also provides each station-master with the means of stopping any approaching train, if danger has been shown to exist; and an indicator keeps him acquainted with every movement on his section of the road. An extra signal, to be used in foggy weather or in dark tunnels, is a rod which not only strikes the engine, but, by an additional device, causes the whistle to sound; and, it is said, it can be applied to the brake and made to stop the train. The long use of this signal in the Harlem tunnel is relied on as proof of its excellence. The application of the system to switches and draw-bridges needs no explanation; and the application of all these systems to a single track, while it presents points of difficulty, is a matter of detail which need not be discussed.

BEAN'S ATMOSPHERIC SIGNAL

is a safeguard against the dangers arising from open switches and draw-bridges; and it is also applicable to stations and crossings. A brief account of this device is given in Appendix G. The Old Colony road has tested this device by using it at exposed points for more than two years, gradually increasing the number of instruments in use, and now having them working at distances varying from 1,000 to 1,400 feet at one draw-bridge, two stations, and four switches. This signal is simple and inexpensive; and, so far as it has been used, and for what it undertakes to accomplish, it seems to be an almost faultless device.

In the appendix also may be found tables showing some results of the working of Hall's and of the Union electric signals; also brief accounts of devices which were exhibited to the board, but which are not subjects for full reports, because they have not been put to the practical test which is needed before such report can be made.

In conclusion, it is evident that the time has not come when the adoption of any one of the devices exhibited for giving automatic signals should be required by law. No party has asked for legislation; and Mr. Hall strongly disclaims any desire for legislative action. Nor, pending further experience on the part of railroad men, and further experiments by electricians and other inventors, can it be thought strange that railroad companies hesitate to equip their roads fully with imperfect devices, which may soon be set aside for better. Many ingenious men are giving their thoughts to railroad signals. The laws of the force, which most of them are trying to use, are not fully known, and the force is not capable of entire control. The railroad managers of England, and indeed of Europe, are more than skeptical as to the use of automatic signals, electric or otherwise. They would regard reliance upon such signals as criminal recklessness, if they were not supplemented by other appliances. Many railroad men in this country share this feeling; and this refers not only to railroad managers, who might be suspected of being influenced by undue economy, but to skilled superintendents and other experts who have no such motive. At present, no one has the right to say of any system of signals, as a whole: "This is the system that ought to be adopted on all roads." The desire is natural that some tribunal should decide at once which is the best, and that the Legislature should order its adoption. But the time for such a decision has not yet come, even if any automatic device can ever be found which will alone answer all the purposes of a safety railroad signal.

Yet it should be remembered that these imperfect devices do render great service in announcing danger and preventing accidents. The worth of a safety signal is to be estimated chiefly, not by counting the number of its false alarms, but by its well-founded alarms. Even an occasional failure to give warnings of danger, while it forbids sole and implicit reliance upon an automatic signal, does not prevent its being of great value as an auxiliary. When the terrible consequences of a railroad disaster are considered, a preventable accident becomes a crime. The public have a right to expect that their safety will be guarded by every reasonable precaution, and that devices designed for this end should not be rejected simply because they have not attained perfection. Railroad managers should be quick to guard their tracks, and especially all draw-bridges and other points of special danger, by those appliances that seem to them best adapted to insure safety. It is proper to add that our chief railroad companies have shown a praiseworthy spirit, both in testing new inventions and in adopting those that, upon trial, have commended themselves to their judgment.

The Metropolitan, September 24th 1881.

33/35

Electric Fire Alarms.—Several kinds of fire alarms are on view at the Paris Electrical Exhibition. In the simplest form, the person who gives the warning makes an electric contact between two wires, and this causes an electric current to go to the station and to ring a bell there. According to this system, there must be a separate bell and wire for each signalling station. There is another kind, in which one wire serves for a large number of different signalling stations, and at the central office a bell is rung and an index points to the particular station which has made the signal. The simplest form of this kind of instrument seen is the street fire alarm of Mr. E. B. Bright, which is entirely free from all clockwork or other mechanical movements, which are always liable to get out of order. In front of his exhibit and at the sides he has eight street posts such as are actually employed by the Metropolitan Board of Works. When a fire breaks out in any district the glass of the nearest alarm post—say, No. 4—is broken and a handle is pulled out. This immediately causes a bell to ring at the fire station, and the fireman turns a pointer round a dial until the bell ceases to ring. This will happen when the pointer is at No. 4 on the dial. He then knows the locality of the fire, and signals to the station that attention is being paid. The manner of doing this is extremely simple. A current is always passing through the wire which connects the different stations. It also passes through the circuit which rings the bell. Another current also passes through another circuit in the electrical bell, with a resistance inserted just sufficient to prevent the bell from ringing. When an alarm is made an additional resistance is added to the circuit, which disturbs the balance, and the bell rings until, by turning round the pointer on the dial, sufficient resistance has been put in to restore equilibrium. The number then indicates the particular station, as each station has a different resistance. Mr. Spagnoletti also has a simple form of alarm—the dial at the fire station has a pointer, which is moved round by a succession of electric contacts, like a Wheatstone's step-by-step alphabetic telegraph. The number of currents determines the position on the dial at which the hand will point. Each wall or pillar post in the streets has a box with a handle outside; when the handle is lifted a metal ball runs down inclined planes, making contact as it runs, and so sets the dial at the engine-house to the particular street whence the signal came. Captain Shaw, who recently visited the Exhibition, was particularly interested in a new signalling apparatus, capable of doing more than those just mentioned. This is the invention of Mr. Mackenzie, of America. It has only just been finished in time for the Exhibition here. Each station can send any one of ten messages, which may be "fire," "police," and so on. There may be 100 such stations on one circuit. The sender of the message presses down a lever and one of ten buttons, corresponding to the ten messages he can send. At the receiving station three wheels are set in rotation by gravity, and stop at the right place so as to show through three shutters the number of the station which is signalling and the object of doing so. The wheels are stopped by ratchets, and the position at which they are stopped depends upon the depth to which the ratchet has descended under the influence of a succession of currents coming from the signalling station. When the first of these revolving wheels is stopped its momentum releases a catch which brings the next ratchet and wheel into action, and then it in turn puts into gear the third. The mechanism is extremely simple—the transmitter consists of a clock train which moves a piece of metal over a series of contacts. The number of these determines the position at which the ratchet at the fire station will stop. The revolving wheel at that station is immediately caught, and sets the next wheel in rotation by the time the signals are ready to act upon it. This is an extremely interesting piece of apparatus. Its applications are not limited to fire alarms or police calls, and it requires a very slight addition to its bulk, and no additional complexity, to enable it to transmit ten thousand or even a million different signals from a single station. [illegible]

34

LES POMPIERS et les COMMUNICATIONS TÉLÉGRAPHIQUES

La Science pour tous, Sept. 11 1880

L'OPTIMISME, en toute chose, est une disposition fâcheuse de l'esprit qui est souvent funeste au progrès, et ne permet pas de se tenir suffisamment au courant d'améliorations réalisées par autrui et dont on pourrait faire son profit; mais, en France, combien ne voyons-nous pas de gens qui pèchent par excès contraire et qui n'apprécient que ce qui se fait en dehors de leur propre pays!

Combien de fois n'avons-nous pas vu porter aux nues l'organisation des services destinés à combattre les incendies en Angleterre et en Amérique, par exemple, et affirmer que notre service à Paris est dans l'enfance! On nous a dit combien il fallait de minutes et de secondes pour atteler une pompe et la mettre en état de se rendre avec son personnel sur le théâtre de l'incendie; cela est fort bien assurément et nous serons les premiers à reconnaître l'excellence de cette organisation; mais, dans la pratique et dans les résultats, croit-on que nous soyons aussi complètement en retard que des esprits prévenus l'affirment?

L'expérience et la statistique démontrent que les pertes provenant du fait d'incendie sont sensiblement les mêmes à Londres, à New-York et à Paris, proportionnellement à l'importance de ces villes.

Le journal *la Lumière électrique*, dans un travail dû à M. du Moncel, notre éminent électricien, fait connaître que Paris possède un réseau télégraphique qui ne le cède en rien à ceux des villes étrangères qui ont adopté ce système.

On va pouvoir en juger.

A Paris, le corps des pompiers fait partie de l'armée et forme un régiment d'élite, composé d'hommes adroits, intelligents et dévoués. Ces hommes sont casernés et les casernes, au nombre de onze, sont réparties dans les différents quartiers de la ville. En dehors de ces casernes, et distribués à peu près également sur toute l'étendue de la capitale, existent plus de quatre-vingts postes qui sont reliés par groupes avec les différentes casernes, pourvues des engins nécessaires et ont toujours un nombre d'hommes suffisant pour parer à toutes les éventualités.

Enfin, il y a un poste central dans lequel est installé l'état-major, où arrivent tous les avertissements et d'où émanent tous les ordres. Ce poste central est relié télégraphiquement avec toutes les casernes.

Cette organisation, à laquelle on travaillait depuis plusieurs années et qui a fourni d'excellents résultats, a été terminée en décembre 1879. Ajoutons qu'une communication existe également avec la Préfecture de police, le Bureau central des Eaux, l'Assistance publique, l'Administration centrale des Télégraphes et enfin un certain nombre de dépôts de la Compagnie des Omnibus, pour obtenir, le cas échéant, des chevaux.

Les circuits qui réunissent tous ces postes fournissent une longueur totale de plus de 235 kilomètres de fils, qui sont presque entièrement souterrains et fixés à la voûte des égouts; 2.550 mètres seulement sont aériens. Par le fait, ce système est devenu toute une organisation de télégraphie qui a acquis une activité assez grande pour occuper journellement, au poste central, trois hommes et fournir des échanges de correspondances s'élevant en moyenne à une centaine de dépêches reçues et transmises chaque jour, soit pour signaler des incendies, soit pour des détails administratifs, soit pour des ordres de service qui en forment le plus grand nombre.

Il faut bien le reconnaître, les pompes à vapeur du service de la Ville de Paris ne sont pas aujourd'hui très-nombreuses, mais on en augmentera la quantité, et il est probable que, dans un court délai, on aura aussi des attelages tout préparés pour n'avoir pas besoin de s'adresser à des compagnies particulières; c'est là le seul point d'infériorité qui nous distingue encore de certaines grandes villes étrangères, comme Londres et New-York, bien que l'on n'ait pas encore eu à signaler d'une façon sérieuse l'insuffisance de notre matériel de secours en usage.

L'organisation télégraphique du Musée du Louvre pour les incendies présente des dispositions particulières que l'on ne trouve pas ailleurs, en raison des trésors artistiques dont la valeur est incalculable que renferme cet établissement. On a dû naturellement multiplier les appareils avertisseurs et indépendamment d'un certain nombre de sonnettes d'alarme, le gardien chef, le plombier et plusieurs autres agents sont en communication avec la caserne de la rue Jean-Jacques-Rousseau.

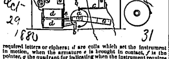
M. du Moncel, bon juge en la matière, estime que le système télégraphique des pompiers de la Ville de Paris *remplit toutes les conditions de sécurité désirables*. On ne s'en préoccupe pas moins vivement des améliorations à introduire dans l'organisation de ce service, et nous croyons savoir qu'on se propose de compléter le réseau télégraphique, déjà si important, par l'établissement d'un réseau spécial d'avertisseurs électriques disséminés sur tous les points de la ville et mis à la disposition du public.

Nous croyons en avoir assez dit pour permettre de reconnaître que notre capitale n'est pas aussi déshéritée que l'on voudrait bien le dire au point de vue spécial qui nous occupe.

Ce n'est pas seulement à Paris que la question est à l'ordre du jour; nous savons que déjà, dans plusieurs villes de province, notamment à Reims, la télégraphie électrique a été utilisée pour le service de secours en cas d'incendie; il y a encore beaucoup à faire, il est vrai, mais ces améliorations ne sauraient tarder à être apportées dans un service dont tout le monde reconnaît l'importance au point de vue de l'intérêt général et particulier.

Engineering

1212. Electrical Fire Alarms: C. E. Spagnoletti, London. [6d. 4 Figs.]—The apparatus has a train of clockwork to run off paper ribbon (similar to a Morse instrument); it is started into action by the current that gives the signal from the place of alarm. A bell and an indicator denote when the instrument requires re-winding. Alarm bells call attention to a signal. These bells may be of the ordinary "trembling" system, but attached to them is an earth connexion for the bell hammer to work so that the line wire may be discharged and any number of bells connected with one wire. A code of letters or ciphers is used to denote the station from whence the alarm came. In the figure the improvements are shown adapted to an ordinary instrument. The wheel *a* has on it slots *b* and projections of metal (not shown) for producing a rubbing contact with the spring *c*. The wheel is rotated by the instrument, and the contact with the spring *c* makes the



required letters or ciphers; *d* are coils which set the instrument in motion, when the armature *e* is brought in contact, *f* is the pointer, *g* the quadrant for indicating when the instrument requires winding. Refers to two other arrangements for signals and makes three claims: (1) Connecting the bells to the earth for discharging the line wire. (2) An arrangement of graduated slopes in connexion with a ball for sending signals. (3) The automatic system for starting the receiving instrument. (March 20, 1880).

35

and then to make its elongation and contraction by low sounds evident to the eye.

It therefore appears from these experiments, that wires conveying those currents of electricity which are required for telephonic purposes expand and contract as they are heated and cooled, and as the variations in the strength of the current are small compared with the strength of the current itself, the expansion and contraction vary in the same ratio as the condensation and rarefaction of the air particles conveying the sonorous vibrations which produced these vibrations.

The mechanical changes, or molecular vibrations in the wire, due directly or indirectly to telephonic currents, which result in the reproduction of sound, bear a close analogy to the mechanical changes due to the direct transmission of sound, but with this important difference, that while the vibrations due to sound are progressive along the wire, and their velocity is low and easily measured, those due to thermal effects are practically instantaneous, and therefore affect simultaneously the whole length of the wire.

Note.—De la Rive, in 1843 (*vide* "Electricity," vol. i., p. 304), observed that an iron wire emitted sounds when rapid discontinuous currents were passed through it, but he attributed the effect to magnetism, for he failed to obtain the same effect in non-magnetic wires like platinum or silver.

Graham Bell found, in 1874, that a simple helix without an iron core emitted sounds, and (in 1876) that very distinct sounds proceed from straight pieces of iron, steel, retort carbon, and plumbago when conveying currents.

Professor Hughes showed that his microphone was reversible, that is, that it could receive as well as transmit sonorous vibrations.

Mr. Weisendanger (*Telegraphic Journal*, Oct. 1, 1878) reproduced sounds on a microphonic receiver, which he called a thermophone, and attributed the effect to its true cause, viz., the expansion of bodies under the influence of heat, which, in fact, is the explanation of all microphone receivers.

Ader reproduced speech by the vibrations of a wire conveying currents of electricity, but he found that only magnetic metals were effective, and therefore, like De la Rive, he attributed the result to magnetic agencies. (*Vide* Count du Moncel, *Telegraphic Journal*, March 1, 1879.)

These and many other sonorous effects of currents on wires may be really due to such heat effects as I have described.

W. R. SYKES' DOUBLE ARM BLOCK INSTRUMENT.

As used on the Main Line of the London, Chatham and Dover Railway.

Fig. 4 is a front view of a complete instrument for working both the up and down traffic, and is fixed at each end of a section. A (fig. 4) is a dial fitted with two arms, B and B.I., mounted behind a post, C; the arm, B.I., on the right hand side of C is worked by an insulated rod, D (figs. 1, 2, 3), connected to the reversing axle, E (figs. 1, 2, 3), the end of which passes to the outside of the case, and by means of knob F (figs. 1, 3, 4), can be turned to the right or left. On the other end of reversing axle, E, is fitted a cam, G (fig. 2), which works between two springs, H, H.I. (figs. 1, 2, 3).

The double stud, I, I.I. (figs. 1, 2, 3), is fixed between the springs, H, H.I., on the back of case, and on turning the knob, F, say to the right, the reversing axle, E, with the cam, G, turns also, cam G taking spring H.I. away from the pin of stud I, and allowing spring H to make contact with the pin of stud I. Cam G also makes contact with H.I.

Spring H is connected to the zinc of the battery; spring H.I. to the copper of the battery.

The turning of knob F, in addition to reversing the battery connections, also (by means of rod D) moves the arm, B.I., to a horizontal or "danger" position. By depressing the key or tapper, K (figs. 1, 2, 3, 4), which is connected to terminal 4 or Line, the latter, by means of the contact block, M (figs. 1, 2), is connected to reversing axle E and cam G, and thence to spring H.I. By the depression of the key also, the insulated back portion, *k*, of the key or tapper, K, raises a spring, N, which, together with terminal 6, is connected to terminal 1 or Earth, into contact with stud I, I (stud I being in contact with spring H), thereby sending the Copper current to Line and the Zinc to Earth.

By turning the knob F to the left, the arm, B.I., is lowered to "Clear," and the key being again depressed, the current is reversed, Zinc going to Line, and Copper to Earth.

The foregoing describes the arrangement for sending reverse currents, which is all mechanical. We will next consider the working of arm B, which is controlled by the instrument in the next section. Arm B is mounted on an axle having behind the dial a steel arm, O (fig. 2), kept magnetised by magnet P (figs. 1, 2, 3), working between two shoes, *n*, *s*, of the electro-magnet, Q (figs. 1, 2, 3). In giving "train on," by depressing key K, without moving knob F, arm B being at "clear," a current is sent to the electro-magnet of the instrument in the next section, which rings the bell there by attracting armature R (fig. 3), but does not alter position of arm B of that instrument. If the train is accepted, the knob, F (of instrument in next section), will be turned to the right, putting arm up to "danger," and the key depressed sending a current to line (which enters *viâ* 4, K, M.I. (fig. 2), to terminal 5 (fig. 2) into electro-magnet Q; from thence it passes through terminal 6 (fig. 2) to earth. This causes arm O to be moved from *n* to *s* (fig. 2), raising arm B to "danger."

When a "clear" signal is given, knob F will be turned to the left and arm lowered to "clear," the key depressed, and a reverse current sent into electro-magnet Q, which will bring arm B to "clear." It will be seen that the current passes direct from the battery without going through any coils or electro-magnets to line, thus saving a great portion of the ordinary gear put into block instruments.

In whatever position the arm of one instrument stands—Up or Down, Clear or Blocked—so the current is sent, putting the corresponding arm at the other end of the same position.

These instruments have been made partly from the old tapper bells by "Izant," and make a good and cheap block instrument with only *one* wire. The cost of each instrument is about £5 10s., and the old tapper bells can be altered at much less cost.

qui peuvent se trouver dans l'atmosphère ...

La Nature

STANISLAS MEUNIER.

Nov 20th 1880

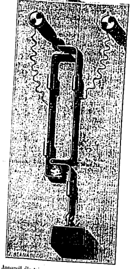
APPAREIL ÉLECTRIQUE AVERTISSEUR

DES INCENDIES

On a déjà imaginé un certain nombre d'appareils qui ont pour but de faire entendre une sonnerie électrique d'alarme, dès que la température du milieu où ils sont placés s'élève au-dessus de la moyenne normale. On connaît l'avertisseur, qui consiste en un simple tube thermométrique à mercure: quand le mercure s'élève au-dessus d'un certain niveau par suite d'une élévation de température anormale, il arrive à toucher deux fils de platine séparés l'un de l'autre et mis en relation avec une pile électrique et une sonnerie; en les touchant, il ferme le circuit et la sonnerie fonctionne.

M. G. Dupré vient de faire construire chez M. Dubosq un appareil basé sur le même principe, mais dont la disposition est nouvelle et originale.

Deux tiges métalliques AB, CD sont mises en relation avec la pile et la sonnerie électrique par l'intermédiaire des boutons R et Q. La tige CD est séparée de la première tige AB, qui est fixe, par une petite masse de suif placée à la partie inférieure, des deux tiges (voir la figure ci-dessus). Si la température vient à s'élever par suite d'un incendie, le suif entre en fusion, la tige CD, sollicitée par le poids E, s'abaisse et arrive en contact avec la tige AB; le contact s'établit, comme on le voit ci-dessus, à la partie supérieure du système. Le circuit est alors fermé; la sonnerie d'alarme se fait entendre.



Appareil électrique avertisseur des incendies.

Le Propriétaire-Gérant : G. TISSANDIER.

Imprimerie A. Lahure, rue de Fleurus, 9, à Paris.

~~Eng. Mechanic~~

ALARM SIGNALS FOR STEAM-BOILERS.

July 25 1880

ARRANGEMENTS for signalling when the pressure in a steam-boiler rises above a certain point, or when the water falls below a certain level, have been recently patented by Mr. W. White, of Greenock. The patentee employs an electric bell, which may be placed in the office, or in some place where attention will inevitably be called to the neglect of the boiler attendant. In the arrangement, as applied to the pressure-gauge of the steam-boiler, in addition to the usual indicating hand or pointer, moving round the dial face of the gauge, and marking the pressure of the steam in the boiler, there is fitted a stationary pointer, which may be moved round by hand, and set at a point indicating any desired degree of pressure, on a swivelling pivot, centre pin, or stud, fitted in an eye in a small metallic bracket or rod, secured over the face of the gauge to the metallic case, or bezel ring, holding the usual glass face, but separated or insulated from that case or ring by a wooden, vulcanite, or other non-conducting piece, interposed between the metallic portion of the bracket, or rod, and the ring or case. This fixed or stationary hand or pointer is fitted with a tip of platinum soldered on, or provided with an inner projecting pin or stud, with which the moving indicating hand or pointer, or a curved platinum wire thereon, comes into metallic contact, when by the boiler pressure it is caused to travel round the gauge, to indicate the pressure at which the stationary hand is set. The insulated setting hand or pointer is connected by an insulated wire or rod, passing out of the gauge through the insulator, with a wire held by a binding-screw in contact with the gauge, and leading to one pole or electrode of an electric battery, and the usual moving hand or pointer is also connected by a wire attached to the case, and leading from the gauge through the magnet coil of an ordinary electric trembling bell to the other pole or electrode of the battery. When the pressure of the steam in the boiler causes the moving hand to travel round to, and make contact with, the projecting pin or platinum tip, on the setting pointer or hand, the electric circuit is completed through the wires and the pointers of the gauge, and causes the bell to ring and warn the fireman or attendant, until the pressure of steam is again reduced. The bezel ring holding the glass over the face of the gauge, is hinged, or it may be otherwise fitted to it, and securely locked by means of a padlock fitted after the stationary hand or pointer is set at the number expressing the limit or pressure to which it is desirable or safe to work the boiler, so that this hand may not be reset or tampered with by the fireman or other attendant. In cases where the maximum of pressure to which the boiler is worked would be constant, or never exceed a given amount, an insulated terminal plate might be fitted to the metallic bezel ring of the gauge, with which the moving hand or pointer would come in contact when it reached to, and indicated, the limiting pressure, and would then cause the electric bell to ring, or give an alarm. The apparatus may also be made to sound an alarm when the boiler pressure, as indicated by the gauge, becomes lower than is desirable, by fitting an additional insulated hand, which would be set at the minimum working pressure by hand after steam is raised in the boiler, and the moving hand indicates a higher pressure. The same arrangement of apparatus is obviously applicable to vacuum gauges. In the application of the improved apparatus, which is intended to give an alarm or warning of the water in a boiler either rising considerably above, or falling below, the normal position, the usual rod or lever passing from an indicating float in the boiler is fitted with small pointers or levers, and is connected by metallic contact of the parts of the boiler to a wire attached to the boiler, and leading to an electric battery. When the float rises or falls with the water in the boiler, considerably above or below its usual level, these pointers correspondingly rise or fall, and come into metallic contact with a platinum contact point on a stationary insulated terminal plate, connected by a wire leading through the magnet coil of a trembling bell to the battery, and causes the bell to sound an alarm to indicate such unusual rise or fall of the water-level. By a slight modification of this alarm apparatus, the float is connected by a cord or chain with a balance-weight passed over a pulley carried on a spindle in a bracket over the boiler. The spindle of the pulley is fitted with a hand or pointer, which moves with the pulley as it oscillates or revolves by the action of the float and weighted cord; and when this pointer moves considerably round to one side or other to indicate in the usual manner an extreme rise or fall of the water in the boiler, comes into metallic contact with a stationary pin or stud of platinum or other metal on either side of the usual indicating segment, which is in this case, however, insulated from the bracket. The insulated segment and bracket are fitted with wires, leading to a battery and bell coil, and the making of contact between the pointer and stud causes an alarm to be sounded, and indicates audibly that the water level is extremely high or low. In these arrangements of safety alarm signalling apparatus described, the electric bell might be fitted in the engine-room, and an additional electric bell, acted on by the same battery, and set of wires, might also be placed in the manager's or engineer's room. In works where a large number of boilers are used, the improved apparatus can be connected to the gauges or water-level indicators of each boiler, and only a single bell used in the engine-room or manager's office.

Another arrangement for indicating low-water, which is not patented, we believe, is the electric indicator of MM. Lethuillier and Pinel, of Rouen. By means of this apparatus, the water-level in a boiler may be ascertained at any distance from the latter. The arrangement employed for this purpose consists of an indicating tablet, which may be placed in any part of the establishment, however remote from the boiler-house, in the office of the engineer, or the superintendent, or within reach of the boiler inspector. This tablet is connected with the electric indicator, which is fixed at the top of a vertical tube above the boiler, by two electric conducting wires. At the lower part of the scale of the indicator are placed two pieces of copper, upon each of which is fastened a small plate. These platinum wires are superposed at a distance of 0·08in. When the index, which is attached to a vertical rod connected to the float in the boiler, descends, it rests on the upper plate of platinum, depresses it, and puts it in contact with the lower plate. An electric current is thereby established from a battery, connected with the apparatus, causing a bell on the indicator to ring, while, at the same time, the sign "low water" appears on the tablet. Similar pieces of copper and platinum are fixed at the upper part of the scale, and when the index reaches this limit in consequence of the rising of the float, the bell rings as before, and the indication "high water" is shown on the tablet. In order to remove the warning word from the tablet, a button is pressed, which returns the indicating parts to their normal position.

Engineering News Oct 4 1880

Mr. W. J. Phillips, superintendent of the police and fire alarm telegraph, of Philadelphia, says that the present system is twenty-five years old, and the majority of the lines are almost worthless, needing constant repairing and great battery power to keep them up to their work: that they might be patched up and even extended, but their usefulness would be shortlived and the expenditure of money for that purpose injudicious. In one section, comprising the First, Second, Third, Fourth, Fifth, Seventh, Eighth, Ninth, Twenty-sixth and Thirtieth wards, there are forty-four boxes, but there should be seventy in addition, or one hundred and fourteen in all. In another section seventy-five more boxes are needed. Mr. Phillips estimates the total cost of improving and extending the system at $81,300, of which amount $45,300 is required for new boxes and repairs, $24,000 for work and material, and $12,000 for refitting the Central Station.

3. 38

39

La Lumière Électrique

Journal universel d'Électricité

51, RUE VIVIENNE, PARIS

ÉDITION BI-MENSUELLE

Paris et Départements : Un an.................. 15 francs. | Union postale : Un an............................ 20 francs.
Le numéro : Un franc.

Administrateur : A. GLÉNARD. — Secrétaire du Comité de rédaction : E. HOSPITALIER

N° 19 — 1er Octobre 1880 — Tome II

SOMMAIRE

REPRODUCTION DES SONS

SOUS L'INFLUENCE DE LA LUMIÈRE

PHOTOPHONE DE M. GRAHAM BELL

37

Il nous est arrivé tout dernièrement d'Amérique la relation d'une communication très-intéressante que vient de faire M. Graham Bell à la dernière session de l'Association américaine pour l'avancement des sciences, sur la production des sons par l'action de la lumière, phénomène qui l'a conduit à un nouvel instrument auquel il a donné le nom de *photophone* (1).

Au moyen de cette appareil, un rayon lumineux projeté à distance sur une substance impressionnable à la lumière, peut, étant modifié dans son intensité sous l'influence des vibrations de la voix, impressionner suffisamment cette substance pour que celle-ci puisse reproduire la parole avec l'aide d'un téléphone, *même sans téléphone*, sous certaines conditions. De cette manière on peut parler à travers l'espace *sans fils conducteurs* et aussi loin que le rayon lumineux peut agir sur la substance sensible. Est-ce là cette invention qu'on nous a fait entrevoir comme ayant été l'occasion du pli cacheté déposé par M. Bell à l'Institut de Franklin, ou une invention collatérale?... Si c'est la première hypothèse qui est la vraie, j'avoue que tout ce qu'il y avait de mystérieux dans cette découverte, pourrait se réduire à la proportion d'un fait ordinaire; car la découverte actuelle, bien que très-intéressante, n'a rien par elle-même que de très-compréhensible, puisque depuis longtemps on sait que la lumière détermine sur les substances photogéniques, des actions physiques ou chimiques qui peuvent intervenir, comme l'a démontré M. Ed. Becquerel, soit pour déterminer des actions électriques, soit pour modifier l'intensité des courants transmis par leur intermédiaire. On a, d'ailleurs, démontré que le téléphone permet de révéler la présence de ces courants quand ils sont interrompus et quelque faibles qu'ils soient; toutefois la production des sons par *l'action directe* de la lumière est plus extraordinaire, et montre une fois de plus combien nous avions raison de dire, que des *vibrations sonores* peuvent *parfaitement résulter d'actions moléculaires*. Cette fois on ne viendra plus nous parler de la *nécessité de vibrations tranversales*, et MM. les acousticiens seront bien obligés de reconnaître que leur science est bien peu avancée.

Ce qui est surtout curieux dans les expériences de M. G. Bell, c'est que la propriété d'influencer moléculairement les corps de manière à changer certaines de leurs propriétés physiques, n'est pas le propre du sélénium ni des substances photographiques; ce serait, suivant lui, une *propriété générale*

(1) Il paraît que cette idée était déjà *venue* à Bell dès 1878, et que, dans un mémoire présenté par lui à la Société royale de Londres le 17 mai 1878, il a dit qu'il était possible d'entendre l'effet d'un nombre interrompant l'action de la lumière sur une plaque de sélénium. Déjà en septembre 1878, dans la première édition de mon ouvrage sur le téléphone, p. 193, j'avais indiqué des expériences de MM. Willoughby-Smith et Siemens qui montraient qu'on pouvait obtenir des sons, en projetant un rayon lumineux sur une goutte de sélénium introduite entre deux électrodes de platine dont les dents étaient intercalées dans leurs intervalles respectifs, et mises en communication avec un téléphone à pile.

40
31

THE FIRE TELEGRAPH OF PRAGUE AND SMICHOV.

Engineering (Oct 8. 1880)

(Concluded from page 226.)

We shall now describe the arrangement of the street boxes by reference to our illustrations Figs. 2, 3, and 4, annexed. The annunciator shown in these figures resembles in its chief features the instruments made by Messrs. Siemens Brothers, and which were described in these pages some time ago.* The present instrument differs, however, from Siemens' apparatus in some interesting particulars. The chief part of the apparatus is a train of clockwork driven by the weight F. This clockwork when

Fig. 2.

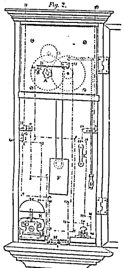
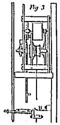


Fig 3



moving turns a contact wheel A, the circumference of which has a series of suitable projections. By these projections the spring B is raised from the contact C on which it rests during the intervals. In the position shown in Fig. 2, the (constant) current is freely passing through C and B. If a signal has to be given, the handle D is pulled, when the clockwork is released, and the wheel A begins to revolve. Whenever a projection of this wheel passes below the lever B, the current is broken, and as each breaking of the current causes a dot or dash (according to its duration) to be made by the Morse apparatus at the central station, it is easily understood, that according to the shape of the wheel A various signals will be given by different instruments. Every instrument has a wheel of a shape differing from all others. The apparatus shown in our engraving would, *e.g.*, send the signal . . —. (the letter *b*), which would be repeated thrice, as the wheel A makes three revolutions whenever it is released, after which it is automatically stopped.

In order to be ready for service, the apparatus must be wound up, which is done by the little handle E hung up for that purpose in the case of the instrument. As in Messrs. Siemens' apparatus, an ordinary sending key L is fixed in the case, so that any person practically acquainted with telegraphy can correspond with the central station. In the fire annunciator of Messrs. Siemens Brothers a galvanometer is included in the circuit. This galvanometer serves a double purpose—first, it does duty as a receiving instrument in corresponding with the central station;† secondly, it shows by its movements whenever the line is used by some other annunciator, preventing thus practically a double use of the same line. In the apparatus we are just describing, however, the galvanometer is replaced by a small relay K, whose armature carries a light arm striking a bell whenever the armature is released by a breakage of the current. This arrangement has some advantages. The movements of the needle of the galvanometer may easily pass unnoticed, especially at night, whereas the sound of the bell is at once more intelligible to the general public, and facilitates the "reading" of an answer by a trained telegraphist. In fact correspondence may be carried on in the dark, which is not possible when a galvanometer is used.

As a special feature of novelty, however, the arrangement of the electrical connexions within the instrument must be described. The apparatus is placed in a casing which is closed by a glass door. Whenever this door is closed it presses back a button G, which establishes a contact between two pieces H and I, as will be understood from Fig. 3. Thus, whenever the door is shut, the current will pass through the apparatus by the following way, viz., (Fig. 2) 1, H, I, 2, 3, 4, 5, 6, 7, 8, 9, 10, C, B, 11, 12, 13, 14, L, 15, 16, 17, 18, 19, 20, 21. If, however, the door is opened for the purpose of using the apparatus, the button G is released, and the contact between H and I is broken (as shown in Fig. 3). Now the current entering at 1 and passing to H cannot go directly to I, and it is therefore obliged to go by *a*, *b*, *c*, *d*, through the relay K, then by *i*, *m*, *n*, *o* to 2, from whence it takes the same course as described before. In other words, by opening the door the current is prevented from passing directly from H to I, and it is therefore obliged to take a circuitous route passing through the relay K. The advantage of this arrangement will be easily understood. The receiving apparatus, whether a galvanometer or relay, presents always a considerable resistance to the passage of the current. Now, if a large number of street boxes is included in a line, the aggregate resistance of all their receiving instruments is very great, and requires a battery of high power. In the apparatus as described, however, the current does not pass through the relay, unless the annunciator is used. Thus the ordinary resistance—when all relays are put out of circuit, all doors being shut—is very small, and even when a street box is used, only one relay is put in. As a matter of course a considerable saving in battery power is the result, an important item in a system worked by a constant current. This arrangement has been introduced by Mr. Francis Schmidt, of Prague.

Finally, it remains to explain the action of a circular brass disc M, shown at the bottom of the case in Fig. 2. Should the cord carrying the weight F break, or should the weight run down, the weight would fall upon the disc M, and, pressing it down, would establish a contact between two wires β and γ. Thus a new way (6, α, β, γ, δ, 13) is opened to the current and the line remains unbroken even if the wheel should happen to be just in such a position as to hold the arm B raised from the contact C.

Fig 4 Third line calling the central station

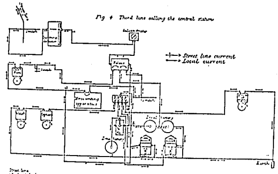
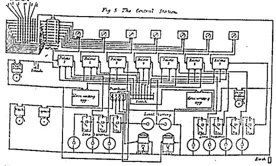


Fig 5 The Central Station



The annunciator cases just described are enclosed in wooden boxes, which are fixed to the outside of the houses in such a way, that their face is flush with the wall and their lower edge is about 4 ft. to 4½ ft. above the ground. Externally these street boxes are painted grey, the middle field being red. This red field bears in white letters the designation "fire annunciator" in both current languages ("Pozarovy automat" and "Feuer automat"). In the centre of the field a small ornamental casting in white metal, representing the arms of Prague, is fixed. The number of the line (III.) and the designation of the annunciator (*b*) are also given.

These street boxes are locked, and can be opened only by means of a key. The locks are, however, of the simplest description, and they are made all of the same pattern, so that any box can be opened by any key. Every policeman, and every nightwatch, as well as the concierge of the house where the firebox is fixed, is provided with a key. The glass door of the inner casing is simply shut without being locked.

It is, of course, open to question, whether such a system of limited access to the fire-bells is preferable to the possibility of a free use. The number of false alarms would be certainly increased by a free access to the annunciators, at the same time the instruments would be more liable to be damaged; on the other hand, however, the chief advantage of a fire telegraph, the saving of time, is much reduced if the annunciators are accessible only by means of a key which is in the possession of persons who are not always on the spot just when

* Vol. xxiii., page 225.

† Even if a user of the street box sends a signal only by pulling the handle D, he receives an answer from the central station (viz., the answer "understood").

ichov we have used the term "average
ance" of a house from the next street
his term was there for the first time
us, we shall explain its meaning more

rea F may be divided into n equal
n, $f=\frac{F}{n}$, either by regular triangles,
by hexagons (Figs. 1, 2, 3). The
ance D of the furthest point of the
enclosing each figure, from the centre
will be:

he triangle, $D=0.87738\sqrt{f}$
, square, $D=0.70711\sqrt{f}$
, hexagon, $D=0.62040\sqrt{f}$

on an area F there are n points, so
corresponding to each point is $f=$

t the following question:

ie maximum distance of any other
a from the next of these fixed points,
hat these fixed points are uniformly
r the area?"

as been said above, we know that
fixed points the centres of either
es, or hexagons, the required maxi-
will be different in either of these
ill be greatest if we divide the area
Thus, to find the maximum distance
an area from the next of a number
equally distributed over this area,
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ng at the respective centres of these
quired maximum distance will then be

$=0.87738\sqrt{f}=0.87738\sqrt{\frac{F}{n}}$,

e we call "the maximum average
y point of the area from the next

41

Le Golfe de Naples

Dimanche 19 Juin 1881

Un télégraphe autour du monde

Nous trouvons dans le *Moniteur industriel* des renseignements précis sur la solution d'une question de haute importance, agitée depuis quelque temps relativement à l'établissement d'un télégraphe sous-marin qui relierait entre elles les principales contrées du globe.

Parliament during the ensuing session.

31 Engineering Dec 10th 1880

ELECTRICITY v. FIRE.

The first five minutes' work at extinguishing a fire is, it is said by competent authorities, worth all that can be done in the next five hours. Few will dispute this, and therefore the question of how we are to obtain hold of this precious five minutes is one well worth consideration. In America, besides all the wonderful arrangements for dropping the driver of a fire-engine through a trap-door and down an inclined plane into his seat, electricity has been largely employed to gain time, and in London the mere connexion of the fire stations with one another by telegraph has been for many years in use, but the mode of warning the fire stations in London has until recently been entirely dependent on messengers from the neighbourhood of the fire itself. Thus more than five minutes is always lost.

Mr. Edward Bright has attacked this precious five minutes by electricity in two different ways. The first, and what we may term the saving of the messenger's-time-plan, is the one that concerns the public generally the most. It consists in having posts in the street from which any policeman or authorised person having the key of the box in his neighbourhood can, by pressing a knob after opening the box, call the attention of the fire station to the fact that a fire has occurred near that particular box, and the second plan consists in arrangements by which fire in any large building gives its own warning, and by a little manipulation shows at once its particular locality in that building. The first system is one that should be employed therefore in every town, and the second in every building of special importance. Both depend on a very clever application of the principle of the Wheatstone bridge used in telegraph testing. Taking first the street arrangement: In the fire station we have an arrangement of the Wheatstone bridge in which the two fixed resistances of the bridge exist in the ordinary form, and in place of the galvanometer a relay which acts on a bell. The third part of the balance consists of coils of definite resistances which can be brought into circuit by moving a handle, and the fourth part consists of the lines of wire which join the various posts and of definite resistance coils varying at each post fixed at the posts themselves. Thus suppose No. 1 post has 10 units, in its coil then No. 2 has 20 units and so on; these resistances are cut out of circuit at the boxes, and can only be placed in circuit by pressing the alarm knobs. When the arrangement is ready for use all these coils are out of circuit, and as the resistance of the line is balanced by suitable coils in the third side of the balance, the current, which is constantly kept on at the station, has no effect on the bell, since the relay circuit which rings the bell joins two points of equal potential. On pressing a knob the resistance at that post is thrown into circuit, the balance is disturbed, and a current passes through the bell relay ringing the bell.

The person in charge at the fire station having his attention thus called, proceeds to find the number of the post where the knob is pressed. This he does by turning on resistance coils in the third side of the bridge by means of a handle, until the bell ceases to ring, and the place where his handle stops indicates the station calling, as the resistance thrown in corresponds with the resistance added at the calling post. By suitable means he can also give a signal to the post calling to indicate that the call has been received. The system is in use in a part of the City and Borough, the posts being connected through one of the wires belonging to the Post Office. Already, between August 28 and October 11 of this year, twelve fires have been signalled to the Fire Brigade stations. In some of these cases the engines had actually arrived at the fire summoned by the alarm before the messengers had arrived at the Fire Brigade station. In the system actually in use the knobs when pressed place the resistances in circuit in which the current is constantly on. But Mr. Bright also adopts the plan of having all the resistance bobbins in circuit, and the knob merely making earth and thus cutting out all bobbins beyond that one. A third plan is evidently possible, which seems to us preferable, and that is to have the end of the line insulated, and let the press of a knob place line to earth through the definite resistance of that particular post. No doubt by practice the best system will be discovered, but this adaptation of the Wheatstone bridge as a means of localising a fire call is decidedly ingenious, and a step in the right direction.

For the detection of fire in buildings and localising it the same principle of the Wheatstone bridge is employed, only the contact is made automatically by the action of increased temperature on a spring made of two metals. Thus in each room of a building to be protected is a small bobbin of wire offering a definite resistance. All these bobbins are in consecutive circuit, and connected in one of the sides of the Wheatstone bridge. Near each is a small box containing a spring, which when the temperature to which it is exposed rises to a certain point, makes a contact between that part of the series of bobbins and a wire leading direct to battery. Thus the electric balance is disturbed, the bell rings, and by turning a handle until the bell ceases to ring, the watchman can find the exact room where the rise of temperature occurs. There seems to be nothing in this arrangement open to objection, and when we consider the complicated clockwork arrangements used in America, Mr. Bright's seems simplicity itself, and one well worth a trial in our public buildings. When we recollect that during the last forty-five years the Houses of Parliament, the Royal Exchange, and a large part of the Tower of London have been burnt down, to say nothing of Covent Garden, Her Majesty's, and half a dozen other theatres, besides numerous large warehouses, mills, &c., it is certain that no system which offers such a fair chance of success in giving instant warning of fire should be allowed to be neglected whilst our public buildings run the risk, which they certainly now do, of being destroyed at any moment by fire for want of some means of giving notice within that first five minutes which the fire authorities hold in such reverence.

Electrician Dec. 11. 1880

LITERATURE.

Electrician Dec 11th 1880

Beschreibung der Neuen Feuertelegraphen-anlage in Stuttgart Von W. E. Fein.

In the whole history of the electric telegraph there is probably nothing more surprising than the slowness with which it has in this country, and on the Continent generally, indeed, been specially applied to the announcement of fires. Its application to this purpose seems to have been initiated by America, and there certainly carried to a high degree of perfection. This remissness is the more unaccountable as, apart from the obvious advantage, theoretically, of using such means, the logic of facts is overwhelming in favour of such a course.

Two years ago the municipal authorities of Stuttgart awoke to the desirability of having a system of fire telegraphs, and placed the work in the hands of a local firm of electrical instrument makers, Messrs. Fein, who have just published a clear and well-illustrated little book, describing how they carried out the undertaking.

The telegraph system at Stuttgart is worked on the radial—not the circle or loop line plan—that is to say, the Automatic Fire Annunciators, as they are called (we should have preferred indicator), the speaking Morse and telephone stations (Messrs. Fein having adopted telephones in some instances) all radiate from the central station, with which they are in circuit.

The Stuttgart automatic fire annunciators are worked upon the ordinary principle of a permanent current from the central office, broken by pulling the little knob, and thus allowing the contact wheel to rotate. The periphery of this wheel is so shaped that it breaks the current in such a way as to form, *ipso facto*, a certain letter of the Morse alphabet, which signal is produced, of course, on the instrument at the central station. This signal is varied in such a manner that each point has its own special one, and this indicates the position near which the fire has broken out. Instead of having the key of the automatic fire indicator kept by the police or at the house nearest to it, Messrs. Fein advocate the plan of lightly soldering it to the box itself, from which it can easily be broken off and used when necessary, by which means much invaluable time may be saved—the policeman, even in Germany, not being always at hand when wanted—which applies also to unofficial persons, who are likewise liable to mislay keys as well as other important things.

The Palace and Royal Theatre are included in the 75 points from which fires may be indicated, as well as the towers of 2 churches, the Stuttgart municipal authorities taking a very different view to that of a High Church vicar in a suburb of London, who a few years ago refused to allow the fire escape to be kept against the parish church, which he considered it would desecrate. By an ingenious arrangement of Messrs. Fein's the watchman at each church tower must make the circuit of the tower before he can give the signal to the central office, which is done every night at certain fixed times, showing that he is attending to his duty. In view of the enormous reduction of serious fires effected by the use of a good telegraph fire system—4 per cent. as against 29 per cent. formerly—it is to be hoped that in this country we shall more generally avail ourselves of such valuable aid in overcoming one of our most dangerous enemies to life and property.

31

FIRE-DAMP AND ELECTRICITY.

A most ingenious plan for detecting the presence of fire-damp in mines in time to obviate its disastrous effects has been recently suggested by the celebrated Belgian engineer, M. Somzee, whose eminent name and well known experience are sufficient guarantees that he would be the last man in the world to lend his name to anything chimerical. It is well known that the safety lamp is at present the sole indicator of the approach of fire-damp actually employed; and it is equally notorious that its warnings, in nine cases out of ten, come too late. The flame of the safety lamp elongates, and gives out a more intense heat whenever the fatal gas is at hand; but before those who are on the look-out for those infallible indications of danger can effect their escape, the proportion of fire-damp in the air has already become too strong for them, and the inevitable explosion overwhelms them in an instant. M. Somzee proposes to organize a series of indicators capable of giving instantaneous notice of the presence of fire-damp in any part of the mine, so as either to afford the miners time to escape, or enable the mining engineers to remove the danger by regulating the ventilation of the mine before the gas has had time to collect in dangerous quantities. For this purpose he utilizes the elongation of the flame of the safety lamp, and its increased caloric power (already alluded to) in the air infected by fire-damp, in the following way. A number of safety lamps, each provided with a specially prepared but very simple apparatus worked by electricity, and under the control of a mining engineer in a central office, are placed at different points of the mine, each lamp being connected with a bell at the central office by means of a metallic wire. The bells and lamps have corresponding numbers, and the sounding of one of the bells is the signal of an escape of fire-damp in that part of the mine where the lamp corresponding to it is placed. But this is not all. M. Somzee has discovered in the telephone a still more reliable agent for detecting the approach of the insidious fire-damp. The flame of the safety lamp, as it begins to dilate in its cylinder, should, if the cylinder be properly disposed, commence to sing, and if the upper surface of the lamp is provided with a telephonic apparatus in connection with a receiver at the central office, the receiver will begin to sing at the same time as the flame. Fanciful as this scheme may appear, it appears to have been received with great favor in Belgium, and no doubts seem to have arisen as to its practicability. The singing bird in the eastern fable, which warned the young prince of impending danger, will, if this scheme be carried through, be quite eclipsed by the singing telephone warning the miners of the near approach of their deadliest foe.—*Building World.*

M. Somzée, a Belgian engineer, proposes to utilise the safety lamp for revealing the presence of fire-damp in collieries. It is well known [illegible] flame of the lamp elongates and [illegible] higher calorific power when in air which contains light carburetted hydrogen, or marsh gas. A piece of metal is so placed [illegible] be elongated by this flame; this produces electric contact, and causes a bell to ring. Several of these lamps should be placed in different parts of the mine, and the bells numbered.

Telegraphic Journal Dec 1880

31

44

OBITUARY.

ANSELL.—On the 21st December died George Frederick Ansell, who was well known to the scientific world by his fire-damp indicator, intending to prevent explosions in coal mines. Mr. Ansell was born in 1826. In early life he studied surgery, but not finding it suited to his taste, he decided to attend the lectures at the Royal College of Chemistry and the Royal School of Mines, where he was soon appointed lecture assistant to Dr. Hofmann. His next appointment was to the professorship of Chemistry at the Royal Panopticon, where he succeeded in volatilising gold, and made important experiments upon iron, steel, &c. In 1855 Lord Palmerston gave him an appointment in the Royal Mint under the mastership of Mr. Thomas Graham, where he rendered valuable services and obtained considerable credit by his treatment of brittle gold. His pen was usefully employed in numerous essays, his most important literary work being *The Royal Mint.*

HOW RAILWAY TIME IS KEPT.—There are in use between Albany and New York 13 electric clocks, two of the number being placed in the waiting-rooms, and one in the dispatcher's office at the Grand Central Depot, New York. The time on the clock in the depot at East Albany corresponds exactly with the time in New York. Each one of the clocks is connected with the general superintendent's office in New York, in which the railroad time is kept on what is called the "big clock." Conductors, train men, and others are compelled to keep their watches in strict conformity with the superintendent's clock. It is set by standard time, and connected with the time service department of the gold and stock telegraph. The time is distributed all over the line each week day as follows: At 10 o'clock 58 minutes and three seconds A.M. the word "time" is sent by the main office to the telegraph stations between New York and Albany. The word is repeated for 28 seconds, during which time operators must see that their instruments are adjusted. At 10 o'clock and 59 seconds, seconds commence beating, and continue for 50 seconds. The word "switch" is then sent over the wire, and operators having electric clocks connect them immediately with the circuit known as No. 9 wire. Ten seconds are allowed in which to make the connection. At 11 A.M., with one touch of the New York key, the hands on the different clocks are set to 11 o'clock.

31

Electric Signalling on Railroads.

MESSRS. G. BOUSCAREN, C. & P. Engineer, and S. Woodward, Superintendent of the Cincinnati Southern Railway, under instructions from the president and general manager, have recently investigated the subject of block signalling for railways, with a view to the adoption of the best system for that road. For this purpose they visited Boston, New York and Altoona, Pa. In their report, after describing the block signal tower system employed by the Pennsylvania Railroad quite extensively on its lines, which involves the construction of an expensive tower every three or four miles, and the constant employment of a skilled telegraph operator at each end of the block, they say in reference to the Automatic Electric Signal System:

Several plans have been suggested and tried to avoid the expensive necessity of a man and a building at the end of each block, by connecting electrically the track with the signal post in such way that every train passing the end of a block will move the signals at each end of the block automatically. The signal discs or arms are generally moved by a falling weight mechanically connected with and held in check by the curvature of an electro magnet, the electric current being supplied through a special wire.

This system, although doing good service on several roads, cannot be considered as perfectly reliable, the operation of the signal, depending as it does on the insulation of the wire, which is affected greatly by atmospheric changes.

A great improvement was lately introduced in this system by the Union Electric Signal Company by the substitution of the rails of the track for the wire as conductors of the electric current. The principal advantages gained by this arrangement are:

First—That the large section of the rail offers so little resistance to the electric current, and the electric tension is so much reduced thereby that insulation of the rails is not necessary, and a single battery jar furnishes a reliable current, which is unaffected by the condition of the weather, the only precaution necessary being to connect every consecutive rail by a piece of wire united to the rails, and to guard against defective contacts at the joints.

Second—That the signals are not only reversed to danger by every passing train, but also by the presence of a car on the track at any point within the block, or by a broken rail or an open switch, all of which are frequent causes of accidents undetected by other systems of signalling.

Third—That the effect of any disorder in the apparatus is: *always* to turn the signals to danger, which is a most desirable feature in automatic signals.

The undersigned witnessed the operation of these signals on the Boston end of the Fitchburg road, where they have been in successful operation for several years. They are highly praised by the officers, and are now being introduced on other parts of the road.

The Pennsylvania Railroad is now introducing these signals on its main line between Altoona and Philadelphia, for the purpose of subdividing their blocks into smaller sections.

The undersigned believe that the hand system and the Union Electric Automatic system should both be experimented upon on the Cincinnati Southern Railway before the division of the entire road into blocks.

They recommend that certain designated sections of the road be fitted up with the block tower system, and tunnels No. 24 and 26 with the Union Electric Signal apparatus, and the two systems thus competitively tested. Their estimate of the expense of construction and equipment for the signal towers: twelve stations is $10,530, and for the Union electric signals, 8 stations, $2,680.

The report and recommendation have been approved and the work ordered to be prosecuted without delay.

45

31

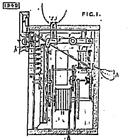
ABSTRACTS OF SPECIFICATIONS.

*We are indebted to our contemporary The Engineer for the diagrams which illustrate these abstracts—*ED. E.]

1942. IMPROVEMENTS IN AND RELATING TO APPARATUS FOR TRANSMITTING FIRE ALARM AND OTHER SIGNALS.—*By William Phillips Thompson.—(A Communication from Abroad, by Monsieur Jaques Victor Michel Bartelous, of Bruxelles, in the Kingdom of Belgium.)*

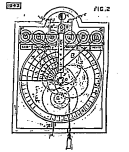
"The automatic system which I have invented," says M. Bartelous, "works by electricity, and enables one to place upon a single wire an indeterminate number of instruments, each possessing a particular signal which makes known to a receiving office which apparatus has been at work." This apparatus can render in particular the following services:—First, it establishes an automatic communication between the notifiers of conflagrations (hereafter called the alarm givers) and an office, whether of police or otherwise; second, it puts into the hands of certain persons a means of prompt communication, enabling them to call in medical or police

1942 FIG. 1.



assistance, or any other aid it may be considered useful to organise, independently of any other applications that the same system may receive. The alarm-givers, whatever be their system, are in electrical communication on the one hand with the ground, and on the other with a terminal, whence the current passes to an electro-magnet. During the passage of the current in the magnet its soft iron cores attract a soft iron armature which terminates transversely a lever. This latter being made of conducting material with the exception of its axis, which insulates it, establishes when in repose electrical communication with the central battery by a movable piece fixed on a shaft. When the lever turns on its axis and takes the new position, this movable piece, which was supported on the lever, is released and takes a new position, the axis turns round a quarter of a circle, and with it the indicator needle K, terminated by a heavy disc which turns and takes the position K'. This needle moves in a glass case, and according to its horizontal or vertical position one is enabled to see whether the apparatus has been at work or not. The rocking movement of the lever breaks communication with the movable piece, and causes the suppression of the alarm-givers. At the same time the clutch by which the lever is terminated at its other extremity rises and produces the liberation of a wheel, G, which turns round by means of clockwork. On the fore part of the lever F there is a block which, when in repose, rests upon two pieces, themselves supported by rods J, J'. The right one J' establishes communication with the receiving office, the battery, and the earth, the left, J, with the remainder of the system (or line

1942 FIG. 2



wire). The movement of the armature raising the block cuts off all communication with the line wire and receiving office. The interruption of the current from the line wire whilst the apparatus is in action, and its restoration thereto after the revolution of the dies, may be produced by a supplementary mechanism replacing the action of the rods. The first rod is entirely suppressed and replaced by a flexible conducting wire, which connects the terminal J to the cross-piece carried by the lever. The second rod is shortened, and instead of descending to the cross-piece it is terminated at K by a hook at right angles. A metallic piece in the form of a V, and movable round the axis H, replaces the original arrangement. The lower branch of this piece is terminated by a heavy weight, G, which rests upon one of the extremities of the cross-piece I; the other branch ends in a thin blade, and rests when the apparatus is in repose upon the projection K at the end of rod J'. When in this position the current, therefore, passes from the terminal J' through K, G', H, G, across the pieces I I, along the flexible wire *f f*, and joins the terminal J, where ends the line wire of the rest of the system. If, on the contrary, the apparatus is at work the lever F, and consequently the cross-piece I I, are raised; the piece G, H, G', partakes of this movement, oscillating around the axis H, and the current no longer gets beyond J', since the contact is broken between G' and K. The wheel G is the medium for giving the signals. It is divided on its first quadrant into six or more concentric bands, each of which is put into communication (by a small wheel rolling upon it as it rotates) with a similar number of contact makers, T, above each of which is inscribed the destination or duty assigned to it. When the apparatus is in repose these little wheels rest upon an insulating band, X Y. In the three other quadrants the wheel does not carry any signals except upon the outside circle, and the signals there inscribed signify, according to their number as to series and order, the house which is setting the apparatus in action. The five concentric bands around the centre carry special arrangements corresponding to the services asked for, and these signals are transmitted by pressing down one of the five buttons T. As to the sixth band it can, by means of a button, L, be put into communication with the office for a voluntary signal of conflagration. It is divided on its circumference into four sections; the first is made of conducting material, divided into a small number of divisions, and sets an alarum in motion; the second, which takes up the rest of the first quadrant, is an insulator; the two last carry signals which indicate the series and number of the house. Whilst the outside circle carries an insulating band, the wheel uses the space to produce special signals. Outside the concentric circles which have just been described there is round the whole circumference of the wheel a metallic band, upon which rests a spring which establishes a permanent communication with the earth. The apparatus is capable of producing two sorts of signals, one sort automatic, the other voluntary. In order the better to explain the working of the apparatus, the wheel is supposed to be divided into sixty divisions, although the system permits of as many divisons and as many contact makers for alarms as experience may show to be useful. As soon as the electric current is closed automatically by the agency of an alarm-giver, an alarm bell rings in the receiving office and gives notice of a conflagration, the armature of the transmitting apparatus turns on its axis, and the wheel G is set in motion. The ringing continues during the rotation of a portion of the wheel, this portion being a conductor, and of greater or less extent, over which I suppose the last concentric circle: during the rotation of the part, since this circle is an insulator, communication is interrupted, and the ringing ceases; but when the three other quadrants of the wheel are passing the successive openings and closings of the current produced by metallic pieces inserted into the mass of the wheel, the greater part of which is insulating, somewhat in the fashion of type in a composing stick, they transmit a series of signals, the particular combination of which indicates first of all the series and then the number in this series of the house whence was despatched the signal of distress.

ment, sont animés d'un mouvement en sens inverse l'un de l'autre; 2° les électro-aimants de chaque mouvement d'horlogerie sont polarisés, l'un positivement, l'autre négativement; 3° il n'y a qu'un seul cadran; 4° enfin, il se trouve entre les deux dernières roues RR de chaque mouvement d'horlogerie (fig. 4) une roue folle, qui est toujours menée par une quelconque des deux roues RR, et dont les dents sont calculées de façon à ce que cette roue O, entraînée par une quelconque de ces deux roues RR, ne soit jamais gênée dans son évolution par l'autre de ces roues RR. Selon que l'un ou l'autre des mouvements d'horlogerie des barillets est actionné par le courant, l'une ou l'autre des deux roues RR fait tourner l'une ou l'autre des deux roues *rr'* dont l'axe commun porte l'aiguille du cadran. L'engrenage de chacune de ces deux dernières roues *rr'* est tel que, menée par la roue à rochet R, elle est sans action sur celle-ci (roue menée non réciproque).

Les déplacements de la roue O sont limités par un régulateur spécial. Cette roue O porte une aiguille appelée à se mouvoir sur un cadran gradué, et qui indique la hauteur de l'eau chaque fois que le mouvement exécuté par le niveau, soit de haut en bas, soit de bas en haut, dépasse dix centimètres. La même roue O transmet ses mouvements à une crémaillère *horizontale*, qui glisse entre des guides fixes et est munie d'un crayon à molette. Au contact de ce crayon, marche, sur un rouleau tendeur parallèle à la crémaillère, une bande de papier animée d'un mouvement uniforme par un appareil d'horlogerie. Le crayon trace ainsi, sans interruption, la *courbe* exactement figurative du régime des eaux. En cas de crue torrentielle, lorsque l'aiguille arrive au point marqué *danger*, une sonnerie éveille, de jour comme de nuit, l'attention des personnes qui se trouvent dans le voisinage du récepteur; un simple coup d'œil au cadran permet d'apprécier la hauteur des eaux et le degré de gravité du danger. Entre le bord de l'eau et la station, un *seul* fil télégraphique, le fil de ligne L, relie le propulseur au récepteur.

Il est aisé de comprendre les avantages de l'appareil de M. Camille Gros. La science y trouve son compte, car les observations journalières peuvent être automatiquement enregistrées, et on obtient une courbe mathématique du phénomène. Les autres systèmes, et en particulier le téléphone, ne peuvent donner cet important résultat. L'employé est-il occupé, distrait, endormi même, la sonnerie électrique vient l'avertir que le danger accourt, pressant, imminent, et qu'il doit, sans tarder, prévenir l'autorité locale, qui, à son tour, donne l'alarme. Mieux encore : le cadran indicateur peut être placé extérieurement; chacun peut le lire aussi facilement que celui d'un baromètre ou d'une horloge. En comparant ses indications avec les renseignements donnés par un tableau placé à proximité sous cadre grillagé, faisant connaître la rapidité de marche de la masse d'eau en raison de son volume, chaque riverain sait combien d'heures, de minutes, il a devant lui pour mettre sa personne et ses biens en lieu sûr. L'appareil Gros devient alors un véritable instrument météorologique populaire, analogue à ceux que l'on a si utilement placés depuis quelques années dans nos villes pour nous tenir au courant des perturbations atmosphériques, et non moins indispensables que ces derniers.

Après la description de ce télégraphe hydrostatique, faite par M. l'ingénieur des mines Vital devant la Société des lettres, sciences et arts de l'Aveyron, et, sur le vœu unanime de cette Société, le Conseil général de l'Aveyron accorda des fonds pour la construction d'un premier spécimen du système. Des expériences eurent lieu, aux frais de l'État, sur le Lot, entre Penchot et Capdenac, avec une distance de 14 kilomètres entre le propulseur et le récepteur. Elles réussirent complètement, et il est à désirer que l'administration supérieure se prononce d'une manière définitive.

MAURICE GIRARD.

BIBLIOGRAPHIE

Zoologie élémentaire, par FÉLIX PLATEAU, professeur à l'Université de Gand, membre de l'Académie royale des sciences de Belgique. 1 vol. in-18, de la *Bibliothèque belge*. Mons, Hector Manceaux, 1880.

L'auteur de cet ouvrage a adopté un plan original et ingénieux. Après avoir consacré quelques chapitres à des notions préliminaires indispensables, M. Félix Plateau aborde l'étude des différents groupes du règne animal, en choisissant pour chacun d'eux, un type facile à se procurer, et dont la dissection puisse être faite d'une façon pratique par tout le monde. C'est ainsi que la grenouille sert d'exemple pour les Vertébrés, la limace rouge pour les Mollusques, l'écrevisse pour les Arthropodes, etc. Cette méthode excellente est développée avec un véritable talent d'exposition par le savant professeur de l'Université de Gand. La zoologie est avant tout une science d'observation; M. Félix Plateau a voulu l'enseigner par l'observation.

Le Feu à Paris et en Amérique, par le COLONEL PARIS, commandant le régiment des sapeurs-pompiers à Paris, avec 4 cartes représentant les plans de défense de Paris contre les incendies. 1 vol. in-18, Paris, Germer Baillière et Cie, 1881.

Excellent ouvrage, écrit par un auteur éminemment compétent, qui montre ce qu'on fait en Amérique pour combattre l'incendie, et ce qu'on peut faire à Paris avec les ressources actuelles, insuffisantes dans bien des cas. La Ville de Paris ne refusera pas, nous l'espérons, les ressources matérielles les plus complètes, à un corps d'élite, dont le courage, la vaillance et le dévouement sont devenus proverbiaux.

Scientific American.
APRIL 8, 1882.]

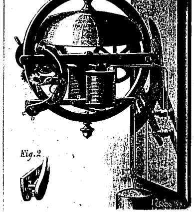
NOVEL STRIKING MECHANISM FOR ELECTRIC BELLS.

The device shown in the engraving provides for a long stroke of the bell hammer, with the movement of the hammer always in one direction. The hammer is made in the form of a segment of a ring, and is carried by a shaft driven by a weight or spring. The hammer is released and stopped by an escapement controlled by an electro-magnet.

The hammer, A, is pivoted loosely to a curved arm placed on the shaft and carried by a pawl engaging a ratchet on the

Fig. 1

Fig. 2



BOWERS' STRIKING MECHANISM FOR ELECTRIC BELLS.

shaft. The outer end of the hammer is free to swing in and out through a limited distance, but is held normally at the inner limit of its movement by a spring which also holds the pawl into engagement with the ratchet.

On the end of the curved arm there is an escapement pin, *c* (see Fig. 2), and on the armature lever, B, are two lugs, *a b*, placed one for contact with the end of pin, *c*, when the armature is down, and the other for contact with it when the armature is raised in contact with the magnet. The contact of the lugs, *a b*, by pin, *c*, arrests the hammer and prevents its being revolved by the weight.

The curved hammer is below the edge of the bell, at one side, in such position that the hammer strikes at about the end of its upward movement. As the shaft carries the hammer the centrifugal force acting on the long arm overcomes the resistance of the spring acting against the short arm, and throws the end of long arm outward, so as to come in contact with the bell; this checks it and allows the spring on short arm to force the end of long arm inward, when it passes the bell and moves on until arrested by the pin, *c*, and lug, *a*. When the armature is raised by closure of the magnet circuit the lug, *a*, is raised above pin, *c*, and the lower lug, *b*, brought behind the pin. When the armature is released by breaking the circuit the lug, *b*, is carried down, and the pin, *c*, being released, the hammer revolves, and the blow is struck at completion of the revolution.

This invention was recently patented by Mr. George E. Bowers, of Fitchburg, Mass.

Menlo Park Scrapbook, Cat. 1046

No. 32. "Telegraph Other Than Electrical"

This scrapbook covers the years 1875-1881 and contains clippings about telegraph devices. Despite the title, there are a few items on electrical telegraphy, along with a few clippings about the telephone in England. The book contains 140 numbered pages.

Blank pages not filmed: 2-3, 32-139.

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Telegraph
other than Electrical

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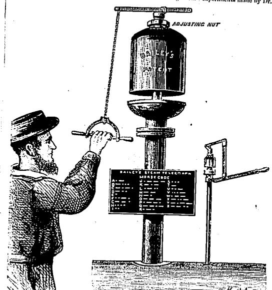
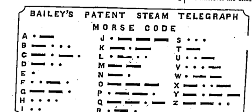
SEA TELEGRAPHY IN SPECIAL RELATION TO THE LOSS OF THE VANGUARD.*

By Mr. W. H. BAILEY.

To communicate by signal is a practice of considerable antiquity, but the time at our disposal will only permit of a very brief reference to some of the early means by which people, separated by distance, have been able to communicate with one another. The prophet Jeremiah exhorts the children of Benjamin to set up a sign of fire; and in profane history we have fires, beacons, and torches often alluded to. Agamemnon communicated with his Queen by means of beacon fires on the mountain tops. Again, a very ingenious telegraph is described by Æneas, who lived in the time of Aristotle. It consisted of two tubs, marked inside to indicate the depth of the water, and furnished with small taps. The tubs were filled with water and placed on distant hills in charge of men with torches. Upon the elevation of a torch twice both taps were started simultaneously, and the water, of course, ran away. But the moment a torch was elevated by the sender of the message the taps were stopped. Now, supposing that each inch of water signified a particular message, it will be seen how, by permitting the water to fall to any given level, the message indicated by that level would be conveyed. This system must have been adopted from the Clepsydra, or water clock, which indicated the time of day by the height of water in a similar way. The ancient inhabitants of America would seem to have had communications of a similar nature. The use of torches and beacon fires by night would naturally lead to the use of the semaphore by day—including under this designation flags or wooden erections with wing pieces or circular plates, such as are in general



use to-day on railways. The semaphore was brought into celebrity in France by three brothers named Chappe, who by means of wing pieces attached to the ends of a bar of wood were able to make a great number of combinations. To Claude Chappe the happy idea first occurred, but he paid the penalty of being an inventor in those days, since his first instruments were destroyed by the ignorant populace. Nothing daunted, however, he continued his efforts, and when by his system the first news of a French victory was sent to Paris, he and his brothers became the pride of the French people. The system soon became well known, and additions were made to it by subsequent inventors. Lord George Murray proposed his shutter telegraph in 1795. It consisted of six shutters working on pivots, and by exhibiting one or more in combination many messages could be sent according to a pre-arranged code. Messages were sent by this means from London to Dover in ten or twelve minutes, and the plan was adopted by the Admiralty, and used many years. But in foggy weather it was useless, and relays of horses had to carry the news. A remarkable proof of its inutility under such circumstances was manifested when one of Wellington's victories over the French was being



announced. The words "Wellington defeated" were signalled, when a dense fog came down, and the rest of the message could not be sent. The consternation in London was very great until the conclusion of the message arrived, and it was found to read "Wellington defeated the French." In the meantime, however, the navy had made but little advance, and ships could only speak each other by a clumsy system of flags by day and coloured lanterns by night. Rear Admiral Sir Home Popham, in 1801, introduced several modifications in semaphores for land and sea, and also a system of spelling by means of flags. His ideas were adopted, and the celebrated words of Lord Nelson, "England expects that every man this day will do his duty," were the first transmitted to the fleet by the new system, which was then on its trial as an experiment. Probably the greatest advance made in signalling at sea, however, has been the results of the joint labours of Captain Colomb and Major Bolton. These gentlemen have introduced a system of telegraphing at night by means of flash lights, using oil lanterns for short, and magnesium and other lights for great distances. The inventions of these gentlemen have been so good that they have been adopted by the British and Foreign Governments for communicating between vessels at night. They were used also on land in the Abyssinian expedition. Captain Colomb and Major Bolton in their flash light system have incorporated the idea of short and long lights, but it will be obvious that the invention, excellent as it is, will not meet all the conditions under which signalling is necessary, for the very best system of telegraphing at sea by signs may be rendered absolutely useless by a dense fog or smoke. I hope at some future time to explain the details of the system to this society, since the inventors have kindly placed their models and apparatus at my disposal. Just now, however, it will be well to bear in mind that the system may be worked in combination with that which I have specially to explain to you in such a manner that signals may be both seen and heard.

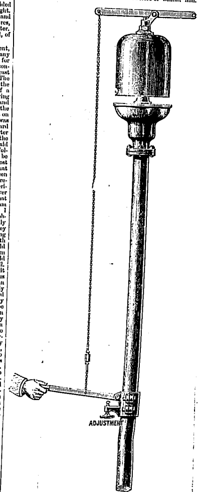
Hence it will be seen that telegraphs may broadly be divided into those which speak by sound, and those which speak by sight. In the first we may include guns, trumpets, drums, gongs, and steam whistles, and in the latter flags, torches, lanterns, fires, semaphores, needles, and other instruments of a like character. We are chiefly concerned, however, with telegraphing by sound, of which I will now proceed to speak.

My attention was first drawn to this subject by Captain Brent, then commander of H.M.S. Bellerophon, and having made many experiments I have come to the conclusion that it is possible for vessels to speak each other in dense fogs, and under other conditions at distances apart ranging from three miles up to at least six or eight, according to the conditions of the atmosphere. The experiments made by Dr. Tyndall in May, 1873, demonstrated the possibility of hearing a sound of a definite volume at distances varying from three and a-half to twelve and three-quarter miles, according to the atmospheric conditions; but that on one occasion when the wind was against the sound it could be heard at a distance of nine and a-quarter miles: and it is my object in the course of this paper, and with the aid of the experiments which are to follow, to show that the sound can be so utilised and directed as to almost literally talk. I may mention that the whistle on the table has been made from the patterns that I prepared for the Trinity House experiments on sound, conducted at Dover by Professor Tyndall. I believe that it was there demonstrated that steam horns were better than whistles. I may be permitted, however, to observe that these horns cost exactly five and one-third times more money than the whistles, and I have a strong impression that if the cost of both had been equal, the verdict would have been otherwise. It seems from this that making a noise in the world is simply a financial problem after all.

To speak first of vessels at sea, it may be said that the most dangerous conditions under which a vessel can move are such as prevailed recently upon the occasion of the Vanguard disaster. As dense fogs invariably occur in calm weather it will be apparent that sound telegraphs can be used with the greatest facility when there is most serious occasion for their services. I hope I shall be able to prove to you that it is perfectly possible and comparatively easy for one man to speak to another at, say, a speed varying from ten to twenty, and even up to thirty words per minute, according to distance. The instrument which I propose to use is a large steam whistle so designed that a pianoforte touch will give a large opening to the steam way, and enable a percussive short or long sound to be emitted. The diagram on the wall shows a sectional view of my patent steam whistle telegraph. It will be observed that the centre spindle has upon it two equilibrium valves, which are so balanced as to be affected by the lever with the greatest ease, even though there may be a pressure of eighty or a hundred pounds to the square inch on the valve faces. This arrangement makes it possible for large whistles to be worked whose supply pipes may be three, four, five, or six inches in diameter. The bell of the whistle is adjustable in order that high or low-pressure steam may be used, and the best results be thus obtained from the steam that the boiler may carry when it is at work. This steam whistle I propose to elevate about ten or twelve feet above the head of the operator, who by means of a chain attached to the lever, and a handle, can work it and send messages by means of the dot and dash system, using either the Morse or any other code or alphabet. I prefer the Morse code for what appear to me sufficiently weighty reasons. In the first place, this code is already in use wherever the electric telegraph system is known. Every telegraphic instrumentalist in this country, in France, America, Russia, India, Germany, or anywhere else, uses this alphabet. And further it is fortunate that this alphabet can be either written, seen, or heard. This peculiarity is particularly serviceable in this instance, and I wish specially to draw attention to the universal adoption of the Morse code, because if this system of signalling is to be introduced, to be of real service, it must be international, in order that the vessels sailing under all flags may be able to use it with mutual benefit. This fact enables us to see that a staff already educated is immediately available. I have made experiments in various parts of this country, and have on three separate occasions obtained the services of young men from the postal telegraph stations in the towns in which I have happened to be, and they have instantly understood the dot and dash sound telegraphy, and have been able to use my small instruments without any previous practice at all. I have not been able to make experiments of a thoroughly definite nature on long distances to ascertain as to how far sound may be sent by one of these instruments, but I believe that one of 12in. diameter is quite capable of being used successfully through a fog for a distance of six miles. That is to say, that should two vessels get separated in a fog they would be able to communicate with each other, supposing them both to be provided with 12in. whistles, even should they be six miles from one another. But I have made definite experiments with whistles 6in. in diameter, and by one of that power sound may be distinctly heard and interpreted over a distance of three miles.

I exhibit a cast iron plate having the Morse alphabet in raised characters upon it. This I would place immediately below the telegraph whistle, so that any one wishing to send a message, though he should not understand the alphabet, might yet do so readily by reference to the table. And those not technically acquainted with the system might easily master it. I am told by those connected with electric telegraphs in this country that a sharp lad can commit this alphabet to memory in two days; that it takes a dull lad four or five days, and a man from a week to a fortnight, according to his capacity.

The utility of such a system as this is at once apparent when the circumstances under which the late collision between the Iron Duke and the Vanguard took place are remembered. The Trinity House regulations at present are that during a fog every steam vessel must whistle under certain conditions; but the whistle is unintelligible, or at least unintelligent, and indicates very obscurely the whereabouts of the vessel blowing the whistle. In fact, if any one will shut his eyes and listen to a steam whistle, he would find it extremely difficult to tell whether it was before or behind him.



The want of this definite information was lamentably manifested in the recent collision. But if both vessels had been fitted with such instruments as I have described, they would not only have heard the whistle, but at the comparatively short distance which separated them they could have carried on a conversation, could have asked each other the direction in which each was going, the rate of the speed, or in short almost anything at all. Thus it will be at once seen how invaluable such a provision would have been.

Although I use the Morse code in order to show to-night the velocity with which telegrams may be sent, it is possible that codes already in use in the navy for flashlight purposes may be better than the Morse alphabet. Naval men will be the best judges of this if the instruments are practically tried. At the conclusion of my remarks, any of you who will write a short sentence may have it telegraphed into this room from an instrument 12in. in diameter, which is fixed on a boiler a few hundred yards from the building, and thus some idea of the time taken to send information may be gained.

There are also small instruments on the table which we will use for sending messages from one room to another.

It has been proposed by Mr. Swann that whistles should be sounded by the revolutions of a drum, like an organ barrel, and driven by a small engine. A stereotyped international code could be continually sounded in a fog, indicating the exact course of the vessel. Mr. Swann and I have endeavoured to bring his invention into use at a great cost to ourselves, but it is obvious that this system would be useless unless made compulsory by the authorities.

But although I have so far called special attention to the utility of my system in foggy weather, it must have been apparent that it would be quite as useful under more favourable conditions. By this means, indeed, news could be communicated from one vessel to another as fast as a man could write, and with much greater facility than under the condition of things now prevailing. A vessel coming from a distant quarter of the globe meeting another, and having important intelligence to communicate, may do so by simply diminishing her speed, and no time need be wasted while boats are being sent with letters. What a great boon this would be to the newspaper press in general may be readily understood, when it is borne in mind that the most that it is possible to obtain from outward-bound vessels are a few brief

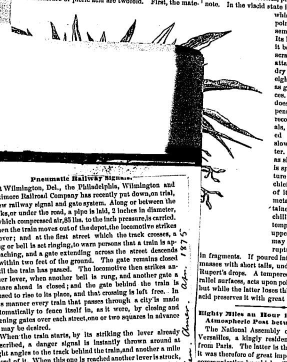
* Manchester Scientific and Mechanical Society.

cut off and laid in the sun on moist sand, where they root freely in a few weeks, and often keep on flowering as though nothing had happened.

A Profitable Source of Picric Acid.

G. C. Wittstein calls attention to a new source of picric acid. This is a long and well known drug, the resin of *xannthorrhœa arborea*, a plant which is a native of Australia. It is known as acaroid resin and as the yellow resin of Botany Bay in New Holland (*resina acaroidis* and *resina lutea Novi Belgii*). The advantages of using this substance for the manufacture of picric acid are twofold. First, the mate-

the adhering nitric acid driven off at 212° Fah. The total residue weighed 100 grains, almost ⅞ of the resin taken; it was yellow and crystalline, and contained nothing amorphous but single crystals of oxalic acid. The picric acid thus obtained, after recrystalizing to secure the oxalic acid, weighed 75 grains. Hence, the yield is 50 per cent of the crude material.



Fused Boracic Acid.

Fused boracic acid, which approaches glass in some of its external characteristics, presents some properties worthy of note. In the viscid state it may be drawn out into threads, which solidify rapidly, and from this point of view its ductility rather resembles that of silica than of glass. Its hardness, between 4 and 5, places it between fluor spar and apatite; it scratches glass, and is with difficulty attacked by sand, and even by emery, dry or with oil. It takes seven to eight times as much time in grinding as glass under the same circumstances. This resistance to friction, which does not accord with its hardness, depends doubtless, as M. Damour has recognized in the case of other minerals, on a speciality of structure. Melted boracic acid, in mass, becomes slowly hydrated in contact with water. In powder it is acted on rapidly, as shown by Ebelmen. If the powder is sprinkled with water, its temperature may rise to 100°. Boracic acid is chiefly remarkable for the persistence of its temper. If poured upon a cold metallic surface, glassy plates are obtained, the under surface of which, chilled by the metal, is more strongly tempered and more expanded than the upper. Hence results a flection which may be strong enough to cause the rupture of the plate and its projection in fragments. If poured into oil it may be obtained in small masses with short tails, under the same conditions as Prince Rupert's drops. A tempered plate of boracic acid, with parallel surfaces, acts upon polarized light like tempered glass; but while the latter loses this property by re-heating, boracic acid preserves it with great tenacity.—*V. de Luynes.*

to the Roman period. On the latter supposition they would seem to show that too much time had generally been ascribed for the accumulation of deposits. Mr. Deas, C.E., remarked upon it as a noticeable fact that the canoe recently discovered near the large crane at Stobcross had been embedded at a point on a level with the Roman roadway. He intended shortly to expose a portion of the roadway so that those interested might have an opportunity of viewing it.

INSTITUTION OF CIVIL ENGINEERS.—On Tuesday evening, M. Charles Bontemps, engineer in the French postal service, read a paper on "Experiments on the Movement of Air in Pneumatic Tubes." The establishment of the pneumatic system in Paris afforded the author an opportunity of investigating the movement of air in the tubes. For this purpose a system of registration was adopted, electric indicators, connected by wires with a chronograph, being placed at intervals along the experimental tube. Each indicator consisted of a box, containing two cams controlled by springs and a projecting stud. At the spot where the box was attached to the tube, a hole was drilled in the latter, and the box was placed in such a position that the stud entered the hole in the tube, its rounded end projecting slightly beyond the inner surface. The carrier in transit struck the stud, which actuated the cams, and the electric circuit being thereby closed, a mark was made upon the chronograph. This instrument consisted of a train of clockwork giving motion to a cylinder, round which was wrapped a sheet of smoked paper. Parallel to the axis of the cylinder there was a carriage bearing two electric magnets, one in connection with the indicator in the tube, and the other with a second-beating electric clock. Each armature was terminated by a fine point, which reproduced on the smoked paper the oscillations of the palette. Motion was given to the carriage by a cord and weight. The carrier, in passing along the tube, closed the circuit on striking the studs producing a deflection in the straight line traced by one point on the smoked paper. The other point produced a regular indented line parallel to the former, each indentation representing one second. These lines alternated with one another. As soon as the observation was taken the smoked paper was removed, and the surface was fixed by placing it in a solution of gum. The moment of commencing the experiment was electrically noted by a commutator attached to the cock between the reservoir and the tube. The experimental tube had a total length of 6504 feet 8 inches. It was made of wrought iron 2·52 inches in diameter, in lengths of 16 feet 4½ inches; and connected the central station at Rue de Grenelle, St. Germain, with that of the Place du Théâtre Français. From experiments the author deduced:—(1) That the time occupied by each piston in traversing the interval between two successive indicators closely approximated, which showed that the two pistons required similar periods to traverse similar distances. (2) That two pistons which had acquired their normal distance apart, preserved it throughout the whole journey. (3) That the progress of the carrier last introduced was independent of the initial position of the first. From No. 2 it followed that the density of the air was constant from the commencement to the end of the journey as soon as uniform movement in the tube was established.

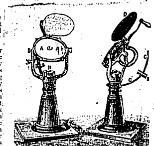
ARMY SIGNALLING.

[9771.]—I SEND a description with diagram of an invention of my brother in Australia, who has desired me to send it to you, as he thought it would be interesting to English readers. The account is taken from the *Sydney Mail*.

At a time when the attention of the public is constantly being directed to military matters, anything that relates to what may now be truly called the science of warfare will no doubt prove interesting to the readers of the ENGLISH MECHANIC. An instrument has lately been designed by Lieut. T. S. Parrott, Volunteer Engineer, New South Wales, proposed to be used for army signalling purposes. The annexed engravings show the front and side elevations of a sematrope, the name given to the instrument. It is an adaptation of the heliostat, or heliotrope, used in trigonometrical surveying operations, and is capable of being used with facility under moderately favourable conditions of atmosphere to a distance of about fifty miles, over which extent messages may be transmitted; and although such an instrument may be used in surveying operations, the peculiarity of its construction has been so regarded as to give the greatest possible facility to the transmission of telegraphic messages by means of the Morse or any similar system:—"The first point of difference between this instrument and the heliostat is in the reflecting medium employed, which is a mirror, the reflecting surface of which is an arc 4·5in., whose versed sine is ·01. The object of this curve is to meet the difficulty arising from the apparent motion of the sun, which is constantly changing the direction of the reflected rays from the surface of the mirror. The effect of this curve is to disperse the rays to such an extent as will materially increase the length of time during which the flashes can be made without adjustment, and at the same time without reducing, to any serious degree the brilliancy of the light. In signalling with a mirror it is a very essential point that it should be free from the slightest vibratory motion—in fact should be fixed perfectly steady, and remain so—during the process of flashing the signals. This object is attained by fixing the moveable portion of the instrument to a heavy cast-iron base, around the top of which the mirror is made to revolve, and to which it is firmly clamped when in position. Another feature peculiar to this instrument is in the lens tube for directing the rays, which has been so arranged as to work independently of the mirror; it is made to revolve around the upper part of the cast-iron base upon a curved arm, whose centre coincides with the centre of the mirror, to which point it is therefore always directed (the tube being fixed at right angles to a chord of this arc, on a sliding bar, which may be clamped in any position).

"The heliotrope was invented by Gauss (a celebrated German mathematician) about the year 1821, for the purpose of rendering the vertices of the triangle visible in the triangulation of the kingdom of Hanover. Captain Drummond, R.E., afterwards invented an instrument (called the heliostat) which was used with great success in the triangulation of Great Britain, and similar instruments have been used in geodetic operations in the United States of America and other countries.

"The Germans appear to have given the most attention to these instruments, and have at various times introduced improvements in their construction—improvements chiefly intended to overcome the difficulty of directing the reflected rays to any given remote point.



"The principal features of the sematrope which render it available for signalling purposes are:—

"1st. The convexity of the reflecting surface A, by which means the reflected rays of the sun are diverged, and will therefore be visible from a distant point for a much longer period of time than rays reflected from a plane surface.

"2nd. The lens tube B, for indicating the direction of the reflected rays, is so arranged that it may be adjusted without moving the mirror.

"3rd. The mirror may be adjusted without giving any motion to the arm C carrying the lens.

"4th. A moveable cover, D, to the mirror is provided, by means of which flashes of light may be shown in such a manner as to transmit messages by a system similar, to that adopted in electro-telegraphy.

"In 'Chambers' Encyclopædia' the heliotrope is described as being used by surveyors for rendering distant stations distinctly visible. This is managed by placing a mirror at the distant station, and adjusting it so that at a particular hour of the day (arranged beforehand) the light of the sun shall be reflected from the mirror directly to the surveyor's station.

"The surveyor must make his observation almost at the instant he sees the glancing of the mirror, as the constant change of the sun's position in the heavens produces a corresponding change in the direction of the rays reflected by the mirror. Gauss invented such an instrument about 1821, which is used abroad, especially in America, for geodetic surveys, and is said to possess such power that a mirror 1in. square is visible 8 miles off in average sunny weather, and appears as a brilliant star at a distance of 2 miles; while some heliotropes have been used so powerful as to be visible nearly 80 miles off.

"The term heliostat, applied by Captain Drummond to an instrument invented by him for the same purpose, more properly belongs to an instrument invented by S. Gravesande, consisting of an equatorial revolving on its polar axis, so that the sun, when once accurately in the focus of the telescope, continues steadily fixed there.

"Recent experiments have been made with a sematrope by Mr. Parrott, which have proved the capability of performing the work for which it was designed."

Lieutenant Parrott has also made experiments with his instrument by the light of the moon, and succeeded in flashing messages over a distance of 8 miles.

Frank Parrott.

Pneumatic Railway Signals.

At Wilmington, Del., the Philadelphia, Wilmington and Baltimore Railroad Company has recently put down, on trial, a new railway signal and gate system. Along or between the tracks, or under the road, a pipe is laid, 2 inches in diameter, in which compressed air, 85 lbs. to the inch pressure, is carried. When the train moves out of the depot, the locomotive strikes a lever; and at the first street which the track crosses, a gong or bell is set ringing, to warn persons that a train is approaching, and a gate extending across the street descends to within two feet of the ground. The gate remains closed until the train has passed. The locomotive then strikes another lever, when another bell is rung, and another gate a square ahead is closed; and the gate behind the train is caused to rise to its place, and that crossing is left free. In this manner every train that passes through a city is made automatically to fence itself in, as it were, by closing and opening gates over each street, one or two squares in advance as may be desired.

When the train starts, by its striking the lever already described, a danger signal is instantly thrown around at right angles to the track behind the train, and another a mile ahead of it. When this one is reached another lever is struck, and the last mentioned signals are thrown back to their former positions, showing the first mile to be clear; and the two other signals, one behind and one a mile ahead of the train, are exposed, and so from mile to mile along the whole road. At every point of its progress a train is thus between two signals, one to warn trains coming toward it, the other to warn trains following it.

Scien. Amer. Apr. 1875

Eighty Miles an Hour in Pneumatic Tubes.—The Atmospheric Post between Paris and Versailles.

The National Assembly of France holds its sittings in Versailles, a kingly residence distant some eleven miles from Paris. The latter is the real seat of government, and it was therefore of great importance to introduce a means of communication by which official documents could be transmitted between the two places, at any moment when required, with great rapidity. For this purpose the pneumatic method has been put into operation, with much success, and it is stated that letters and packages are now sent through, in either direction, in eight minutes' time, being at an average velocity of more than eighty miles an hour.

To produce this enormous velocity—the tubes being only four inches in diameter—requires the use of three steam engines having an aggregate of one hundred and fifty horse power, besides other extensive apparatus, which we will briefly describe, quoting from a recent number of the *Engineer*.

A report on the system of M. Crespin, on the application of pneumatic power over long distances, has been reported upon by M. Tresca, of the Conservatoire des Arts et Métiers, with the Academy of Sciences, and the report is now published. We copy from the *Engineer*.

When it was found necessary to connect Paris and Versailles by means of a pneumatic tube, it was impossible to make use of the method adopted in Paris, which only gives the required speed over a distance of about 1 mile. The problem was to apply the same force along a line from 11 to 12 miles in length. This result has been obtained by the adoption of an apparatus called a relay, which, placed at various points along the line, acts upon the train and urges it at full speed to the next station. The column of air within the tube is set in action by forcing or by exhaustion, and the two operations are employed concurrently, but in a novel manner.

As in the pneumatic telegraph, M. Crespin uses a series of boxes to form a train; the impulse is given by forcing the air in at one end of the tube and exhausting it at the other; the pressure accumulated in the reservoirs comes into action at the moment the train passes a relay, and continues until the arrival of the train at the next post, when it is taken up by another reservoir, and so on to the end.

The line is double, up and down, and each is divided into sixteen sections of 3,650 feet in length, and each section has its relay. The necessary motive power is obtained from three stations, one at each end of the line, the other in the middle. The last is the most important, and comprises two engines of fifty horse power each, with pumps capable of exhausting the 280 cubic yards contained in the part of the line it serves in ten minutes, at the same time storing it in the reservoirs under the pressure of one atmosphere, necessary to supply successively behind the train 188 cubic yards

S. A. Sep. '75

8

The Heliograph of Mr. Mance.*

BY C. BECKER.

Though the general introduction of Electric Telegraphy, and the all but universal adoption of the Morse alphabet, it occurred to Mr. Mance—who has the advantage of a thorough knowledge of both, and the privilege, if it can be called one, of a long residence in a country with plenty of sunshine—to develop and improve the existing appliances into a system. His aim has been to produce an instrument which is very compact, very portable, easily set up, and easily worked. Although he was first in favor of larger instruments (which are still preferable for permanent stations), he is now convinced that an instrument of the size here shown is all that is requisite. The chief objection to the adoption of the sun-telegraph is, that we cannot command the sun to shine in the same manner that we can control a galvanic battery; and it must be understood that Mr. Mance advocates his system only as an auxiliary to other systems of field telegraphy. It would come into operation at distances when other methods are useless or tediously slow, and it compares favorably with existing systems of signaling in cheapness, range, rapidity of communication, and, last, in portability. The flashes are invisible to any one placed far to the right or left of the direct line, so that, from elevated points, far distant communications could be kept up with a fortress without the besiegers having any suspicion of the fact.

It would be superfluous to give instances, when within the last few years the use of these instruments might have brought about the most important results.

The instrument consists of a light, but firm, tripod-stand, similar to those used for prismatic compasses. On the top a plate is moved by a tangent screw which admits of quick and slow motion, and the plate carries on a pin a semicircular ring, which again carries on pivots the round mirror, the silvering of which is removed in the center for the space of a circle about 3-16th inch diameter. To the plate is also attached a simple key, which is pressed down and springs back like an ordinary Morse key. This key is connected with the top rim of the mirror by a steel rod, which can be lengthened and shortened—as occasion may require—by turning the handle and screwing the rod through the small brass ball which secures it to the edge of the mirror.

By means of the last-named adjustment and the tangent-screw the glass can be altered, as the ever-changing position of the sun may require.

From 12 to 15 yards in front of the instrument is placed a sighting-rod. This rod is to mark a spot exactly in a line with the center of the heliograph and the distant station. A metal stud marks the spot, and a wooden cross-piece marks where the flash rests when not directed on the opposite station.

The instrument can be set up ready for working in a few minutes. When the exact position of the distant station is not known, a flash of sunlight must be thrown in the direction of the most likely points, and this must be continued till it is answered by a flash, which indicates that a distant signaling party is on the look-out. Then, after releasing the tangent-screw, the glass must be turned to a convenient angle, and the sightingstick must be directed in a line with the distant station by looking through the small aperture in the center of the mirror. When this is effected, the stud must be raised or lowered till it is in the line of vision on a level with the center of the glass and the distant flash, and the short cross-piece must be placed at right angles to the upright, about a foot below the stud. After being thus adjusted the instrument must not be moved.

The spot will be observed gradually to rise or fall, according to the direction in which the sun is apparently moving. The handle of the key, or the tangent screw, or both, as the case may be, must be turned slightly after every two or three words, to insure, as far as possible, that the center of the spot shall be on the stud when the key is pressed down.

When the sun is rather low in the heavens, and behind the signaller, it becomes more difficult to direct the flash with accuracy. In consequence of the obtuseness of the angle the spot loses its circular form, and becomes rather dim when reflected on the stick. If it is required to work frequently with the sun in this position, the employment of a second glass on a light tripod stand is recommended.

But it would be useless here to enter more into the minutiæ of working the instrument: suffice it to say that, in experienced hands, twelve words and more per minute have been obtained, while others state that men—after a fortnight's practice—could attain only from four to five words per minute. As to the distance, 10 and 20 miles—and in very clear weather 40 miles—have been obtained.

A number of officers of the Indian Army have tried and reported upon the instrument, and—with the exception of one—all report most favorably of the system as an auxiliary to existing systems, and efforts are being made at the present moment to insure their adoption for the Indian Service by the authorities.

*Read before the Society of Telegraph Engineers.

1875

Engineer Mch 18 1881

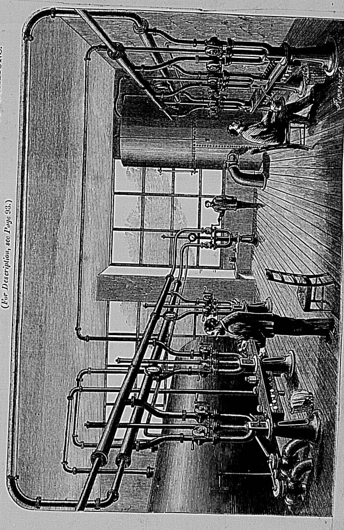
According to the census lately taken, the population of the German Empire is now 45,194,172 persons.

During a hailstorm in Geneva on January 19th, Prof. Colladon observed the hailstones as they fell repel each other mutually and to bound about after lying quiet for a moment or two on the ground exactly after the fashion of the pith balls in Newton's well-known experiment of the electric hail. The observation, says *Nature*, would appear to have a bearing on Volta's somewhat neglected theory of the formation of hail.

9

PARIS PNEUMATIC TELEGRAPHS; GENERAL ARRANGEMENT OF STATIONS.

(For Description, see Page 93.)



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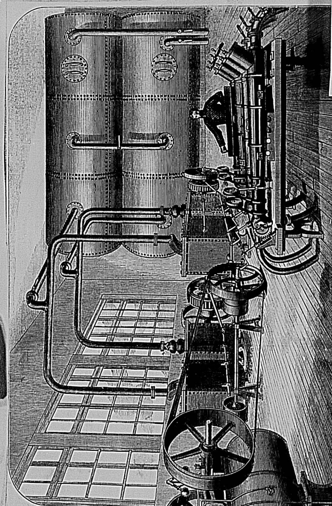
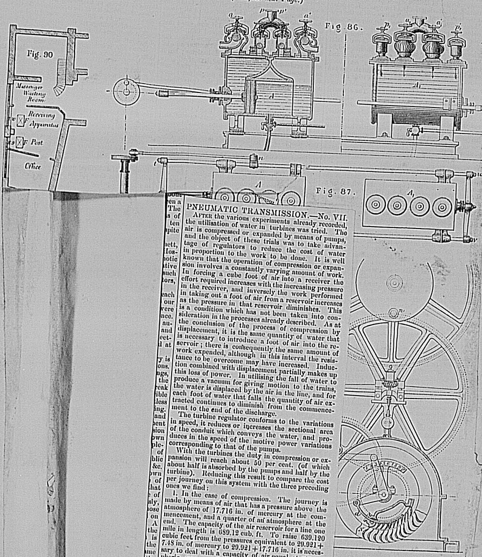


PARIS PNEUMATIC TELEGRAPHS; ARRANGEMENT OF TURBINES AND PUMPS, &c.

(*For Description, see next Page.*)



11

PNEUMATIC TRANSMISSION.—No. VII.

AFTER the various experiments already recorded, the utilisation of water in turbines was tried. The air is compressed or expanded by means of pumps, and the object of these trials was to take advantage of regulators to reduce the cost of water in proportion to the work to be done. It is well known that the operation of compression or expansion involves a constantly varying amount of work. In forcing a cube foot of air into a receiver the effort required increases with the increasing pressure in the receiver, and inversely the work performed in taking out a foot of air from a reservoir increases as the pressure in that reservoir diminishes. This is a condition which has not been taken into consideration in the processes already described. As at the conclusion of the process of compression by displacement, it is the same quantity of water that is necessary to introduce a foot of air into the reservoir; there is consequently the same amount of work expended, although in this interval the resistance to be overcome may have increased. Induction combined with displacement partially makes up this loss of power. In utilising the fall of water to produce a vacuum for giving motion to the trains, the water is displaced by the air in the line, and for each foot of water that falls the quantity of air extracted continues to diminish from the commencement to the end of the discharge.

The turbine regulator conforms to the variations in speed, it reduces or increases the sectional area of the conduit which conveys the water, and produces in the speed of the motive power variations corresponding to that of the pumps.

With the turbines the duty in compression or expansion will reach about 50 per cent. (of which about half is absorbed by the pumps and half by the turbine). Reducing this result to compare the cost per journey on this system with the three preceding ones we find:

1. In the case of compression. The journey is made by means of air that has a pressure above the atmosphere of 17.716 in. of mercury at the commencement, and a quarter of an atmosphere at the end. The capacity of the air reservoir for a line one mile in length is 689.12 cub. ft. To raise 639.120 cubic feet from the pressures equivalent to 29.921+7.48 in. of mercury to 29.921+17.716 in. it is necessary to deal with a capacity of air equal at atmospheric pressure to 236 cubic feet. The work necessary to force these 236 feet of air into the reservoir at the mean pressure of $\frac{17.71+7.48}{2}=$ 12.60 in. will be found by calculation to be equal to 173,170 foot-pounds, which represents the useful work of the pumps driven by the turbines, assuming that the duty is 50 per cent. as above stated, which would give a total force to be developed by the turbine of 173,170×2=346,340 foot-pounds, and a volume of water under a head of 36 ft. of about 154 cubic feet. The price of water being

... cubic feet, and that consequently the cost of ...er journey is reduced to 18.24×.1055=1.924d. ... application of turbines for the compression ...thus realises a very marked economy. Another ...age it presents over the preceding systems i... affords means of easily increasing the initi... ...re of the air, and thus of imparting variabl... ...ties to the trains. With air at an effectiv... ...re of one atmosphere at the moment of d... ...re, a speed of .621 mile per minute is attaine... ...have assumed that in working by vacu... ...pressure at starting is equal to 15.748 in. ...ry, in order that on arrival the press...

8 80 12 Sun Aug 3. 1881. Scientific Am. Oct 8. 1881.

MACHINE-MADE ELECTRICITY.

Its Test in the Western Union Main Office for Telegraph Purposes.

The substitution of dynamo-electric machines by the Western Union Telegraph Company in its New York main office for the chemical batteries has given such good satisfaction that the most of the old batteries, though still in place, have been cleaned up. None of these batteries has been in use for several months, except for short wires inside of the city. The last of the wires radiating from New York to be operated by machine-made electricity were the quadruplex lines, the longest of which are to New Orleans and to North Sidney, in Cape Breton, the terminus of the Anglo-American cable. The use of the machines, although there is little doubt it will be continued, is yet declared to be only in its experimental stages.

All the electricity used on lines running out of New York comes from two banks of machines, each bank run by a small engine of about ten-horse power. There are five machines in each bank. One of the five machines merely furnishes electricity to convert the bent soft iron bars of the other four machines into magnets, so that, in fact, each bank has only four machines for the distribution of electricity to the company's wires. Each machine is the same in principle as those used for producing electric lights, that is to say, a bobbin wound from end to end with insulated wire is made to revolve near a magnet. A current is thus formed in the wire wound about the magnet. In one of the banks of machines the bobbins are turned one way, producing positive electricity, and in the other bank they are turned the other way to produce negative electricity. Both kinds are required to meet the requirements of different offices.

The power of electricity to perform telegraphic work is called its potential, and the potential is reckoned in volts. The company gets from the first machine in the bank a potential of about seventy volts, that is to say, the equivalent of seventy cups of the Callaud battery formerly in use for main lines. A wire leads from this machine to convey electricity to those lines that require only seventy volts to operate them. There is a connection between the armature of the first machine and that of the second, at the further end of which a second wire leads to the switchboard. Its potential is about 140 volts, and it supplies lines requiring so much potential. There is an increase of potential in each machine, but it is not necessarily doubled each time, since the potential depends not only upon the rapidity with which the bobbin is geared to run, and the strength of the magnet, but on the amount of resistance. From the fourth machine is obtained a potential of about 310 volts, which is used only on the Chicago, New Orleans, and long quadruplex lines.

In case either of the two banks mentioned needs repair a third bank, run by a separate engine, may be put in use to supply either positive or negative electricity. First the new bank is set in motion and its electricity is put upon the lines which carry a double supply for a moment until the other bank is stopped. The effect on the lines is not noticeable, because, although the quantity of electricity is increased, the potential is the same.

The difference between quantity and potential is illustrated by electricians as follows: If a drop of water is closely confined and heated, it will develop a violently explosive force; but it would be instantly exhausted. On the other hand, the steam from a boiler, although by no means so hot, may be drawn off in a continuous jet. It is also said, by way of illustration, that there is not a sufficient quantity of electricity in a whole thunder storm to run a single line of telegraph, but what there is there has a terrific potential. Potential gives working power. Quantity enables the electrician to feed many lines.

There is a very low resistance in these machines, or, in other words, the electricity produced finds an easy channel. For this reason the current is supplied to each line through a resistance coil of German silver wire wound around a chalk cylinder, which furnishes a definite amount of resistance. Otherwise an accidental short-circuiting on one line might divert from all the other wires the current necessary to use it.

The company has put machines into its New York office only. In one sense they are not so much under control as the old batteries. In the case of the batteries just as many cups as might be desirable to work a line could be used. Now the electrician, if seventy volts is not enough to work a line, must tap the second machine and get double the number of volts. He cannot get any intermediate number. The machines are found to be cheaper by nearly one-half than the chemical batteries were. They take less space, and are more easily taken care of.

The Heliograph.

The London *Daily News* states that they have to thank the heliograph again for an important message received from General Stewart, and announcing the result of an attack on the British troops, in which the enemy seems to have suffered severely. The message is dated Camp Ghuzni, April 22, and was received at the India Office the following day. It is very probable that the news could not have been brought so speedily by electric telegraph. The heliograph does not require the route to be kept open. The line of communication cannot be cut, for the simple reason that the signaling takes place over the heads of the enemy, and the stations required are but few and far between. A ten inch mirror, and this is the diameter of the ordinary field heliograph, is capable of reflecting the sun's rays in the form of a bright spot, or flare, to a distance of fifty miles, the signal at this interval being recognizable without the aid of a glass. That is to say, two trained sappers, each provided with a mirror, can readily speak to one another, supposing the sun is shining, with an interval of fifty miles between them, provided their stations are sufficiently high and no rising ground intervenes to stop the rays. The adjustment of the military heliograph is a very simple matter. An army leaves its base where a heliograph station is located, and after traveling some miles desires to communicate with the stay-at-homes. A hill in the locality is chosen, and a sapper ascends with his heliograph, which is simply a stand bearing a mirror swung like the ordinary toilet looking glass, except that besides swinging horizontally it is also pivoted so as to move vertically as well. Behind the mirror, in the very center, a little of the quicksilver has been removed, so that the sapper can go behind his instrument and look through a tiny hole in it toward the station he desires to signal. Having sighted the station by adjusting the mirror, he next proceeds to set up in front of the heliograph a rod, and upon this rod is a movable stud. This stud is manipulated like the foresight of a rifle, and the sapper again, standing behind his instrument, directs the adjustment of this stud until the hole in the mirror, the stud, and the distant station are in a line. The heliograph is then ready to work, and in order to flash signals so that they may be seen at a distance, the sapper has only to take care that his mirror reflects the sunshine on the stud just in front of him.

* Papers read before Physical Society.

should not exceed 27.16 in. Under these conditions the cubic capacity of the reservoir should equal 494.5 c. ft. This reservoir being originally full of air at atmospheric pressure, the amount abstracted by means of the pumps will be at each stroke of the piston, equal to the capacity of the pump barrel (the pressure being the same as that in the reservoir).

The mean pressure in the reservoir is

$$\frac{29.921+15.748}{2}=22.834 \text{ in.}$$

To reduce the pressure in the reservoir from that of the atmosphere to 15.748 in., it is necessary to withdraw a capacity of air at the average pressure equal to

$$491.5\times\frac{29.921-15.748}{22.834}.$$

The work to be performed by the pumps is the difference between the work at atmospheric pressure equal to 29.921 in., and that at the mean pressure 22.834 in. Its equivalent is the product of the volume, $491.5\times\frac{29.921-15.748}{22.834}$, by the difference $(29.921-22.834)=7.087$ in. of mercury, which converted into equivalents of water represents 3.85 in. On making the calculation it will be found that the amount of useful work of the turbine is equal to about 153,000 foot-pounds, which corresponds to the power developed by the water used of 306,000 foot-pounds, representing a quantity of water with a fall of 52.5 ft. equal to $\frac{306,000}{52.5\times62.5}=$ 93.28 cubic feet. The cost of a journey under these conditions would be, therefore, 1.7d.

The arrangement of the double acting pump adopted is shown in Figs. 86 and 87, on the opposite page. One of the barrels A supplies the compressed air, and the other A_1 exhausts the reservoir; this action being produced by the suction valves $a\,a^1$ and the delivery valves $p\,p^1$. These latter admit the compressed air to the reservoir, and the former exhaust the air from the vacuum reservoir. The other valves $a\,a^1$, $p\,p^1$, are in communication with the atmosphere. The pistons P, P_1 are fitted with gun-metal rings, and motion is given to them through the crosshead $t\,u\,v\,x$, and the connecting rods $m\,n\,p\,q$, which are actuated by the turbine. This system is employed for working a post like Fig. 47 (see page 353 of our last volume). The dimensions of the whole apparatus are such that they can exhaust the air to give motion to the trains on the section 7-10 (.621 mile long) and compress it for working the similar sections 10-9 and 9-8.

The pumps make 22 strokes per minute, and the respective volumes A and A_1 are 2318 and 1891 cubic inches. Proper means are provided for keeping the pumps well supplied with water. In the turbines employed the number of openings for receiving the water can be varied according to the work to be done, by means of a centrifugal regulator. We may now give a description of Fig. 88. The water enters the turbine by the passage O and is spread by means of the directrices M upon the wheel N, which is thus caused to revolve together with the shaft $y\,z$. With a fall of 39 ft. 6 in. a turbine of this pattern 23⅝ in. in diameter makes 245 revolutions per minute, and discharges 1.72 cubic feet of water per second when ten openings are supplied, which is the maximum number in this type. The speed of 245 revolutions per minute is reduced down to 22 before it reaches the pumps by the gearing $a\,b\,c\,d$. To the last wheel d are attached the connecting rods $p\,q$ of the pump.

The regulator R receives motion by means of the wheel b, in accordance to the variation in the speed, and turns the wheel l either in one direction or the other, by means of the bevel wheels f and f_1. The motion of the wheel l determines the advance or recession of the covering plate d, which opens a greater or less number of orifices.

It will now be expedient to group the various details together into their proper positions, in order to give a clear idea of a station. Figs. 89 and 90 on the opposite page are plans of the floors of a station in which the method of working by compression and exhaustion by means of turbines is employed for three sections, 7-10, 10-9, and 9-8. The station is situated at point No. 10, Fig. 47, see page 353 of our last volume.

The basement contains the turbines T, the pumps B, and the pressure and vacuum reservoir C and D respectively, with the necessary connecting pipes.

On the ground floor, Fig. 90, are the receiving apparatus E and F connected with the lines 7-10 and 10-9; the rarefied or compressed air is conducted by special pipes.

The drawing shows two turbines and two pairs of pumps, as the station is designed for a continued service, and it is necessary to have the second in readiness whilst repairs are being executed.

Finally, in order to work the transmitting apparatus, transmission shafts control the cocks placed in the feeding pipes. It is sufficient to close or open these cocks to stop or start the pumps for compression or exhaustion, according to circumstances.

The water of the Ourcq has not an equal pressure throughout Paris. When the level of the station is as high as that of the basin of Villette, which is fed by this river, it is necessary to abandon the use of water, or rather other water may be utilised (for example, that of the Seine, Dhuys, &c.), but the cost is doubled at least. It is, therefore, necessary to make use of steam power, which is inconvenient of application in the crowded portions of the city.

We here make a new step in the direction of economy, for it will be easy to show that it is cheaper to employ steam for driving pumps arranged as just explained, than water. Using again the same data as before, the work necessary for compressing the air required for one journey is 173,170 foot-pounds. The time assumed for the journey being 15 minutes, the work to be performed by the machine is equivalent to .35 horse power.

The proportion of useful work given out by the pumps may be taken at 70 per cent., so that the actual power required would be .50 of a horse power to compress the air required for one journey.

The consumption of coal per horse power per hour may be assumed as 6 lb., and this would only show a cost of .14 pence per journey.

But the cost of coal is not the only one to be considered in this calculation. Additional labour is involved, the value of water, oil, &c., must be also be included, and indeed the cost of the coal may be assumed as one-third or one-quarter of the total outlay. Taking this latter proportion, we shall have the result of

$$.14\times4=.56d. \qquad . \quad . \quad . \quad (6)$$

as compared with the result previously obtained by the other methods—the turbine, and displacement, simple or modified.

Referring only to the cost (4) which refers to compression with turbines working under a head of 52.5 ft., we find that steam power costs 2.5 times less than that derived from the water of the Ourcq, utilised in the best possible manner.*

We indicate the two principal methods of working by compression or exhaustion in the illustrations on page 88. The upper figure shows the general arrangement of the station in the Place de la Bourse, in which are placed seven vertical receiving and distributing apparatus. Two reservoirs in communication with the water mains producing the compressed air by displacement in the accumulators are placed in the basement of the station.

The lower figure shows the arrangement of the central station Rue de Grenelle, St. Germain, with horizontal receiving apparatus, and pumps worked by a six-horse portable engine. With this power, trains are worked over nearly 9 miles of line, the intervals between each being 15 minutes.

The receiving apparatus in reality occupy two different parts of the stations, they have, however, been grouped together that they may be seen in the drawing.

* In all the calculations that we have thus successively presented for estimating the comparative cost of working, no account has been taken of first establishment charges, or of amortisation.

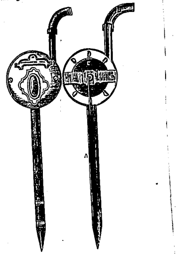
.94

The Mance heliograph, an optical telegraph apparatus, has been recently tried for telegraphic purposes across the Straits of Gibraltar, from Algesiras to Ceuta, a distance of seventeen miles. The rate of transmission is about half that of the Morse. When a new "heliograph" for night signalling and cloudy days is completed, the system will be adopted, as it is found difficult to maintain the ordinary submarine cables across the Straits.

14

PNEUMATIC PEN.

AMONG the many attempts of inventors to supply a ready means of copying an indefinite number of writings, drawings, etc., is the apparatus shown in sketch, which, apart from the question of utility, is at least simple and ingenious. The pneumatic pen, as it is called, is not new in principle, as a perforating machine, acting in a similar way, has been in use by embroidery manufacturers for many years, and all that the inventor of this apparatus has done is to arrange the whole thing in such a simple way that it can be as readily used as an ordinary pen. The tube A in the illustration contains the needle B, which is connected to a crank on the axis of the fan-wheel C. Rapid motion is imparted to the fan by means of a blast of air either from the mouth of the writer or an air-bellows, through the flexible rubber tube D, connected with a



PNEUMATIC PEN.

foot-bellows or blown from the mouth of the operator. On moving the point of the pen over a sheet of paper, it becomes pierced with very fine holes in lines of the desired pattern. Ink or color is then spread over the surface which fills the holes, and passes through the stencil to as many sheets of paper as may be brought in contact with it. Originals may, it is stated, be multiplied in this way at the rate of 300 per hour. —*Eng. Mechanic.*

Dec. '76

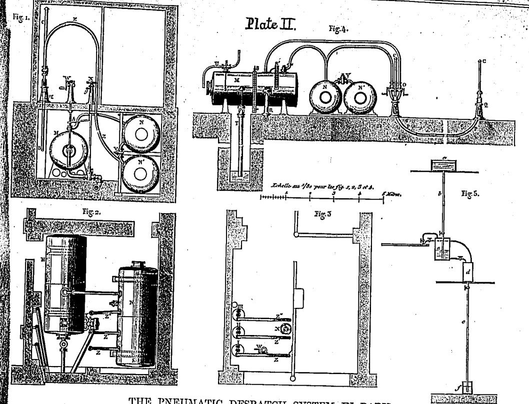
The Western Union Telegraph Company are laying down two pneumatic tubes and underground wires in New York, between the main office, corner of Broadway and Dey-street, to No. 14, Broad-street office. Two tubes will also be laid from the main office to 134, Pearl-street, and the Cotton Exchange offices. June '76

The pneumatic tubes will be of brass, which has been decided upon as preferable to lead or iron for this purpose. The carrier is a gutta percha pouch or box, covered with felt, two inches in diameter, with a band of felt projecting around the ends. Each carrier has a capacity for 50 messages, which are kept in place by a rubber band.

Duplex engines (working both by compressed and exhaust air) are to be used to force the boxes through the tubes, by means of which boxes will be sent in alternate directions through the pipes. The pistons of the pumps have an internal diameter of over two feet.

Subterranean wires will also be laid over the same routes, in cast iron pipes three inches in diameter, and which will be capable of containing 125 wires each.

The work is being carried out under the superintendence of Mr. George B. Prescott, the electrician to the Company, who came to Europe two years ago to examine the various systems employed in England and the Continent.



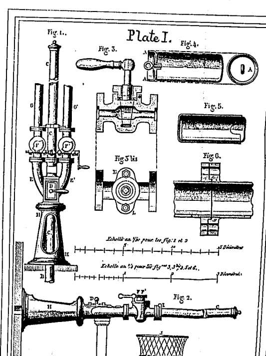
THE PNEUMATIC DESPATCH SYSTEM IN PARIS.

[illegible]NEUMATIC DESPATCH SYSTEM IN PARIS.

[illegible]ris at the present time is traversed by [illegible] th[illegible]een miles of tubes, through which [illegible]sages are transmitted between nearly all principal localities in the city by pneumatic pressure. Paradoxical as it may appear, the rapidity with which despatches may [illegible] means be sent between short distances [illegible] that of the telegraph, when the number of distinct despatches which it is possible [illegible] in a given time is taken into consideration. Forty messages of one hundred fifty [illegible] each per hour is about as rapid [illegible] as can ordinarily be accomplished on a [illegible] wire, allowance being made for the [illegible]sary writing out of the despatches, etc. [illegible] the pneumatic tube connecting with the [illegible] stock quotations are forwarded to various parts of the city at the rate of 8000 per [illegible], it being possible to start twenty trains [illegible] boxes containing four hundred written despatches each in that period of time.

[illegible] apparatus employed, invented by MM. [illegible] and Rouart, is extremely simple, and [illegible] be understood from the annexed engraving, extracted from the *Bulletin de la Société [illegible] Encouragement pour l'Industrie Nationale.* [illegible] tubes are of a uniform diameter of 2.6 inches, and are drawn of wrought iron. The joint which connects the sections is represented in Fig. 6, Plate I., and is rendered tight by a thin sheet of india-rubber placed between the partitions. These connections are placed at distances of about 25 feet apart. The carriages used are of two kinds: those which receive the pneumatic pressure, and so are forced through the tubes; and those which make up the train, which is drawn by the former, and in which the written messages are directly deposited. The first are hollow cylindrical boxes of wood or metal (Fig. 4, Plate I.), and to the rear of each is secured a leather-flanged disk, which packs itself against the interior of the tube when impelled by the blast. The other carriages are of metal, covered with leather, and resemble in shape and form small cigar-cases (Fig. 5, Plate I.). They are about 4 in. less in diameter than the tube, and simply glide along its interior when drawn by the pulling carriages above mentioned. The speed of the train is some 30 miles per hour, under a total pressure in the tube of from 44 to 55 lbs.

The principle of the apparatus, by which air is compressed in rear of the carriages, or a vacuum formed in advance of them, either or both of which means of propulsion can be used at will, is exhibited in Fig. 5, Plate II. *a* is an air-tight reservoir, connected by the pipe *b* with the elevated receptacle *c*. In the latter water enters from the city mains, and, descending with a pressure proportionate to the head, enters *a*, and compresses the air



THE PNEUMATIC DESPATCH SYSTEM IN PARIS.

therein until an equilibrium of pressure ensues. If *a* contain one cubic foot of air, for example and the water enters to fill half its volume, the air then will be under a pressure of two atmospheres, and may be led off by pipes to perform its work. A reverse process produces the vacuum. The water already in *a* is led into the chamber *d*, whence a tube, *e*, descends to a chamber situated more than 32 ft. below. *d* being full of water, and communication being opened through *e* and shut from *a*, it is obvious that a water barometer will be formed and the water descending in *e* will leave nearly, a perfect vacuum in *d*. It remains only to shut the cock in *e* and open connection through the pneumatic tubes when the normal air pressure in rear of the carriages will impel them.

The starting and receiving apparatus, which are identical, and may be placed *either vertically or horizontally*, are shown in Figs. 1 and 2, Plate I. B is the message tube, terminating in a vertical portion C, on which is an iron box D, having a door which may be hermetically closed. From said box extend branch tubes, EE′, in which are placed valves or cocks, operated by the toothed sectors FF′, and the endless screw and crank shown. The arrangement of these valves is such that when one is opened the other is closed, and *vice versa*, the single crank operating both at once. The train of carriages is dropped through the box D into the tube C, the door is closed, and if compressed air is to be used, the handle is turned so as to admit the pressure, for example from tube E; the other tube, which opens into the atmosphere, is necessarily then closed. If a vacuum is to be employed, the crank is turned so as to reverse the valves, the compressed air being shut off, and that of the atmosphere allowed to enter.

When the carriages reach their destination, they pass the box D, where the compressed air finds an exit, and shoot into the prolongation C. By compressing the air before them they form an air cushion, which checks their momentum without shock, and they rebound. They then may be removed at D, or may be allowed to accumulate in C, which is hinged at I, Fig. 2, so as to be opened when desired for their removal. Electric communication between stations gives warning of the departure of trains, etc.

The air-compressing and vacuum apparatus actually in use is exhibited in plan Figs. 2 and 3, and end and side elevations in Figs. 1 and 4, Plate II. M is the water chamber, and N N (two cylinders being employed for economy of room) are the air or vacuum chambers. O is the transmitting apparatus, P the tube, and Q the receiver. R is the water-pipe leading from the city mains, the water from which compresses air in M, which air is then drawn off for use into the cylinders N N. S is a water-gauge to show the water level within. The chamber M may also be used as a vacuum

16

1876

M. Henri C. Mance a imaginé un héliographe avec manipulation du système Morse. Il se compose d'un petit miroir qui refléchit les rayons solaires et dont le rayon est perceptible, avec une bonne orientation, jusqu'à une distance de 80 kilomètres. La manipulation consiste à faire frapper le miroir contre une vis qui fixe le point d'orientation, de la même manière que l'on manœuvre un levier Morse. Beaucoup plus simple dans son mécanisme et dans son réglage que les appareils héliographiques déjà imaginés (notamment celui de M. Lesseurre qui a été expérimenté et, dans certaines circonstances, appliqué en Algérie à des distances de 30 à 40 kilom. [1]), l'héliographe de Mance est comme l'héliographe Lesseurre, basé sur une combinaison de rayons de longue et de courte durée, correspondants aux traits et aux points de l'appareil Morse. La difficulté pratique, pour des distances un peu considérables, consistera toujours dans la recherche du point de l'horizon vers lequel doit être cherchée l'orientation et, cette première opération une fois faite pour être découvert du correspondant, dans le maintien rigoureux d'une exactitude presque mathématique de l'orientation, la moindre petite déviation ayant tout de suite pour effet d'écarter de beaucoup les rayons réfléchis, du champ d'observation du poste correspondant. Pendant la nuit, l'on peut recourir à une source de lumière artificielle, mais son éclat plus faible ne saurait naturellement être réfléchi par le miroir à d'aussi grandes distances.

[1] V. Annales télégraphiques, No d'Octobre-Novembre 1855 et le rapport favorable du maréchal Vaillant, Comptes-rendus de l'Académie des sciences, séance du 16 Juin 1856.

IMPRIMERIE RIEDER & SIMMEN A BERNE.

Le Golfe de Naples

Jeudi 18 Août 1881

Le télélogue

On vient de faire en France des expériences nombreuses et variées sur une nouvel appareil de télégraphie optique, appelé télélogue. Ces expériences étaient dirigées par une commission prise dans une section technique de télégraphie et désignée en même temps par le ministre des postes
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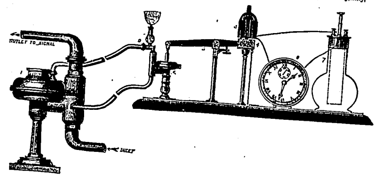
FLASH-SIGNALS.

By D. Bruce Peebles.

The apparatus consists of an ordinary gas-governor (1)—the one we have here is a dry governor, but it may be either of the wet or dry kind; it is entirely inclosed—and a small controlling governor (2) arranged to throw the pressure of the inlet gas upon the bell or diaphragm of the larger or supply governor, thus opening the valve. A small stream of the inlet gas flows into and out of the diaphragm, or bell chamber, and may be let away through an orifice, either into the main outlet or by a separate outlet-pipe, thus



PEEBLES' ELECTRIC FLASH-SIGNALLING APPARATUS FOR LIGHTHOUSES, RAILWAYS, ETC.

allowing the governor to be easily controlled, and weights being put on or taken off, the small governor opens or closes the valve of the large one.

The small governor (2) is loaded to give a supply of gas just sufficient to keep the burners lighted, or this may be done by means of a by-pass, with regulating stopcock; and a separate weight, sufficient to give a maximum supply of gas, is connected to one end of a lever (3), the other end of which is fitted with an armature (4) in a position to be acted on by a small electro-magnet (5). When the electric circuit is closed, the magnet causes the lever to lower the weight on to the small governor diaphragm and open the valve; but the weight is suspended from the lever by a loose link (6), so that only the pressure of the weight acts upon the governor. When the electric circuit is broken, the lever, having its armature end sufficiently heavy, lifts up the weight from the governor, and closes the valve. We see, therefore, that the small governor acts on the large one, by loading or unloading the bell or diaphragm with pressure instead of weights; and this principle may be modified and carried out in several ways. The electro-magnetic action is got from a small bichromate battery (7), and the small timepiece (8), which makes and breaks contact, is arranged to give six flashes each minute—but any other reasonable number of flashes can be given, if required—while 1,000 lights can b

as easily acted on as the seven we have here. For lighthouse purposes, or wherever a timepiece is employed to work the apparatus, it may be considered preferable to dispense with electricity, and place the lever (3) in a position, so that it may be acted on directly by the clock, and this can readily be done by a simple mechanical arrangement, as a very small amount of power is required to lift the lever and lower the weight on to the small governor. We now put the apparatus in action, and it will be observed that the flashes are given with a precision that leaves nothing to be desired. It will be readily understood that, while the rapidity of the flashes can be greatly increased, the duration of the flash can be prolonged, if necessary. The small current of controlling gas may either flow into the main outlet-pipe, or into a separate pipe, as before stated; but it is advantageous in this case to make the outflow pass through the small orifice by a separate pipe (9), as by increasing or diminishing the size of the orifice the flash may be made sharp or sluggish, as wished, without in any way altering the pressure of the gas supplying the signal-lights.

This method of flash-signals may also be applied to railways, and a train may be made to give a visible signal of its approach at any distance from the station. A powerful gas-light might be placed at any central point which could easily be seen from any part of the station where the train is expected, and it would only be necessary to get the wheels of the engine or carriages at a mile or two miles distant, as the case might be, to touch a spring, make contact, and close the circuit, when the light would at once flash forth at full power, warning those at the station that the train was approaching. The light could either be allowed to go down after the train had passed the contact spring, or remain as a signal until some of the officials at the station released the catch-pin, thus letting the gas down again to a minimum.

The system might also be used for giving a visible time-signal all over a city, say, at nine o'clock every night, so that in every house in which gas is used, the time could be obtained by noticing the gas-flame, which would be lowered for a second or two at the particular hour agreed upon. This could easily be done by acting on the station-governor at the gas works, and correct time would be insured by using one of Mr. Frederic Ritchie's regulated clocks, a number of which are now in use in Edinburgh and other places.

It seems well adapted also for Professor Jenkins and Sir Wm. Thomson's system of eclipse signalling by the Morse alphabet, the dot and dash being represented by long and short period of darkness.

A method of balloon signalling might also be established wherever a supply of gas could be obtained. The balloon would carry up flexible gas-tubes, and the flame would be protected by a lantern and wind-guard. In such a case, if used for war purposes, a cypher would be fixed on for giving the messages, and the gas might be compressed and transported to any suitable place for giving the signals.

There is yet another purpose it might be applied to. A small apparatus of this sort might be attached to the gas-pipe of any licensed houses whose landlords were suspected of setting Forbes Mackenzie at defiance. It would, in such a case, be set to turn off the gas at eleven o'clock P.M., and put it on on again, say at six A.M. The authorities would only have to see that the clock and battery were attended to once a week, and might then rest assured that, so far as gas was concerned, no supply would be had after the legal hour of closing.

Lastly, it could be attached to the station-governor of any gas-works, and adjusted so as to give the day and night pressure at any hours the manager wished, so that, if all of us here who have station-governors had also a controlling apparatus such as this, we might have set it before leaving home to-day, with a certainty that the night pressure would be put on in our absence at the exact hour we arranged the timepiece to make contact.—*Journal of Gas Lighting*.

17

Berlin Pneumatic Despatch.—The proposed pneumatic despatch line in Berlin will have 26 kilometers of tube, and 15 initial stations. The wrought iron tubes have a clear breadth of 65 millimeters, and lie about one meter below the surface of the ground. The letters and cards which are to be forwarded have a prescribed size, and are enclosed in iron boxes, or cartridges, each of which can hold 20 letters or cards. In order that they may pack closely, they are covered with leather. From 10 to 15 cartridges are packed and forwarded at a time; behind the last cartridge is placed a box with a leather ruffle, in order to secure the best possible closure of the tube. At four of the stations are the machines and apparatus needed for the business. The forwarding of the boxes is effected either through compressed or rarefied air, or through a combination of the two. Steam engines of about 12 horse power are used for the condensation or exhaustion of the air. Each main station has two engines, which drive a compressing and an exhausting apparatus, the steam for each engine being furnished by two boilers. Large reservoirs are employed both for the condensed and for the rarefied air. The former has a tension of about three atmospheres; the latter, of about 35 millimeters of mercury. The air, which is heated to 45° C. by the compression, is cooled again in double-walled cylinders which are surrounded by water. The boxes travel at 1,000 meters per minute; a train is despatched every 15 minutes. Each circuit is traversed in 20 minutes, including stoppages. The cost of the enterprise will be about $300,000.

Aug 77

Telegraphers' Paralysis.—This peculiar nervous affection is causing some alarm at present amongst operators in America, where it appears to be unusually prevalent. It is a numbness and paralysis which affects the thumb, hand, wrist, and even forearm of the operator's right or keying hand, and positive pain is felt in attempting to handle the key when afflicted by it. It is unquestionably due to overstraining of the nerves and muscles in the rapid, minute, and monotonous motions of signalling; and is generally cured by rest. Its greater frequency in America than in Europe seems to be due to the "space" letters of their alphabet, and perhaps to the longer hours that American operators remain on duty. It appears to us that the happy mixture of dots and dashes, long and short signals in the Morse code, as it is used in England and the Continent, is calculated to prevent paralysis, for every dash is a brief rest to the hand. The matter has become so serious in America that there is a talk of introducing a a new code to replace the Morse as there practised. It would certainly be a safeguard against paralysis if every operator would learn to signal, at least moderately fast, with his left hand as well as his right. He could then occasionally rest the right, and perhaps, more expert hand, thus giving it time to recover its full vigour before any over-stressing had taken place. This disease in question excited some discussion in England several years ago, but it appears to have died out of late, since we now hear nothing of it. We should be glad to receive any information on the subject from English clerks, or others, who have it to give, for it may prove useful to American telegraphers. Have the Post Office hours of duty anything to do with its apparent disappearance from among us?

Apr 78

18

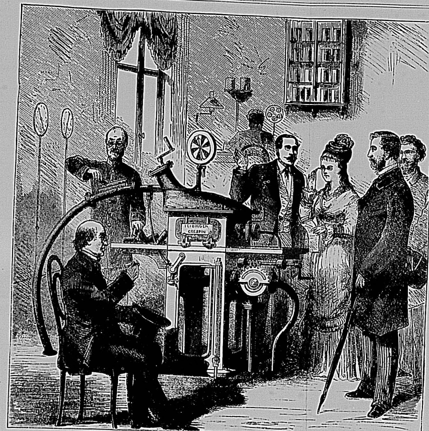
PNEUMATIC POSTAL TRANSMISSION.

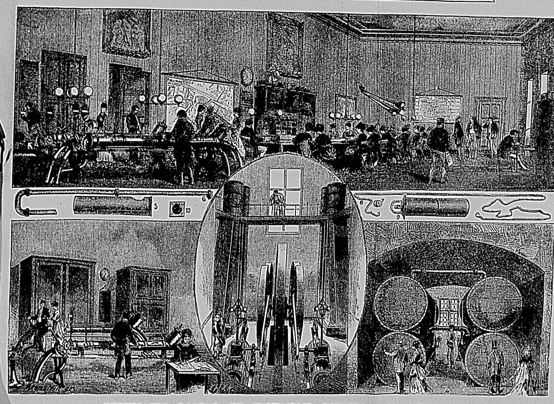
To the public works of large cities of the present day belong not only gas and water pipes, street railroads, electric telegraphs, but also the pneumatic mail connections, or "letter tubes," as they may be called. The electric telegraph requires short messages, and a certain time in condensing them, while the pneumatic mail overcomes all that. The same is not obliged to travel over the surface of the earth, as the tubes are placed subterranean, like the gas and water pipes, and within these tubes run, with a velocity of at least 20 meters in a second, the letters inclosed in boxes.

The whole system rests on the principle of the child's toy, in which, through a quill, peas are propelled in forward or backward directions. The function of the tips is taken up by a steam engine, which forms "vacuum reservoirs" by withdrawing all the air therefrom, and "pressure reservoirs" for the compressed air.

The engine of the Vienna Pneumatic Post Office has 20 horse-power. On the stations is a tubular apparatus, as shown in Fig. 2 of our illustration. An electric telegraph connects the stations to give the signals. Letters may be sent at a certain price and up to a certain weight. The letters are placed into a cylindrical box that fits exactly into the interior of the conducting tubes. Back of one or more such boxes is placed a piston that is fitted by leather packing rings tightly into the conducting tubes, and receives directly the pressure of the air from the air reservoirs. On the main station the engine works directly; on the intermediate stations the iron reservoirs, which are filled and emptied thereby. On the receiving station are means to admit the air so as to retard the speed of the boxes, while brakes and buffers prevent too heavy concussions.

The terminals of the conducting tubes are of polished brass, and resemble somewhat large trombones. The subterranean tubes are sometimes heated up by the friction of the air and boxes, and have to be cooled by water, which is forced out again by the air-pressure as soon as its object is accomplished. Sharp curves have to be avoided. The system of tubes may also be extended into private and business houses, so as to bring them in communication with one of the stations. In Vienna the system has been successfully worked since March 1, 1875, without any trouble or interruption. The large illustration represents the interior of a main and branch station, of the engine, of the air-compressors, and of the receiving and sending boxes, tubes, etc., of the Vienna Pneumatic Post Office; while the second illustration shows the interior arrangement of a Berlin station.





PNEUMATIC POSTAL TRANSMISSION, VIENNA AND BERLIN.

1. Main Station.—2. Branch Station.—3. Air Compressing Steam Engines.—4. Air Receivers.—5 to 10. Receiving and Sending Boxes.

Min & Sc. Pres July 1879

THE HELIOGRAPH.—Devices for signaling, very similar to the heliograph or "sun writer," have been in use for ages. As far back as the Persian invasion of Greece, polished metal surfaces were used to flash the rays of the sun and give warnings of one kind or another. The signaling in this and other cases was, however, imperfect, and could not be carried on over a space of more than 18 miles. But the instrument now in use, the Mance heliograph, is a great improvement, for it not only concentrates the sun's rays but it flashes them with the utmost precision to any required spot, irrespective of the relative location of the sun. It is also provided with a finger key, so that flashes may be made of long or short duration, thus permitting the employment of the Morse telegraphic alphabet. Under favorable conditions intercourse has been carried on through the medium of two of these instruments over a distance of nearly 100 miles, and at several points occupied by the English army in Afghanistan, regular communication is maintained at distances of not less than 50 miles by heliographic signals. The instrument weighs only seven pounds and can be carried and worked by one man. It is, of course, useless in cloudy weather. It has already been proposed to establish a systematic telegraphic communication between various islands in the West Indies by this process, and before long it will be adopted as a means of signaling between vessels when at sea.

Journal of Tel July 1 79

[From *The Journal of the Franklin Institute.*]

Mance's Heliograph.

DEVICES for signaling, in many respects similar to the heliograph, have been in use for a very long period of time. We have a record of the employment of polished metal surfaces to flash the rays of the sun, and thus give warnings of one kind or another, which dates back as far as the Persian invasion of Greece. Immediately after the battle of Marathon, the defeated Persians were signaled by some one on the mountains near Athens, by means of reflected rays of the sun upon the polished surface of a shield, that the city would be put into their possession if they came there immediately with their fleet. Fortunately, in this instance, the signaling was seen by both sides, and the ready interpretation of it by the Greeks, and their speedy return to Athens, saved the city from falling into the hands of the enemy. In this case, the signaling must have been carried on over a space of about eighteen miles, and, with the rude appliances used from that time down to a very recent period, this was about as far as the system could be depended upon to work. But the instrument now in use, the Mance heliograph, is a great improvement on the old methods, for not only does it concentrate the sun's rays, but it flashes them with the utmost precision to any required spot, irrespective of the relative location of the sun. It is, moreover, provided with a finger-key, so that flashes may be made of long or short duration, in this way permitting the employment of the Morse telegraphic alphabet. Under favorable conditions, intercourse has been carried on through the medium of two of these instruments over an intermediate distance of nearly one hundred miles; and at several points occupied by the English army in Afghanistan, regular communication is maintained at distances of not less than fifty miles by heliographic signals. The instrument is admirably adapted for war service, as it weighs only about seven pounds, and can, without difficulty, be carried and worked by one man. Of course, in cloudy weather it is wholly useless, and for this reason can never entirely take the place of flags or field telegraphs; yet there are so many days in a year in which it can be used that it will be strange if it is not made use of in various parts of the world, for commercial as well as military purposes. It has already been proposed to establish a systematic telegraphic communication between various islands in the West Indies by the heliographic process; and we venture to think that before long it will be adopted as a means of signaling between vessels when at sea.

Journ of Tel Aug 1 1879

Dr. Hooke's Telegraph.

IN 1684, Dr. Hooke proposed a kind of mechanical telegraph which, however, was not carried into operation. He prepared as many different shaped figures in wood, as, for example, squares, triangles, circles, etc., as there are letters in the alphabet. He exhibited them successively in the required order, from behind a screen, and proposed that torches or other lights, combined in different arrangements, should supply their place at night. Twenty years later Amontous, of Paris, exhibited some experiments before the Royal family of France and the members of the Academy of Science, showing the practicability of the system.

Mirror Telegraphy.

Journ of Tel Aug 1 1879

INTELLIGENCE from the Cape says that communication has been established between Ekowe and Fort Tenedos by mirrors. It may be of interest to state that some four years ago Lieutenant Parrott, of the Volunteer Engineer Corps of New South Wales, conducted a series of very successful experiments in mirror telegraphy. The discs used were about six inches in diameter, of polished metal, covered with glass. At first the distance separating the two mirrors was from six to ten miles, but eventually the system was tested from the Kurnajong Mountain, about 1,500 feet above the level of the sea, to the lighthouse at the entrance to Port Jackson, 400 feet above sea level, a distance direct of nearly forty miles. Communication was kept up throughout the day with perfect success by rapid and prolonged flashes, representing letters, words, and phrases, or, rather, questions and answers. The flashes are, of course, produced by slightly moving the mirrors. Successful tests were also effected by moonlight for a distance of four or five miles, and on dark, clear nights this system of telegraphy may be carried on by means of lamps with powerful reflectors, the light therefrom being thrown on to the signaling disc. The advantage of this mode of communication during war is apparent to every one.

SOCIETY OF TELEGRAPH ENGINEERS.

Feb 13 1880 Engineering

INAUGURAL ADDRESS.

By WILLIAM HENRY PREECE, President.

In surveying the wide sea upon which the numerous and varied practical applications of electricity are launched for the subject of this evening's address, I have been puzzled to steer a course that shall avoid the dazzling shoals of theory on the one hand, and the dry hard rocks of practice on the other. Hypothesis is a veritable Scylla that captivates the imagination, and often sends the visionary to destruction, while practice alone is a hard-hearted Charybdis that lures the matter-of-fact practical man to folly and expense. Practice must be tempered with theory to utilise advantageously the great forces of nature, and theory itself must be based on practice, or on facts, to be comprehensive and acceptable. Hence success is the offspring of the marriage of practice and theory, and, therefore, as the two are so intimately connected, I have determined to steer a middle course to-night to survey the progress of each in our profession, and to show their mutual relationship.

What is theory? It is an explanation of the hidden cause of certain effects that are evident to the senses. It is an effort of the imagination to account for operations that are in themselves invisible and insensible, but which result in facts that are observable and known. Thus the movements of all those bright bodies by which

> "the floor of heaven
> Is thick inlaid with patines of bright gold,"

are explained by the theory of gravity. Their appearance, vagaries, and beauties are accounted for by the undulatory theory of light. The warmth that the monarch of them all shed upon this earth countless ages ago, and that is now restored to us in our household fires, is explicable on the molecular theory of heat. The constitution of matter and its various states of solid, liquid, and gas, are completely explained by the atomic theory of Democritus and Dalton, and the modern kinetic theory of gases.

It is impossible for a practical man who has devoted more than a quarter of a century to the application of electricity to useful purposes, to avoid devoting much contemplation to the nature of the agent which he has to make use of. The imagination cannot be checked. The mind will dream and theorise. The untutored savage fancies he hears in the roar of the thunder the anger of the Great Spirit, and the tutored Greek saw in the daily course of the sun the chariot wheels of his god Helios, and in the grey dawn of the morning the advent of the soft and gentle Aurora. The Saxon churl saw in the lambent flame of the phosphuretted hydrogen of his marshes the gambollings of Jack-o'-lantern, or the treacherous ways of Will-o'-the-wisp. Is there a member of this Society who has not striven to peer into the region of the unknown, who has not speculated on the power he uses, or who has not formed some conception in his mind of the nature of electricity? Yet it is remarkable that the answer to the question, What is electricity? cannot even now be given with authority. Faraday, our great apostle, whose researches should be every electrician's bible, declined to venture an answer, nor did he ever directly formulate his ideas on the subject, though his publications indicate pretty clearly and with no uncertain sound what they were. Clerk-Maxwell, while he overthrew all existing theories, failed to supply their place before he was so untimely removed from us. Sir William Thomson, in his published papers, always carefully eschews the consideration of any physical theory of electricity. The French electricians simply use the one-fluid theory as a convenience of language, while the Germans, as a rule, employ the two-fluid theory merely for mathematical purposes. Hence there is no recognised theory of electricity. Some maintain, with Du Fay or with Franklin, that it is a form of matter—a substance; others, following Faraday and Grove, consider it a form of force—a motion—like heat and light. It must be either one or the other. There is no other category in which to class it. If it is not a form of matter it must be a form of force. The question I purpose to discuss is, therefore, Is electricity a form of matter, or is it a form of force?

In discussing such a vexed question it is necessary to be very precise in language to avoid any misconception of my meaning, therefore I will define both matter and force in the sense in which I use those terms. Matter is that which can be perceived by the senses, or can be acted upon by force. It is characterised by weight, inertia, and elasticity. Force is that which produces, or tends to produce, the motion of matter. It may be pressure, tension, attraction, repulsion, or any thing capable of causing alteration in the natural state of rest or of existing motion of matter.

Matter consists of sixty-four known elements which have not yet been decomposed by any known means. There may be other elements that have not yet been discovered by chemists, but they must exist in some known compound. Matter is found in either the solid, liquid, gaseous, or ultra-gaseous state, and it occupies space. It consists of molecules and atoms. The atom is the smallest indivisible part of an element, and a group of atoms of the same or of different elements forms the molecule, which has a definite magnitude and is unalterable in form for each substance. The mass of a substance is the aggregate of the molecules of which it is composed. There is no generation or destruction of atoms. The indestructibility of matter is a fixed law in nature. The size of the molecule is approximately known. Sir William Thomson says: "If we conceive a sphere of water as large as a pea to be magnified to the size of the earth, each molecule being magnified to the same extent, the magnified structure would be more coarser-grained than a heap of small lead shot, but less coarse-grained than a heap of cricket balls." Fifty million molecules ranged in single file would occupy an inch. They are highly elastic, and unless interfered with would move with constant velocity in straight lines. When they can move about freely without interfering with each other's proceedings, we have the ultra-gaseous state of Crookes, a state found only in very high vacua and under certain adventitious circumstances. When they collide and impinge on each other according to the law of the impact of elastic bodies, interfering with each other's path, we have gases as we know them; when their mean free path is so reduced as to bring them within the sphere of mutual attraction, without too narrowly restricting their play, we have liquids; when the attraction becomes cohesion and the motion of the molecule is confined to its own sphere, we have solids. The number of molecules in a given volume of gas is known, and their velocity calculated. In hydrogen the velocity at 0 deg. Cent. is 6097 ft. per second, the number being 10^{21} per cubic inch. The mean free path of a molecule in air at ordinary pressures is the ten-thousandth part of a millimetre. Besides their constant motion in straight lines the molecules may be set in vibration, rotation, or any other kind of relative motion whatever.

This is the atomic theory of matter born in the brain of Democritus "the laughing philosopher" 2300 years ago; preached by Epicurus in Athens, and taught by Lucretius in Rome before the Christian era; lying dormant for eighteen centuries, until it was formulated by Dalton in the last century, and removed from the region of pure speculation by Joule, Clausius, Clerk-Maxwell, and Crookes during our days.

The definition of force shows us that whatever changes or tends to change the motion of matter (or of the molecules of which it is composed), by altering either its direction or its magnitude, is a form of force. Thus gravity is a form of force, for it attracts all matter to the centre of the earth, and it is measured by the rate per second at which a body acquires a velocity in this direction when falling freely at a given spot. Heat is a form of force, for it throws the molecules of matter into violent vibration, or it increases the velocity of their motion in straight lines, which thus becomes the measure of its heat or its temperature. Light is a form of force, for it is produced by the undulation of the molecules of matter, and it is transmitted by the undulations of that medium called ether, which fills all space.

No man has seen or can see a molecule, nor have we any objective idea of what force really is. When we attempt to reach beyond these definitions, we tread upon the threshold of the holy of holies, on whose confines only are we permitted to dwell, and into which we are not yet allowed to enter. "Hitherto shalt thou come but no further, and here shall thy proud waves be stayed." Let us, therefore, be content with precise definitions and clear mental conceptions, speculative though they be, of matter inert and of matter in motion. The *ultima thule* of the scientific man is theory, and at any time his most cherished notions may be

> "Melted into air, into thin air."

The scientific man, while rather too fond of decrying the exercise of faith in others, is himself the humblest slave of the imagination. A physical theory may be complete. The various facts and laws which it embraces may be related mathematically with one another, yet one single incompatible phenomenon may dissolve it,

> "And, like this insubstantial pageant faded,
> Leave not a rack behind."

Hence, while apparently dogmatic in my description of the present theory of matter and force, I wish it distinctly to be understood that it rests, and must continue to rest, on the imaginative power of the mind.

Nevertheless, subjective speculation may become objective reality. Who is there that doubts the existence of the ether filling all space, transmitting those exquisite and delicate vibrations which impart to us the sensation of light and heat from stars and nebulæ countless millions of miles away? And with regard to the atomic structure of matter, though but a speculation as yet, it is so complete, so apt, and so thorough, that for my part I have not the slightest doubt of its reality, and therefore I submit it with apparent dogmatism.

When we take a given free mass and impress upon it a given force, we throw that mass into motion; for instance, when we fire a loaded cannon, we have imparted to the ball "energy" and in virtue of the motion of the ball, this energy is called "kinetic" Again, if we lift the ball to a certain height above the earth's surface—say to the top of a tower—and let it remain there, we have again imparted to it "energy," but this time it is called "potential," for it is dormant or resting. In each case the energy possessed by the ball is the exact equivalent of the work done upon it, that is, of the force impressed and the distance through which it has acted. The motion of the ball is readily transferred to the motion of the individual molecules of the ball. When, in the first case adduced the ball strikes the side of a ship or a target, its kinetic energy is thus converted into light and heat, which is molecular motion; or, in the second case, when it is allowed to fall, its potential energy is converted into kinetic energy, which again, on coming in contact with the ground, is converted into molecular motion or heat. Energy is always either potential or kinetic, and one of the most remarkable generalisations of modern days is the grand principle of the conservation of energy, which implies that the total energy of the universe is a quantity which can neither be increased nor diminished, though it may be transformed into any of the forms of which energy is susceptible. Energy is therefore as indestructible as matter. All the recent advances in the science of heat have been due to the discovery of this principle, and its application to electricity has gone far to remove that science from the hypothetical state to which it has existed so long.

My purpose is to contend that electricity is not a form of matter but a form of force, and that all its effects are evident to us in one or other of the several forms of energy characterised by the motions of molecules or of mass.

It is interesting to trace the historical growth of theories. The uncultivated human intellect cannot soar above its own limited sphere of childish observation. Whatever is mysterious and incomprehensible in nature is attributed to that which is equally mysterious and incomprehensible. Life has ever been of this character, and heat, magnetism, electricity, and many other unaccountable physical phenomena, have each in their turn been supposed to be cases of life. Even now there are those who would attribute exceptional and peculiar phenomena to spiritual agencies.

Heat was thought by the Greeks to be an animal that ... was then for many centuries thought to be a fluid which, entering into bodies, like mercury, made them swell, and this idea existed until this generation, when Rumford showed it to be a kind of motion, and Joule made it a quantitative form of energy.

Thales, of Miletus, thought that the magnet was endowed with a sort of immaterial spirit, and to possess a species of animation. The Greeks knew also that rubbed amber attracted bits of straw, and supposed it to be endowed with life. Even Boyle, as late as 1675, imagined it to emit a sort of glutinous effluvium which laid hold of small bodies and pulled them towards the excited body. Du Fay in 1733 conceived the double fluid theory, and Franklin in 1747 invented the single fluid theory. Cavendish in 1771 supplied some of the deficiencies of Franklin's theory, but it was Faraday who first exploded the fluid notion and originated the molecular theory of electricity, while Grove boldly classed electricity with light and heat as correlated forces and mere modes of motion.

Light was thought by the Platonists to be the consequence of something emitted from the eye meeting with certain emanations from the surface of things, but no theory of light properly so called was attempted until Newton produced his celebrated corpuscular theory in 1670, which has lasted until the present day. Even as late as 1816 Faraday himself said,—"The conclusion that it now generally received appears to be, that light consists of minute atoms of matter of an octahedral form, possessing polarity, and varying in size or in velocity."* Although Huyghens in Newton's own time conceived the undulatory theory, the superior authority of the great English philosopher overshadowed the lesser light, and it was not until Young and Fresnel at the commencement of this century took the matter up, that the present theory of light took firm root.

Thus we see that all these sciences have passed through the same stages of mystery and fancy, and it is only within the present generation that they have emerged from the mythical to the natural, from mere hypothesis to true theory. Hypothesis is an imaginary explanation of the cause of certain phenomena which remains to be shown probable or to be proved true. Theory is this supposition when it has been shown to be highly probable and all known facts are in agreement with its truth.

(To be continued.)

ELECTRICITY, TELEGRAPHY

Feb 6 1880

MR. GRAHAM BELL.—The committee appointed by the French Minister of Public Instruction has awarded the Prix de Volta—50,000 fr.—to Graham Bell.—*Nature.*

THE FRENCH-AMERICAN CABLE.—The new French cable for America has been placed at the disposal of the public for correspondence. It goes direct from Brest to St. Pierre, and from St. Pierre to Massachusetts, where it is connected with the American Telegraph Union. A new cable will be laid from Brest to Penzance by the *Faraday* steamer, in the beginning of February, and afterwards from Penzance to St. Pierre. The second cable will be used for English telegrams.

THE PACIFIC CABLES.—It is now announced that the duplicate Australian cable has been completed, and is open for traffic. The new cable takes a somewhat different route to the original. The old cable from Singapore landed at Batavia, and the messages were sent over the Dutch Government lines to Banjoewangie, at the furthest extremity of Java, where the Australian section of the cable commences. By the new arrangement the Singapore section is taken direct to Banjoewangie, thereby avoiding the Java land lines, which will effect a great saving of time and tend to greater accuracy, as the messages will pass entirely through English hands.

NEW ELECTRIC CANDLE.—A French inventor, M. Perruche, has presented a new description of electric candle to the Paris Academy of Science. The candle consists of three carbons, two being cylindrical and 0·003 metre in diameter, and applied to each other; the third of square section, 0·005 metre inside, and placed in the angle formed by the first two. The cylinders are in pivoted brass holders between brass plates brought together by a spring. The holder of the square carbon is also capable of oscillation, and the carbon is held by a spring in contact with the other while no circuit passes, but, when the current begins, takes its separate position. It is regulated by an iron lever and electro-magnet in circuit.—*Electrician.*

THE POST OFFICE AND THE TELEPHONE.—With reference to the actions which were recently entered against the Telephone Company for alleged infringements of the Postal Telegraph's monopoly, the *Western Morning News* is enabled to state that an arrangement has been entered into between the Post Office and Bell's Telephone Company by which not only proceedings against the company will be abandoned, but the Postmaster-General undertakes to give every facility for the extension of telephone communications. The Telephone Company will pay a royalty to the Post Office, and may use the post offices and staffs under certain conditions for their work. Thus telephone wires may be run from a post-office to the town offices or country residences of gentlemen, and telegrams arriving at post-offices for them may immediately be communicated by telephone, thus saving time. To country gentlemen whose residences are distant from the nearest telegraph offices this accommodation will be invaluable. Telephone extension is progressing rapidly. One firm, whose offices are in London and Manchester, are laying a wire for telephones between their two establishments.

AN ELECTRIC LOG.—The well-known Massey's log is far from being a perfect instrument; one disadvantage is, that its counter being under water, the velocity at a given moment cannot be determined, and if there is a stoppage, one's ignorance of the point at which it occurred may render the indications rather useless. It has often been proposed to use electricity to transmit log-indications, as this would obviate the inconveniences just noted. An electric log, devised by M. Fleuriais, has been fully tested, with satisfactory results, on board the French frigate *La Magicienne*, in a recent long cruise. From a description of it in *La Nature* we gather that it is partly based on the principle of Robinson's cup-anemometer. A four-armed cross-piece, with cups at the ends of the arms all directed similarly in relation to the arms, is supported on a vertical axis so as to rotate in being pulled through the water, and proportionally to the rate at which this is done. The "mill" is of bronze; but to diminish friction the axis is supported in small blocks of guaiacum, which are at the ends of the arms of a bronze fork, presenting little resistance to the water. This fork is attached, through a short chain, to the log-rope, one strand of which is removed to make a place for the electric cable (a Menier military cable, with seven wires). The wire of the cable passes from the negative pole of a battery on board ship to the log, while the "earth wire" passes from the positive pole into an electric bell (without trembler);

ENGINEERING.

FRIDAY, JANUARY 30, 1880.

TELEGRAPHIC ENGINEERING IN 1879.

In dealing with the general advance of telegraphic engineering during 1879, there are two divisions of the subject under which it may be considered, viz., first, the extension of works, and secondly, the improvements in the apparatus and means employed. As regards the postal telegraph system which forms the greater part of all telegraph lines in England—the rest being the wires used for railway signalling—there has been very little extension of the lines, yet 94 now stations have been opened. There has, however, been a constant advance in the perfection of the apparatus; Wheatstone's automatic apparatus has been duplexed on numerous circuits, and translating relays have been placed at the ends of all submarine cables in circuit on automatic circuits, which has increased the speed 100 per cent. Quadruplex has been extended also to several circuits. The iron wire used for the overground lines has now to be of a specified conductivity, of a certain tensile strength, and to stand a specified torsion, and although the German wire drawers can supply wire for the outer covering of submarine cables delivered on the banks of the Thames cheaper than our midland manufacturers, they cannot supply the wire of the quality required by the Post Office as cheaply as English makers. In the underground wires the Post Office now adopt, wire with only a single covering of gutta-percha, and a new mode of making the joints in the gutta-percha covering by an apparatus invented by Mr. Truman, has been tried with success and is likely to be adopted. A new four-conductor cable has been laid by the Post Office between Port Patrick and Donaghadee to replace the old one; defects have been repaired in the cable between the Welsh coast and Wexford, and 45 miles of new cable are being manufactured by the India-Rubber, Gutta-Percha, and Telegraph Works Company for the renewal of a part of this line. The Shetland Isles and Orkney cables have been repaired. A system devised by the Post Office engineers and electricians of indicating the rise and fall of water in water reservoirs at the engineer's office situated away from the reservoir, has been adopted at the Nottingham and Southport Water Works, and it is to be fitted at other similar places. In a general way the year as regards the Post Office telegraphs has been one of steady progress without any important extensions.

The first establishment of telephone exchanges in England marks this year's history of telegraphic progress. The Telephone Company established about two years ago for the supply of Bell's telephone for private circuits, has, since August of this year, established telephone exchanges in London, Liverpool, Manchester, Glasgow, Dundee, Birmingham, Bristol, Leeds, Sheffield, Bradford, Halifax, &c. The London subscribers amount to 250. The central station is at 36, Coleman-street, and each subscriber can, by calling the central station and demanding to be switched through to any particular member, be thus placed in speaking communication with such subscriber. The lines are mostly carried over houses, but some wires to Westminster are carried along the Metropolitan District Railway. The instrument used is Blake's transmitter, which is a microphone and induction coil with battery in primary circuit, and secondary connected to line, and a Bell's telephone for receiver. Besides the circuits for the telephone exchanges, the company have put up some fifty circuits in London and elsewhere for private firms, including the General Post Office, several dock and railway companies' offices, &c.

The Edison Telephone Company, of London, central office 11, Queen Victoria-street, was established this year early in September for a similar purpose, Edison's telephone being employed. This instrument, which we have fully described, consists of the Edison carbon receiver and the Edison chalk cylinder transmitter; its articulation is loud and clear, but it requires to have the chalk cylinder revolved by hand. Besides the central station there are stations at 34, Eastcheap, 77, Cornhill, and 6, Lombard-street, and arrangements are being made for stations at Westminster, Temple, and Pall Mall. The wires are mostly overhead, but some are to be carried to Westminster in the Metropolitan Board of Work subways. The company has already forty subscribers to the Victoria-street centre, sixteen to Eastcheap, and ten to Lombard-street. One of the circuits from Victoria-street extends to Beulah Hill, Norwood, and amongst the various private circuits established by this company is one between Brighton and Littlehampton, 22 miles in length.

As regards submarine telegraph engineering, the extensions have been considerable. We may first mention the submarine line from Aden to Durban laid for the Eastern and South African Telegraph Company. This cable was constructed and laid by the Telegraph Construction Company, and consists of four sections, namely:

	Nautical miles.
Natal to Delagoa	315
Delagoa to Mozambique	969
Mozambique to Zanzibar	625
Zanzibar to Aden	1902
	3811

It was completed on Christmas Day; the core consists for the three first sections of a conductor of 107 lb. of copper and 140 lb. of gutta-percha to the nautical mile, and the long section, of 250 lb. of copper and 250 lb. of gutta-percha to the nautical mile. Messrs. London and Lucas were the engineers, and Mr. Laws the electrician on the part of the Construction Company at the laying of the cable, and Mr. Forde and Mr. Hockin, of the firm of Clark, Forde, Hockin, and Taylor, were the engineers on the part of the Eastern and South African Company.

The duplication of the Eastern Extension Company's system from Penang to Port Darwin in Australia, is also a work of great magnitude which has been commenced this year and three parts completed. This when completed will be as follows:

	Nautical miles.
Penang to Malacca	275
Malacca to Singapore	116
Singapore to Banjoewangie (Java) ...	920
Banjoewangie to Port Darwin ...	1180
	2491

The core of this cable is composed of 107 lb. of copper and 140 lb. of gutta-percha. Of these the three first sections are completed, and the rest of the cable is about to be laid by the s.s. Seine. The whole of this work is contracted for by the Telegraph Construction Company, Mr. Riddle being the engineer in charge on their part, and Mr. Herbert Taylor on the part of Messrs. Clark, Forde, Hockin, and Taylor, engineers for the Eastern Extension Telegraph Company.

In both these works two new features have been introduced which should be marked as dating from the year 1879. The first is a means of protecting the gutta-percha insulating medium from the borings of the teredo, and other marine insects which have been found to attack the core in shallow seas, and more particularly in the cable between Singapore and Batavia, very many faults having been thus caused. The protection consists of a thin tape of brass laid round the core, which has first cotton tape wound round it to form a bed for the brass tape, and prevent the delicate gutta-percha from injury by the edges of the brass tape. Over the brass tape another layer of cotton tape is placed to keep the former from buckling open. This covering is again served in the usual way with jute forming the bed for the outer wires. In both the duplicate Australian and Cape cables, wherever the cable lies in shallow water, the core is thus protected. The second novelty is in the deep-sea portion only; it consists in placing cotton tape saturated in preservative compound, round each of the homogeneous iron wires separately in order to protect them further from rust, the whole cable being further surrounded, as is now usual, with two layers of broad tape wound in opposite directions and covered with preservative compound. The covering of the wires separately with tape is, it should be remarked, only now as regards its being adopted for deep-sea cables, as it was adopted in shallow water on the present Post Office cable between Holyhead and Dublin cable laid in 1871.

A cable for the German-Norwegian Telegraph Company was laid by the Telegraph Construction Company between Arendal, in Norway, and Hoyer, in Schleswig. The cable is 252 nautical miles in length, and has three conductors each of 100 lb. of copper and 125 lb. of gutta-percha per nautical mile, covered with twelve No. 5 iron wires galvanised, and protected with two layers of tape and compound. The company also made 120 miles of cable for the New Zealand Government, which was shipped in the s.s. Kangaroo with some of the cable for the Aden-Zanzibar section of the Cape cable, and will be laid by that ship. Mr. W. H. Preece was consulting and Mr. F. C. Webb inspecting, engineer, for this cable, which was ordered by telegraph from New Zealand through Sir Julius Vogel, the Agent-General.

The whole of these works, comprising 6704 miles of cable, mark the most busy year even of the Telegraph Construction Company's existence. The company have also this year added to their fleet the magnificent steamer Scotia, formerly the well-known Cunard paddle steamer, and now converted into a twin screw. She is 4666 gross, and 2031 net tonnage, she is 379 ft. long, with engines indicating 2500 horse power, and she has carried a dead weight of 4300 tons. She has water-ballast tanks for 780 tons, and carries three cable tanks below her main deck. The vessel is fitted with two picking-up gears complete, and these are placed on the main deck, the tops of the drums protruding through hatches in her spar deck. This, both as regards the machines being on the main deck, and being in duplicate, is a novelty dating from 1879. She has also duplicate drums to her paying-out gear, and has also steam-steering gear. The vessel has been fitted under the supervision of Mr. Clifford and Captain Halpin, and is decidedly one of the finest cable ships afloat. She went to Singapore, laid her full cargo of cable, and came back in 3 months and 17 days, having steamed 17,850 miles with an average daily consumption of 38 tons. The other

26

...legraph Lines

It would have taxed the imagination of the business world a few years ago to conceive how a new ocean cable and a new land system comprising thirty-five ... of wire, all centring in New York city, could go into operation, as they did yesterday morning, with so little formality, noise and fuss. There were no congratulatory messages, no exploding of guns or of after-dinner speeches, no splurging in the newspapers. There was even no bluster about a reduction of rates. The new French cable company, the Compagnie Francaise du Telegraphe de Paris à New York, began its business existence quietly, with an interchange of private commercial telegrams and did a light day's business. It has not put down rates, although the old rival Anglo-American Cable Company announces that its tariff after February 1 will be reduced from seventy-five cents to twelve and a half cents a word. The lines of the new company extend from Brest, France, to St. Pierre, Cape Breton, Newfoundland and thence to Nausett Light, Cape Cod. From St. Pierre there is a connection to Louisburg, Canada, and from Cape Cod to this city. A cable from Brest is about to be laid by this company to Land's End, England, and from that point another ocean wire will be stretched to St. Pierre, the American landing point. But the quiet opening of the American Union Company yesterday is a yet more notable event. That company, having overcome all obstructions in the courts, goes to work with thirty-five thousand miles of wire, connecting all leading American business centres with the new French cable and with each other, skimming the cream of the telegraph business of this country, and working on a capital that is nominal in comparison with that of its older competitor. Curiously enough this company does not yet talk about reducing rates. It certainly ought to do so, however. It is to be hoped that the American business community at last has a telegraph system that will compete with the old monopoly instead of selling out to it.

EFFECT OF POLARIZATION UPON FRICTION.—Herr Koch has made an interesting experiment regarding the effect of polarization upon friction, the result appearing to have a bearing on the action of the Edison friction telephone. When a plate of platinum or palladium is polarized by means of an electric current, the friction of these metals against a plate of moistened glass increases immediately. To measure the friction, Herr Koch uses the metal in the form of a hemispherical button, resting on the bottom of a glass cup filled with pure or acidulated water. The button serves as a pivot to a magnetic needle, which oscillates under the action of the earth; the decrease of the oscillations measures the friction of the pivot. Polarization is produced by the current of the Daniel element, one pole of which communicates with the metallic button, while the other terminates with a platinum wire entering the water of the cup. The polarization by hydrogen produces no effect, but polarization with the pole oxygenated is found very efficacious. The friction was increased, through this polarization, in the ratio of 2 to 3, and sometimes in that of 2 to 4. This increase of friction appears immediately after the circuit is closed, and disappears immediately when the current is reversed; but it disappears slowly, like the polarization itself, when the circuit is merely opened. Palladium behaves like platinum. Gold gave no effect.

ON Wednesday, September 8, lightning fell on the Sorbonne at about half-past two o'clock. A globe of fire was observed by persons present on the spot. Some of them say it was seen coming from the point of the north-western conductor, which was struck, as well as the south-western, with a great noise. The Sorbonne had, until recently, no lightning conductor, and never, as far as is known, has any thunderbolt struck the venerable abode of the French University. But within the last few months six stems have been erected and connected by an iron bar, making a circuit which goes all over the roof of the immense building. Unfortunately the pit where the earth conductor has been placed is situated at a great distance from the main building, in a courtyard adjoining the laboratory of M. Jamin, and the conductor which connects the roof with this is a square iron box of less than 15 mm. on each side, so that there is not sufficient conductibility in it to establish an efficient connection with the earth. This accident proves the sagacity of M. Karsten, the Schleswig-Holstein physicist, who published a table giving a formula for regulating the dimensions of the connecting-rods with their lengths, as is taught by Ohm's laws. It shows also how little the knowledge of lightning-conductors is spread in France, in spite of the several official commissions which have been established by the Government. Nature Sept 18 1880

27

SOME RECENT ADVANCES IN TELEGRAPHY.—VII.*

YOU were shown in the first lecture that by passing a current through an electro-magnet attraction and repulsion are produced. This attraction and repulsion gives us mechanical power, which we turn into account, and make it the means of indicating by long or short beats the elements of letters that are sent by the current. Here is a Morse embosser. To the armature of the electro-magnet is attached a lever, at the end of which is a style. Each time the armature is attracted the bar is moved, causing the style to press upon paper ribbon, which is mechanically drawn over a grooved wheel, and if a succession of short currents be sent through the electro-magnet, as many dots are embossed upon the paper ribbon; or, if currents causing the armature to be held down for a sufficient time to represent the "dash" element of a letter, as many dashes appear on the paper. But this embossing is difficult to read unless you catch the shade falling upon the dots and dashes, which operation severely taxes the eyes. In 1851, Thomas John, an Austrian engineer, devised a plan by which these dots and dashes could be made in ink; and before you is one of the earliest ink-writing instruments employed, made by the eminent firm of Siemens and Halske. There is exactly the same motion as in the embosser, but instead of the style at the end of the lever, a disc is fixed, which rises and comes in contact with the paper in the reverse direction to which it is rotated. The disc dips into a small well containing ink, and as it revolves continually in the reverse direction to that of the paper, it presents ink on its circumference to the paper and so records dots or dashes, whichever may be sent. With a simple ink-writing instrument such as this it is difficult to get currents of sufficient strength to attract the armature at great distances with force enough to make a mark on the paper. In that case what are called relays are introduced. Let us suppose a line of telegraph as shown in Fig. 6.

You have a battery, with a key, by the simple depression of which a current is sent to line. You have also a galvanometer, which shows whether the current flows or not, and at the end of your line wire you have a "relay" which receives the current, however weak, and immediately brings into force a more powerful current, which passes through the electro-magnet of the instrument, and records the signals received. There has, perhaps, been more ingenuity exercised in the construction of these relays than of any pattern of apparatus used. Here is one of the first relays ever used. It was introduced by Wheatstone to send an alarm, and was produced by the decomposition of water. The gases accumulated by the decomposition of water drove up, by pressure, a column of mercury, which made contact, and so sent an alarm. Another form of relay was by the mercury contacts made by a fork fixed at the end of a needle as you see here. One of the earliest forms of relay introduced into America, and that which is almost universally used over there now, is the Morse. It has certain advantages over other kinds, but being non-polarised, is abandoned in this country, and superseded to a great extent, by that known as Siemens' relay. Here is another relay known as Stroh's, which is extremely delicate and moves with the slightest current, but the most recent one is that known as the Post-office standard relay. All these instruments will be better understood by a little careful inspection; it is quite impossible for me, in the time allotted, to explain their construction. They all perform the same function, viz., to bring into play stronger and more constant currents.

The instrument I have explained to you records dots and dashes on the paper, but you will have noticed that in making these marks a certain sound or beat occurs. Sometimes we read by this sound, and the current performs the dual function of attracting consciousness, either through the eye, by reading the dots and dashes on the paper, or through the ear, by the sounds. We have here, in order to show the actual working of the telegraph, an instrument fixed on a wire, which communicates with the Central Telegraph Station in St. Martin's-le-Grand. It is one of the simplest kind of instrument, a sounder. To show you how these sounds can be translated into the Morse alphabet, I have brought a little instrument (kindly made for me by Mr. Theiler), which emits a fairly loud tone of given pitch.

This little sound-giver is very similar to one brought out some years ago by Mr. Brittain, and was called (after him) "Brittain's Busy Bee."

But the sounder instrument, instead of emitting a musical tone, simply gives a thud, though I would ask you to notice that the sound produced by the attraction of the armature is quite distinct from that made on its recoil. This kind of instrument is used to a very large extent (almost universally) in America; it is a specimen, in fact, of the "pony" sounder used in America, which I brought over on my recent visit. We have rather altered it, and, I hope, improved upon it. We will now call up the attention of the Central Station, and you will have a practical illustration of the manner in which telegraphic business is carried on. To call up an office certain signals, which represent the code of that office, are sent. Every telegraph office throughout the kingdom has its code; Liverpool, for instance, is L V; Manchester, M R; Birmingham, B M, and so on. The code for London is T S, which letters (representing the telegraphic centre of the world) are the initials of Telegraph-street, where the Central Office was formerly situated.

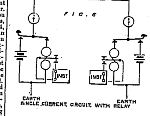


FIG. 6
SINGLE CURRENT CIRCUIT WITH RELAY

That is the actual process adopted for the transmission of news and ordinary messages. You will readily understand upon what trifling differences in sign or tone words depend. The insertion of a dot here, or the omission of a dash there, is sufficient to cause an error. But in spite of this it is very surprising and pleasant to find that out of the 100,000,000 messages repeated every year so few errors are made.

A dot will convert the word save to rave; pound is easily transposed into found, and the words dead and bad are made up of precisely the same number of dots and dashes, as

D E A D B A D

the only difference being the insertion of a space; and a very sad message was sent not very long ago announcing that a favourite daughter was "dead" instead of "bad"—the signals for DE having exactly the same element as B, as shown above. After hearing this you will not be surprised that when a party of young ladies was announced as having "arrived all right," the message was delivered as "arrived all tight;" and that also when a husband went to Brighton to secure apartments, and arranged with his wife that if he found apartments he would telegraph for her to come, but if unsuccessful would return home; he telegraphed "home to-night," but she received the message "come to-night," and the result was that they crossed on the road. Again, a friend of mine was in Manchester, and his only child was at home unwell, he suspected, with the measles; his wife telegraphed "Rash all gone," but he received a message "cash all gone." I could repeat these errors to any extent, many ludicrous, many sad, but all simply dependent upon a very trifling change made in this rather uncertain alphabet. Still, as I said before, when we think of the enormous number of messages transmitted every year, we can only be surprised at the care and skill which prevents a greater proportion of errors.

I want particularly to call your attention to the difference between the ink-recorder and sounder. The latter is the instrument now coming into use with tremendous strides. It has had to force its way a good deal against prejudice and ignorance, but it is steadily and surely making its way into this country. Its extreme simplicity is most striking. In the apparatus upon which you have just heard the news received, we have everything sufficient to fully equip a telegraph station. We have a table upon which is placed your key, galvanometer and sounder, with battery underneath. The galvanometer is simply for the purpose of indicating when a current is being received, should the sounder fail. The advantage of this instrument is its economy. The difference between the cost of a sounder and ink-recorder is very great. Again, the clerk who reads by the sounder, and writes down the message, uses each sense separately, but with the recorder he has to refer to the slip with his eye each time he has written out as much as he noticed by the previous glance, and this constant referring means liability to error. With the sounder the clerk's ear drinks in the sound, and it is the same to him exactly as if the sender were simply speaking to him. The sounder insures wonderful accuracy in the ... telegrams; and one of the most marked effects of the introduction of this instrument has been the reduction in the number of errors made, the reason being that the hand follows the ear; if the ear has learned to read accurately by sound, the hand is sure to send accurately by sound, and this is invaluable, because where we have a good sound-reader there we have a good sender, and the result is accuracy. Also, as the clerk has not to glance his eye from one paper to the other, but simply to write on as fast as he can, the rapidity of the working is increased, because he simply writes down as fast as he is sent to, and, in point of fact, the rate at which messages are taken off is simply limited by the rate at which the clerk can write. It instils into the clerks who use this apparatus care and reliance. It has a kind of disciplinary agency about it, and those who are skilful sound-readers invariably turn out to be self-reliant, accurate, and valuable operators. But the principal advantage attaching to this sounder is that it in reality increases the speed of working, and thereby increases the capacity of the wire for the transaction of business. Certain disadvantages are asserted as belonging to sound reading. One objection is the loss of record. That is a very conservative notion. It is supposed that by having a record of each message that you have a check in case of error. But, as I told you, errors on the sounder are not made, and, therefore, no check is needed, and those who support the old instrument on account of its recorder, can only be classed amongst the staunchest conservatives that we possess. Again, it is said that there is some difficulty in reading the sounder, when other noises take place in the room or shop where it is fixed; but I can only say that in the Central and other large offices where sounders are used and many noises prevail, the sounder is in great favour, and has never been objected to on the ground of its being interfered with by extraneous noises. At other times it has been said that listeners can stand outside a telegraph office and hear all that is going on. They may do so in America, but they cannot in England, for in a well-appointed office the sounder, being placed behind the public counter, ought not to be heard (though I am afraid it often is), but, even if it is, I do not think it is likely that people who could read by sound would find it worth their while to hang about to catch unknown and unexpected messages. I do not think there is much value, if any whatever, in these objections. There are about 1,380 of these sounder instruments in use in the Postal Telegraph Department.

There is another kind of sound-reading instrument called the "Bell." This instrument was introduced by Sir C. Bright and his brother, Mr. E. Bright, as far back as 1853. It is after the principle of one of the earliest forms of instrument, which also recorded its alphabet by different sounds, invented in 1837 by Steinheil. The signals are received on plates varying in sound, one representing a dot and the other a dash.

The signals when sent on this instrument at a rapid rate, seem to form, to an unpractised ear, quite a confusion of sounds, but I have no doubt there are many persons in the room who can easily distinguish the signals sent, and convert the apparent conglomeration of sound into ordinary language. There are 277 of these bell instruments in use in the postal telegraph service.

Another form of sound-giving instrument, called the "Neale," from its inventor, has lately been introduced. It follows the principle of the bell, the different sounds being caused by the beating of the single needle upon metal cylinders of different tone. It is made by substituting for the induced coil of the single-needle instrument an "acoustic" coil of the Neale pattern. It possesses all the advantages of the single needle, with the addition of those of sound-reading, and is certainly calculated to simplify some of the difficulties of telegraphy. The instrument has only lately been introduced, and though likely to be largely used in the postal telegraph service, time has not yet permitted of its being generally adopted. There are many other instruments in daily use which I have no time now to refer to.

There are instruments which record the letters of the alphabet in bold type upon paper slip. One of the most valuable, which is very largely used on the Continent, is the Hughes type-printing instrument. It is also used in England by the Submarine Telegraph Company, and the *Times* newspaper has private wires to Paris and Vienna, and all the news that you see every morning from "Our own Correspondent" in these towns is transmitted direct, and printed in clear type on paper slips by this instrument, which can on its receipt be immediately handed over to the compositors to set up. We have only a few of these instruments in the Post-office. It was used very largely at one time, but we found that it was not equal to the speed required. They are, perhaps, a little slower in the transaction of business on the Continent, or have not yet arrived at that tremendous development of business which we experience, and which compels

* Being the substance of the Cantor Lectures delivered before the Society of Arts by Mr. W. H. Preece.

26

Evening Telegraph ... New York

It would have taxed the
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that will compete with th
instead of selling out to it.

28

NOTE ON THE ZODIACAL LIGHT.* 1880

Science

By Henry Carwill Lewis. Oct 9

The results of a series of observations upon the zodiacal light made by the writer, extending over a period of nearly five years, is here recorded. The special precautions taken, both to train the eye to detect faint lights, and to prevent bias on the part of the observer, were given in detail. The zodiacal light may be divided into three portions—the *zodiacal cone*; the *zodiacal band*; and the *gegenschein*. This division is convenient in observation, saves confusion in description, and may be in part a natural one.

The zodiacal cone.—This, the zodiacal light proper, of most authors, is the well-known cone of light rising along the ecliptic, and best seen in the winter months in the West, immediately after the disappearance of twilight. The time of shortest twilight coincides with its greatest brilliancy. Several observations are given when the writer saw it cast a distinct *shadow* at that time. Its comparative brightness with the Via Lactea at different seasons were given, and its relation to the ecliptic discussed. It was stated that the cone in our latitude is not symmetrical; and that while its axis of greatest brightness lies exactly upon the ecliptic, its axis of symmetry is north of that line. An inner short cone of greater brightness was described. The warm color was shown to be due to atmospheric absorption. No pulsations were ever observed which could not be explained either by atmospheric changes or by changes in the eyesight of the observer. No periodic changes in the zodiacal light were observed; the same series of changes occurring each year with an equal amount of brilliancy. It was shown that while the zodiacal cone is frequently seen by moonlight, the moon appears to have no appreciable influence upon it. The account of the zodiacal cone closes with a description of its *spectrum*, which is always continuous and free from bright lines.

The zodiacal band.—This is an extremely faint zone of light, somewhat wider than the Via Lactea, which, like a strip of gauze, is stretched across the sky along the zodiac from horizon to horizon, and which can be seen at all times. It is a belt which forms a very faint prolongation of the zodiacal cone, and which, like it, is best seen when the ecliptic makes a large angle with the horizon. It is so faint that it can only be seen with difficulty. The best method of observing it is described. It is brightest along an inner line, and fades off more suddenly on its southern than on its nothern edge. It has a width of about 12°, and its central line is slightly north of the ecliptic. Observations prove the zodiacal band to be a constant and invariable phenomenon.

The gegenschein.—The gegenschein is a faint patch of light, some 7° in diameter, which nightly appears in that part of the zodiacal band, which is 180° from the sun. Night after night it shifts its place so as to keep opposite to the sun. It is decidedly brighter than the zodiacal band, and occasionally a central nucleus about 2° in diameter, of greater brightness, can be observed. While the brighter portion of the gegenschein is circular, its faint boundaries have sometimes the form of an oval, whose major axis is parallel to the ecliptic. A large number of maps of its position among the stars have been made, which show that while its central point is always 180° in longitude from the sun, it has a latitude of +2°.

The moon zodiacal light.—An oblique cone of light in the proximity of the moon was described by Rev. G. Jones, but has not been detected by the writer. The light preceding moonrise rises at right angles to the horizon, and seems purely atmospheric. One observer has described comet-like tails on either side of the moon. The writer holds that such appearances are caused by diffraction through floating vapor, since they are never seen on clear nights.

The horizon light.—The phenomenon to which this name is applied, though having no connection with the zodiacal light, is so continually observed with the latter, and at certain seasons is so apt to be confounded with portions of it, that it is necessary to take it into account. The horizon light is a faint band of light with parallel sides, lying all around and parallel to the horizon, and separated from it by an interval of darkness. It is brightest, and terminates most abruptly on its lower edge. This sharp lower edge is 5° above the horizon, while the diffuse upper edge varies in altitude with the state of the atmosphere. The horizon light has a mean width of about 15°. It is purely atmospheric and appears to be caused by reflected starlight. It becomes very bright when the moon is above the horizon. Below the horizon light is a very dark space here called the *absorption band*. This quenches the light of the Via Lactea, the zodiacal cone, and all except the largest stars and planets, which last, while in it, are deeply colored. In the summer, when the ecliptic is low, the horizon light frequently blends with the zodiacal band.

29

MAJOR MACGREGOR'S EKOWE POCKET HELIOGRAPH.

VERY handy and portable form of heliograph has recently been designed by Major Macgregor, of the ...th Regiment. The inventor was led to consider the subject from the success which attended his efforts to communicate, by means of sun-signalling, from Fort Ekowe to the Tugela, in Zululand, last year. The means then at hand consisted only of a looking-glass, in the possession of an officer's servant, which, by suitable arrangement, did the work very well over about 27 miles of country.

From Ekowe, over a distance of 10 miles, Major ... sent messages by means of a shaving glass held in one hand, shutting off the sun with the skirt of his coat in the other.

C, are unscrewed. The two mirrors lie face to face, and the legs and upright of stand (with sight arm folded down) lie parallel to one another, the whole fitting into a leather case 13 inches long, 3½ inches wide, and 1½ inch deep. The instrument weighs two pounds.

The instrument is used in the following manner:—

When the sun, S, is in front—that is, towards the distant station, the heliograph is set up with the sight vane (enlarged sketch seen to the right of fig. 1) in the general direction of the distant station, and the mirror facing in the same direction (as shown by fig. 1).

The eye is then placed as close as convenient to the back of the mirror, and the latter looked through at the centre hole; at the same the V of the sight vane, E, is set in line with the distant station.

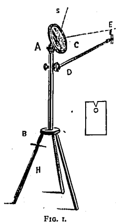


Fig. 1.

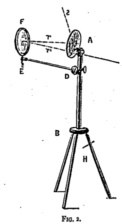


Fig. 2.

The present instrument is extremely portable, cheap, and not liable to get out of order.

The following is a description of the apparatus:—

A B is a metal stand; H, H, H, three legs screwed into base, B; A, a ball and socket, carrying a very short arm, to which is fixed a circular mirror, C, 3 inches diameter, having a small hole pierced through centre of the backing, and the silvering removed at that point. D E is a light arm, about 8 inches long, movable on a ball and socket at D, and clamped by a screw behind D.

F is a circular mirror similar to C, having a straight arm 2 inches long, which fits into a socket at E, the socket being movable on a hinge. The mirror, F, can be removed at pleasure, and the socket, E, turned so as to stand upright, to form a "sight vane" when the sun is in a certain position.

To pack up the instrument, the legs and mirror,

The mirror and sight arm are then so manipulated that the dark spot, cast by the unreflecting centre hole, is thrown on the bottom of the V, in the sight vane, whilst, *at the same time*, the centre hole, bottom of V, and distant station are in one straight line. Thus, the "flash" is directed on the distant station.

Signalling is carried on by using the Morse alphabet of "dots" and "dashes," which is effected simply by interposing and removing the hand, a note book, piece of board, &c., smartly between the sight vane and the surface of the mirror. By this means letters can be sent as fast as the eye can read.

In military signalling it has recently been decided to signal by obscuration instead of by flashing, which renders this instrument rather more handy than if "flashing" only were used.

When the sun is not in the direction of the

32

OPTIC TELEGRAPHY.

A new mode of optic telegraphy has been invented by M. Mercadier which is said to greatly increase the amount of light now used for intermittent luminous signals on ships, lighthouses, &c. The common method is that of bringing a movable diaphragm before a steady source of light. Thus the light is not utilised during eclipse, and it has been estimated that in ordinary systems 65 per cent. of the light is lost (in lighthouses sometimes 90 per cent.). M. Mercadier, according to the *Times*, has lately proposed a new plan, the essence of which lies in varying the source of light, making it flash up to its maximum at one moment, and reducing or extinguishing it at another. This can be done either by promptly varying a supply of oxygen to a low flame or by varying the supply of combustible gas. M. Mercadier describes an arrangement of the former kind, in which he uses a simple petroleum lamp of M. Duboscq; it has a round wick (which does not pass beyond the containing cylinder), and in the centre rises a thin vertical tube, debouching a little below the plane of the wick. This tube admits the oxygen coming from a reservoir. The mode of admission is by pressure with the finger on a key, like that of a Morse apparatus; this has the effect of momentarily releasing a caoutchouc tube (by which the oxygen is conveyed) from the pressure of a clip. The flame then brightens. On taking the finger off, the supply of oxygen is stopped again, and the flame is reduced to very small size. This system, M. Mercadier says, has been adapted to apparatuses of optical telegraphy, and has given good results. We are very curious to learn how the inventor proposes to solve the same problem with the electric light.

The Engineer
Mar. 5 1880

The Engineer March 5 1880

PNEUMATIC TELEGRAPHS.

The system of forwarding telegrams by means of pneumatic tubes has been, really speaking, of slow growth, and beyond its adoption by the old Electric Telegraph Company in the United Kingdom, its spread has been slow in the extreme. Few places on the Continent have adopted it, and about its latest introduction has been in New York. Its early history and introduction are not uninteresting, especially when it is considered that, from its success, many and strenuous efforts have been subsequently made to establish a railway system under similar mechanical arrangements.

The Electric Telegraph Company, about the year 1856, had occasion to establish a purely delivery station at Lloyd's, and from a variety of reasons it was found too expensive to establish a regular telegraph station with wires, instruments, and clerks. Mr. Latimer Clark, who was then the engineer to the company, suggested that by the laying down of a small leaden tube, and the employment of small engine power, air might be compressed, and employed to force the messages through, inclosed in suitable carriers. The idea thus suggested was put into practical operation, and was successful; and it may be remarked that, with few variations, the original system as introduced by Mr. Clark remains in force to the present day. The requirements at that time were simply for the speedy delivery of telegrams, and the tube being found quicker than even wire or hand, its use was extended, until a further development took place, when it was found that by the use of an exhausting pump, or a vacuum, messages could be received at the central station as well as forwarded from there. This alteration occurred some years later, when Mr. Cromwell Varley became Mr. Latimer Clark's successor as engineer to the Electric and International Telegraph Company. The extensions then became more rapid, and previous to the acquisition of the telegraphs by the General Post-office, a large system of pneumatic communication had not only been established in the city of London, but also in some of our provincial towns.

The tubes employed were of lead, 1½in. diameter, enclosed in ordinary iron piping—where the business was large a pipe of 2¼in. was subsequently used—and with the engine was employed a "container," so that a quantity of air might be stored, as that was found necessary when several tubes were at work simultaneously. At the time of the transfer, and for some few years subsequently, the Central Telegraph Station was at the old Telegraph Company's headquarters in Telegraph-street, and remained there until the arrangements were completed for their transfer to the new General Post-office at St. Martin's-le-Grand, but the change in the pneumatic system did not take place until a subsequent period. Previously, however, a double line of pneumatic tubes on the Siemens system—adopted in Berlin—with iron tubes, had been laid down between Telegraph-street and Charing Cross, with intermediate stations at St. Martin's-le-Grand and Temple Bar. These tubes were 3in. diameter, and the stations fitted with a peculiarly clever switch arrangement for the interception and forwarding "carrier."

The change to the New General Post-office involved an entirely reconsideration of the whole question of pneumatic transmission, and when the special stations selected with regard to public and postal convenience were decided on, elaborate experiments were entered into as regards the question of speed of transmission, amount of motive power, size of pipes, and various other details; the result is to be seen at the present time, and but few alterations or amendments have been found necessary. Indeed, the system of tubes as then planned has been found so generally equivalent to the work required, that but few extensions have been made, the most important being that to the Houses of Parliament, which extension by the way was originally contemplated when the Siemens plan was first adopted. It was decided to do away with all the small gauge tubes, and adopt entirely the 2¼in. tube, which, after many experiments, was found to be the best size in every respect.

The plan adopted in this country from the outset and subsequently adhered to has been that of the "radial" system, whilst on the Continent the "circular" arrangement has been preferred. That is to say, it has been considered here—especially in the companies' days when competition was so rife—that speed, and rapidity of delivery were everything. Each important delivery and receiving station was in direct communication with the central station, so that no time should be lost in transmission through other stations, and where the importance of the stations was found of sufficient greatness two tubes were laid, one for sending and the other for receiving messages. On the Continent, however, it is considered amply sufficient to have a circular line with a certain number of stations on it. Trains of "carriers" with one labelled for each station are despatched at regular intervals, and their contents being taken from or added to at the several stations, return to the central station again. This may conduce to regularity, but certainly not to speed. The radial system as adopted by us has invariably been found to be successful, and it continues to give complete satisfaction.

The system of the pneumatic tubes now in use by the General Post-office is about twenty-five and a-half miles in length, of which about six and a-half miles are in provincial towns, the remainder being in the metropolis; the longest tube is that from the central station to the Houses of Parliament, whilst the remainder are almost entirely confined to the City, the longest of these being that to Lower Thames-street, which is almost exactly one mile in length; this is the only tube in the City which has an intermediate station in it. There are many stations close to and there are also many in connection with the central station and its various departments; indeed, these and the tubes in the building inside are so many that they occupy nearly a mile in length.

There are few who witness the expediting of messages through the tubes at the central station who are aware from the simple action of the messenger boys engaged in forwarding, the amount of care and mechanical skill which has been called for, not only in laying the pipes, but also in the arrangement for receiving and forwarding messages. If it were not for extreme care, the soft lead tubes would offer obstacles to the carrier containing the messages, such as to delay if not prevent its arrival at its destination. But science and skill have so far triumphed that the work at the end of the tube is so simple and mechanical that a very small boy can learn in a few moments.

At the receiving, or stations other than the central, all is simple and there is really nothing to be seen. At the central station, however, everything is combined, and we have there the heart of the system, which gives life and vitality through its tubular conductor to the outlying arteries. Taking the general pneumatic system as seen from one's view at the central station, we can see that messages are transmitted by the motive power of air admitted by a peculiar arrangement of valve into a conducting tube, and that the motive power is produced by the action of steam. It may be within the recollection of our readers that a description of the special engines, designed and constructed by Messrs. Eastons and Anderson, appeared some time since in our columns. The engines, it is only necessary to say here, consist of three 50-horse power condensing engines on the compound principle, and we believe it may be safely stated that there cannot be seen anywhere in London a prettier sight than the engine room with all its bright work and cleanliness, reflecting credit not only to the designer, but to those who have the constant task of keeping it as it ought to be. To each engine are attached two air-pumps for either compressing or exhausting air, and the valves connected with these pumps are of such excellent design that the duty of the pumps can be changed without the stoppage of the engine. From the engine-room in connection with the air-pumps are conducted two large mains to the central gallery, the one for the compressed air, the other for the exhausted air; the capacity of the former is 285 cubic feet, that of the latter 439 cubic feet, a greater capacity being always required for the exhaust tubes; but the absolute requirements of such mains is not a stringent necessity; they have been adopted in order to provide an even flow of air, so that pulsation should not occur.

The sight, as we have mentioned, the visitor sees is a long row of lead tubes, terminating in brass valves. These tubes are arranged in the following manner:—At one end of the row are all those which are especially and only engaged in forwarding messages; at the other end are those which are only engaged in receiving messages, whilst between the two are those tubes which alternately receive or send, or are used indiscriminately for either purpose. For the end tubes a single sluice valve is fixed, for the middle a double sluice valve, whose working is simplicity itself; these valves are of considerable merit, and are the design of Mr. Willmott, who has been connected with the pneumatic system from its early days. The messages are enclosed in "carriers," which differ but little from those originally constructed. The carrier as at present improved upon consists of a central tube of wood fibre prepared in a peculiar way—formerly this tube was of gutta-percha—surrounded by a jacket of felt, at one end projecting, at the other protected with buffers of the same material, the central portion being of larger diameter, acting as a piston fitting close to the tube; the loose end also acts as a piston when inflated by the air pressing on it. Between the inner tube and its jacket is a broad elastic band, which on being stretched allows the messages to enter, and on its relaxation keeps them firmly in their place, preventing them from falling out.

It is hardly necessary to explain that when the carrier is placed in the tube, and compressed air is admitted, it is immediately propelled towards the distant end, where it discharges its freight of telegrams; and when a carrier is inserted at the receiving end of the tube, the signal being given, the exhaust is applied, the carrier progresses driven by the incoming air. It is strange to watch the rapid incoming and outgoing of these carriers consequent on the receipt of the various electric signals, for be it known the traffic through these tubes is regulated on the block system, and, indeed, it is not unlike a well-worked railway system.

The amount of air pressure used is as a rule about 11 lb. to 12 lb. per square inch for forwarding, and about 8½ lb. for receiving or vacuum, whilst the pressure of steam in the boilers is from 55 lb. to 60 lb. The engines are not all used at the same time, two engines only are at work during the day from nine a.m. until five p.m., and one from five p.m. until nine a.m. next day. Whilst the two are at work, one is occupied in compressing air, the other in producing a vacuum; and at night time when the single engine is at work, one pump compresses, the other exhausts. Every month an engine is relieved from work, and the spare one takes its place, during which time the standing engine is overhauled.

From the variety of curves and gradients of the pipes it is difficult to arrive at any just comparison of the speed of the various tubes, but there can be no question of the immense advantage in the rapidity of delivering messages within a limited radius by pneumatic tubes. Even with the tube to Thames-street, a mile in length, the time occupied is less than three minutes, and with one about half a mile in length only one minute. As we have before remarked, the system of lead tubes has found universal favour with us, and when once laid carefully and free from fault, it should last for an almost unknown period free from any inherent accident or fault; the only cases of interruption to the passage of carriers are due to external causes from the carelessness of men opening the streets. A pick breaks the outer iron pipe and makes a dent in the leaden tube, causing an obstruction. When such an event occurs, which is extremely rare—hardly one per annum—the damage is soon found and remedied.

Journal ~~Telegraph~~ Sept 15 80

IMPROVED HELIOGRAPH OR SUN SIGNAL.

By TEMPEST ANDERSON, M.D., B.Sc.

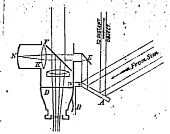
(Read before the British Association, Aug., 1880.)

The author claims to have contrived a heliograph, or sun telegraph, by which the rays of the sun can be directed on any given point with greater ease and certainty than by those at present in use.

When the sun's rays are reflected at a small plane surface considered as a point, the reflected rays form a cone, whose vertex is at the reflector and whose vertical angle is equal to that subtended by the sun. Adding to the size of the mirror adds other cones of light, whose bounding rays are parallel with those proceeding from other points of the mirror, and only distant from them the same distance as the points on the mirror from which they are reflected. Hence increasing the size of the mirror only adds to the field to which the sun's rays are reflected a diameter equal to the diameter of the mirror, and this at any distance at which the sun-signal would be used is quite inappreciable. Adding to the size of the mirror adds to the number of rays sent to each point, and hence to the brightness of the visible flash, but not to the area over which it is visible.

By the author's plan, an ordinary field-glass is used to find the position of the object to be signalled to, and to it is attached, in the position of the ordinary sunshade, a small and light apparatus, so arranged that when the mirror is turned to direct the cone of rays to any object within the field of view of the glass, an image of the sun appears in the field, at the same time as the image of the distant object, and magnified to the same degree, and the part of the field covered by this image is exactly that part to which the rays are reflected, and at which some part of the sun's disc is visible in the mirror.

A perfectly plane silvered mirror, A, takes up the rays of the sun, and when in proper position reflects them parallel with the axis of D, which is one barrel of an ordinary field-glass. The greater part of the light passes away to the distant object, but some is taken up by the small silvered mirror, E, which is placed at an angle of 45° to the axis of D, and reflected at a right angle through the unsilvered plane mirror, F, and the convex lens, K, by which it is brought to a focus on the white screen, H, which is placed in the principal focus of K. The rays from this image diverge in all directions, and some are taken up by the lens, K, and restored to parallelism; some of these are reflected by



the unsilvered mirror, F, down to the field-glass, D, and if this is focussed for parallel rays, as is the case in looking at distant objects, an image of the sun is seen projected on the same field of view as that of the distant object. As the mirrors, E and F, are adjusted strictly parallel, the rays proceeding from F into the field-glass are parallel and in the opposite direction to those going from the mirror, A to E, which form part of the same pencil as those going to the distant object. Hence the image of the sun seen in the field exactly covers the object to which the sun-flash is visible, and in whatever direction the mirror, A, is moved so as to alter the direction in which rays are reflected to the distant object, and the angle at which part impinge on E and are reflected through the lens, K, the image visible in the glass moves in the same direction. Several attempts to produce this result were made by the use of mirrors and prisms, before the lens, K, was introduced, but they all failed. It was easy to make the image of the sun cover the object when the two occupied the centre of the field of view, but directly the mirror was inclined so as to direct the rays not strictly parallel to the axis of the field-glass, the apparent image diverged generally in the same direction along one co-ordinate, and in the opposite along one at right angles to it, so that nowhere, but in one line across the field, did the image lie in the desired position. The mirrors, E and F, are adjusted parallel once for all, by noticing the position on a screen of the small spot of light reflected from the front of F as the light passes from E to K. The mirrors are moved by the adjusting screws till this spot has, to the bright reflection from the mirror, A, the same relative position that the centre of mirror, F, has to the mirror, A.

In actual use the field-glass is first fixed in position pointing to the object, either by holding steadily in the hand, or better by a clamp attached, by which it can be screwed into a tree or post, or fixed in the muzzle of a rifle. The instrument is turned on the barrel of the glass till the sun is in the plane passing through the two axes of the instrument, and the mirror, A, is turned till the bright image of the sun is seen on the screen, H, through a hole left for the purpose in the side of the tube. On looking through the glass the sun's image is seen, and by then slightly rotating the instrument or moving the mirror, is made to cover the object. The mirror, A, is connected not directly to the body of the instrument, but to a lever, B, on which it works stiffly, so as to retain any position in which it is placed. Lever B works easily and has a limited range of motion, to one end of which it is pressed by a spring; slight pressure with the finger moves it and its attached mirror, so as to throw the light on and off the object in a succession of long and short flashes by which letters and words may be indicated. Flashes may also be given by moving the instrument if held in the hand.

The above instrument answers well for all positions of the sun except when very low behind the observer's back. For this case another mirror is provided by which the light is reflected on to the mirror, A. Messrs. T. Cooke & Sons, York, are sole makers of this instrument.

Menlo Park Scrapbook, Cat. 1048

No. 33. "Laws of Electricity and Magnetism"

This scrapbook covers the years 1873-1880 and contains clippings about electrical and magnetic laws and theories. There are 124 numbered pages.

Blank pages not filmed: 2-7.

Laws of Electricity and Magnetism 1048

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Theory

33 Vol 2

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Tel Jour Dec 15 1878

DILATATION OF BODIES BY ELECTRIFICATION.—At a recent meeting of the French Academy of Sciences, M. E. Duter described some experiments tending to show that in certain cases electrification changed the volume of bodies. A large thermometer tube is filled with water and coated outside with tinfoil. The tube then forms a Leyden jar or condenser, the water being the interior conductor, the foil the exterior conductor, and the glass tube the insulator. A platinum wire inserted into the water inside acts as an electrode or charging rod. As soon as the jar is electrified the water is seen to sink to a lower level, at which it remains until the jar is discharged, when it immediately regains its former height. Since, in a condenser electricity only resides in the insulator, it is natural to conclude from this experiment that the glass itself is dilated, and this inference is supported by the fact that whatever be the nature of the armatures, tinfoil, water, saline, or mercury solutions, the same apparent contraction of the internal liquid is observed. In order to remove all doubts M. Duter modified the apparatus by placing the Leyden jar in an envelope of closed glass, terminated also by a thermometric stem and filled equally with a liquid conductor. In this arrangement the liquid of the internal reservoir formed the interior armature of the condenser, and the liquid of the envelope formed the exterior armature, the glass tube forming, as before, the insulator. This glass tube ought, if the inference be correct, to enlarge itself by electrification. The result was that while the inner liquid sank the outer liquid rose to an equal amount, thus proving the accuracy of the inference. As soon as the apparatus was discharged, the original levels were restored. The conclusion is that the internal capacity of a Leyden jar and the external volume are increased by charging it with static electricity. Temperature cannot cause this change since the effect is immediate on charging and discharging. Electric pressure cannot cause it, because it would be the same on both sides of the dielectric, and a diminution of volume would be the result. It is not due to the polarity of the armatures, for on reversing the poles the effect is the same.

M. Jamin pointed out that the first observation of M. Duter, namely, that the internal volume of a Leyden jar is increased by charging it, was noticed by M. Govi about ten years ago, in the transactions of the Academy of Turin; but that he had not seen as M. Duter had done, that the exterior volume also increased.

Tel Jour Nov. 1. 1878

ELONGATION OF A CONDUCTOR TRAVERSED BY A CURRENT.—M. Blondlot has presented to the French Academy of Sciences an account of some experiments undertaken with a view to prove whether or not there is really an elongation of a wire when a current passes in it, as Edlund and Streinitz have believed and Wiedemann has denied. This method is designed to distinguish more clearly than heretofore between the effect due to heating and that due to the current. The principle of it consists in intercalating a thin metal ribbon in the circuit, by means of stout soldered connections. Any effect due to heating will dilate this ribbon both longitudinally and transversely, so as to increase its bulk without deforming it. But the current effect, if it take place, will do so unequally in the two directions, and will consequently deform the ribbon. Any misshaping of the metallic band or of figures traced on its surface ought therefore, M. Blondlot reasons, to be due to the current, and if there be none, such a direct mechanical action of the current does not exist. With the current from ten Bunsen cells no elongation could be detected, although the arrangement was capable of showing an elongation of 0·00000025m. per metre. Ribbons of brass, German silver, and other metals were experimented on, but with the same negative result.

Tel Jour June 15 1873

Action of Electricity on Flames.—Memoir by M. V. Neyreneuf. (Extract by the author).—There has been demonstrated the existence of an electric wind in placing a flame near an electrified point. The experiment is in reality complex, and depends, *inter alia*, upon the nature of the fluid we employ. A flame may be considered as a very good conductor; produced at the extremity of a glass tube well insulated and placed before a point, it attracts the molecules of air that surround this point, and in this manner the wind results. It is susceptible itself of attraction, and with inverse proportionality to the distance of the point; there should therefore exist a certain distance at which the wind acquires a maximum intensity. It is this which I have to make known. If the flame is produced at the extremity of a metallic jet in communication with one of the armatures of a Holtz machine, whilst the point communicates with the other, the electric wind is generally much more intense, but the effects are complex, and follow the relative arrangement of the point and of the flame. Matters arrange themselves always as if the electricity were really propagated in a direction from positive to negative; also a positive point repels the flame, while it is attracted by a negative point. With a Bunsen flame we do not obtain sensible repulsion.

Tel Jour, Dec 1 1877

NATURE OF THE ELECTRIC SPARK IN A GAS.—From researches which he has made, M. Cazin concludes that the electric spark in a gas is due to incandescent gas particles, and solid and liquid particles. The gas particles give a bright line spectrum, and the solid and liquid particles a continuous spectrum. They are derived from the gaseous medium and the electrodes. As the pressure of the gas is increased, the solid and liquid particles become more abundant, the continuous spectrum intensifies, and the bright line spectrum seems to dilate, till eventually the two spectra flow into each other, and blend in one continuous spectrum.

By experiments on the length of the electric spark in different gases at the ordinary atmospheric pressures, MM. Warren de la Rue and Hugo W. Müller find that the length of the spark under the ordinary pressure is longest in hydrogen, nitrogen, oxygen, and carbonic acid. It is nearly twice longer in hydrogen than in air. The spark in air between a point (positive) and a plate (negative) with the battery employed (8,040 chloride of silver cells) was about 0·34 inch in length; in hydrogen the length was 0·60 inch. The length of the spark does not appear to depend on the specific gravity of the gas, but rather on its viscosity.

Tel Jour Dec 15 77

DILATATION OF WIRES BY THE ELECTRIC CURRENT.—It has been thought that the electric current dilates the wire through which it is passing to a greater degree than that due to its heating effect, and results have been obtained supporting the idea. Recent experiments of M. Exner, however, on wires of platinum, copper, iron, and steel, lead him to believe no such dilatation exists. The experiments were made by heating the wires to a steady temperature by the current, and measuring both the dilatation and resistance. By means of the resistance results it was possible to raise the wires afterwards to exactly the same temperature by means of an ordinary source of heat. A comparison of the dilatation when heated by current and when heated otherwise, showed no extra dilatation due to the current.

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ON A NEW FUNDAMENTAL LAW OF ELECTRO-DYNAMICS.

TILL quite recently Weber's law was generally accepted as a fundamental law for all electrical phenomena, embracing the laws of static electricity, and electro-dynamic as well as induction phenomena. It is based (as is known) on the assumption, that two particles of electricity which are in relative motion exert forces on one another, which are different from the forces exerted by the same particles on each other when at rest. The first objections against Weber's law appear to have come from the English side. In Thomson and Tait's Handbook of Theoretical Physics, the Weber hypothesis is cited as an example of a theory which is rather injurious than useful, because Weber's conclusions are in contradiction with the conservation of energy, and because the supposition of two different electric fluids cannot possibly correspond to fact. The English views were adopted and advocated by Helmholtz in a work published in 1870. This work was the beginning of a long controversy with regard to Weber's law, in which various *savants* took part; a controversy which, indeed, still continues.

Recently M. Clausius has sought to replace Weber's law (which he rejects, as contrary to fact, on grounds independent of those of Helmholtz), by another. He starts from representations which differ in essential points from those hitherto common. He supposes that the electro-dynamic action of two moved particles of electricity on each other is by means of matter existing between them. Consequently, it is not necessary that this action depend merely on the relative motion of the particles, but it may also be influenced by their *absolute* motion: since the moved particles behave ever differently with regard to the medium between them, acording to the kind of motion. In this reprerentation, the supposition is no way unnatural, that the direction of the electro-dynamic force does not coincide with the connecting line of the particles. On the basis of this supposition, M. Clausius has given, for the action between two electric particles, general expressions, from which all forces exerted by galvanic currents on each other, and inductive actions, may be deduced. Specially as regards the force which one current-element is subject to from another, M. Clausius obtains an expression for it, which is somewhat more general than Ampère's expression for the same force. Clausius' expression passes into that of Ampère if we give to a certain constant the value 1. In the action of closed currents on one another, which it has only been possible to investigate experimentally hitherto, that constant goes quite out from the result. In this case, therefore, the new law of Clausius agrees perfectly with experience. With regard to that undetermined constant, M. Clausius expresses the conjecture that its value is equal to *nil*, because through this supposition the fundamental equations are brought to their simplest form.

M. Clausius has then further examined the question, whether the new law is in harmony with the principle of conservation of energy. He finds that this is the case if we assume that in each current-element there are equal quantities of positive and negative electricity, and if we take into account not only the action of the electrical quantities of like name, but also those of unlike name. The members connected with the hitherto undetermined constant do not, of course, range under the law of the conservation of energy, but disappear for closed currents. If that constant be equal to *nil*, then even for the elementary action the agreement with the law of conservation of energy is perfect.

In conclusion, M. Clausius gives a further expression for the elementary action between two current particles. It differs from the first, only in the parts by which the action of closed currents is not affected. The further conception (in addition to the one above referred to, and likewise differing from that hitherto common) underlies this expression, that the force which one particle exerts on a second is not similar to the force which the second exerts upon the first.—*Der Naturforscher.*

Tel Jour. July 1877

On a New Fundamental Law of Electro-dynamics. By R. Clausius.—In explaining the phenomena of electro-dynamics, W. Weber has stated a law with respect to the mutual effect of two electric particles when in motion. Let e and e' be the two particles, and r their distance apart, which is to be regarded as a function of the time t. According to Weber, these particles repel each other in a manner represented by the following formula, in which c is a constant:—

$$\frac{ee'}{r^2}\left[1 - \frac{1}{c^2}\left(\frac{dr}{dt}\right)^2 + \frac{2}{c^2}\, r\frac{d^2 r}{dt^2}\right]$$

Helmholz has raised certain objections to this formula, and the author, upon grounds quite distinct from those upon which Helmholz has based his objections, has come to the conclusion that the formula in question does not represent the actual facts. The author's investigations have led him to the statement of another law in this case.

In starting with the idea that the electro-dynamic action upon each other of two moving electro particles takes place through the medium which separates them, we must not assume that this action is dependent merely upon the *relative* motion of the particles, but an influence must be attributed to the *absolute* motion of each particle; for example, if two electric particles move in a parallel direction and with equal rapidity, and are as a consequence equally at rest, they, nevertheless, may exercise an electro-dynamic influence upon each other, for as regards the intervening medium they behave otherwise than as particles really at rest.

The latter part of the paper is devoted to the development and statement of the formulæ used to express the new electro-dynamic law put forward by the author.

Tel Jour May 1. 1877.

11

ON THE TEMPERATURE OF THE ELECTRODES IN THE INDUCTION SPARK.

WHEN discharges occur between electrodes, a very various behaviour of the latter is noticed, and heat actions especially are found to preponderate on one side or other, according as the discharge is in one direction or the opposite. Mr. Hermann Herwig (*Pogg. Ann.*) recently thought he might arrive at a more adequate explanation of the case of the induction spark passing in free air if he determined exactly the influence of an independent heating of one electrode on the phenomena. Such heating, by supplying beforehand a certain portion of that heat which otherwise the discharge must effect, seems specially fitted to throw light on the nature of the relations in question.

In carrying out this plan, the ends of the secondary coil of a large Stöhrer induction apparatus were connected through a sensitive mirror galvanometer, and then brought in a symmetrical manner to the two halves of a severed platinum wire, which were placed horizontally one over the other, and crossing at right angles, being separated by a small layer of air. The free ends of the platinum wires passed over insulated pulleys, and were stretched with weights, while the other ends were connected with the induction wires through a commutator, by means of which the upper wire could be made the positive or negative electrode for the induction currents always going in the same direction. The upper platinum wire could then, by means of mercury cups, and without any disturbance, be inserted in the circuit of a special battery, by means of which it could be heated to the commencement of a weak red glow. The direction of the current used for heating was indifferent for the results of the experiment.

With these arrangements, the effect on the galvanometer of a single making and breaking current was each time observed; first, when both the wires were cold; and next, when either the positive or the negative wire was heated. It is evident that the galvanometer-effect with such induction sparks is also dependent on other circumstances; as on the softness of the electrodes, which in later discharges is greater than in earlier. Hence, a definite explanation could only be expected from numerous suitably arranged experiments; and the mode of proceeding was, that, in connected series, ten experiments were made with cold wires, then ten with glowing of the positive, ten with glowing of the negative, again ten with cold wires, ten with negative glowing, ten with positive glowing, and lastly ten with cold wires. With cold wires, the upper was alternately positive and negative. The average values obtained from several hundred experiments are contained in the following table:—

Separation of the wires.	Deflection. With cold wires.	Deflection. With positive heated.	Deflection. With negative heated.
$\frac{1}{4}$ mm.	126·5	261	337
$\frac{1}{2}$ "	55·5	122·5	201·5
$\frac{3}{4}$ "	40	55·5	175
$1\frac{1}{2}$ "	5	19	82
4 "	4	15	30

"Without attaching too great value to the numbers," says Mr. Herwig, "it may thus be affirmed with certainty that a vigorous heating of the one electrode lets greater quantities of electricity from the action of certain electro-motive force of induction pass over, and that this holds pre-eminently for the negative electrode. The first part of this result might have been expected, as both the tearing loose of metallic particles and the driving of charged air particles out from an electrode already highly heated must take place more easily; it also distinctly shows that both electrodes essentially participate in the discharge. Of much greater importance, however, is the second part, according to which the negative electrode, under the same favouring influence, gives much more abundant quantities of electricity than the positive. Further, the above-mentioned variability attaching to galvanometer actions in such experiments mostly ceases when the negative electrode glows, and secondly it is only in the case of the glowing of the negative electrode, with short distances, that a slight galvanometer action is also sometimes obtained with the closing induction current.

"Thus, what earlier experiments made probable enough, is undoubtedly confirmed (it seems to me) by these experiments, in a more direct manner, that, namely, even in the induction spark, which passes in free air, *the negative electricity is more easily put in motion.* For the gas discharges of the Holtz machine, this has been likewise proved by MM. Wiedemann and Rühlmann."

With the assumption, now no longer arbitrary, that in the separation of charged metal or gas particles from the electrodes the negative charge is more easily carried away, M. Herwig points out that the insufficiently explained one-sided action of such discharges becomes readily intelligible. In general, apart from various conditions modifying the phenomenon, experience teaches that the negative electrode shows the greatest production of heat, when a discharge occurs discontinuously with short impulses; when, on the other hand, the discharge is of a more regular, continuous character, the heat action preponderates at the positive electrode. Now the heat action is chiefly at the place where the electric motion is terminated, or where the electric equalisations specially occur. With the discontinuous discharge the greater mobility of the negative electricity acts so that a stronger backward equalisation of the electricity takes place at this electrode, and, besides, the equalisation must also occur in the portion of air in the neighbourhood of the negative electrode, because, according to Wiedemann and Rühlmann's observations, the more difficultly discharged positive electricity is driven forth with greater velocity from its electrode.

With the more continuous discharge of the Voltaic arc, on the other hand, the interrupting layer may be regarded as pretty conducting, so that the greatest heat effect occurs in the place of the greatest resistance, that is, in this case, at the positive electrode.

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Tel Journ Nov 1 77

Effects of Heat on Voltaic Circuits completed by an Electrolyte. By M. HELLESEN.

I. M. DU MONCEL has shown, that if one of the plates of an electrolyte is heated, there is a thermo-electric action causing a current to be developed, for which the heated plate forms the positive pole. This may become very strong, if the arrangement is such as to maintain the liquid round the two plates at very different temperatures. M. Hellesen connects two test-tubes near the top by a narrow tube, fills them with saturated solution of sulphate of copper, and fixes the copper electrode in one near the top, in the other at the bottom. Then he heats with a spirit lamp the test-tube whose electrode is near the top. A considerable current is obtained, and this electrode is quickly covered with copper. A simpler arrangement is, to fix on the edge of a vessel containing sulphate of copper solution a plate of copper curved so as to touch the surface of the liquid on one side, while on the other it presents, outside of the vessel, a surface which may be heated. The other electrode is immersed at the bottom of the liquid and connected by covered wire with the first; thus a strong current may be had. In these arrangements, the heated parts of the liquid tend to remain at the surface. Using magnetic helices of copper tubes, in which might be made to circulate cold water and super-heated steam, magnetic effects might be obtained (M. Hellesen thinks), which would explain the magnetic state of the globe in virtue of the unequal temperature of the seas. II. If an electrolyte be formed with the smoky flame of a paraffine candle, and a current be sent from 40 Leclanché elements or 30 of bichromate of potash, a strong arborescent deposit of carbon first forms at the end of the negative wire, the branches tending to rise in the direction of the flame, and to regain the positive wire. In a few seconds, carbonised threads, slightly arched, come to be deposited on the latter, also tending to rise with the flame. If you bring the two sets of deposits near each other, there pass a series of brilliant sparks. III. If for the short wire, connecting the anvil of the contact-breaker of a Ruhmkorff coil with the condenser, there be substituted a long wire wound parallely with another on a second bobbin, one may observe, when the ends of the second insulated wire are placed a short distance apart, a pretty strong spark, which can only come from the discharge of the condenser; for it can be produced with quite short wires not wound in helix, it is not influenced by a magnetic core placed in the second bobbin, and the inductor current of the apparatus does not pass into this second bobbin. On the other hand, it increases with the size of the condenser, and depends on the nature of the insulating plates of the latter; the strongest effects being with mica. This spark has in some cases had sufficient tension to traverse several millimetres of air, though only one Bunsen element (middle size), a coil of moderate dimensions, and a secondary wire of 10 metres, have been used.

13

THE TELEGRAPHIC JOURNAL.

VOL. II.—No. 40.

ON THE

ABSOLUTE ELECTRO-MAGNETIC UNITS OF RESISTANCE AND ELECTRO-MOTIVE FORCE, WITH SUGGESTIONS FOR THEIR RE-DETERMINATION.

AT the late British Association Meeting at Belfast a very important communication with the above title was made to Section A by Professor G. Carey Foster.

Kirchhoff and Weber were the first to devise methods of measuring electrical resistance in absolute electro-magnetic measure. Subsequently, Sir W. Thomson suggested a method for the same purpose to a Committee of the British Association, by whom a series of measurements were carried out at King's College in 1863. The results of these experiments have been accepted throughout England, and the B.A. unit has passed into general use as the "Ohm." In Europe, however, its employment has been but partial and its accuracy has lately been questioned by Continental physicists. M. Kohlrausch has lately, by a most careful series of experiments, determined an absolute unit which differs considerably from the ohm, and in his paper (which has been translated into the *Philosophical Magazine*) he assigns his reasons for supposing the ohm to be wrong. Still more recently, Professor Lorenz, of Copenhagen, has by another method made a determination which differs from both the preceding.

The extent to which the three sets of experiments differ is shown by the following comparison: the absolute resistance of a Siemens mercury-unit is—

According to the Brit. Assoc. Committee ...	0·9537
" Kohlrausch	0·9717
" Lorenz	0·9337

Thus, although the results are not concordant, the value obtained by the Committee is intermediate between those given by the other two determinations. With these discrepancies in the results, it is obviously desirable that this most important physical measurement should be repeated with all possible precautions to ensure accuracy.

Foster's method consists (like any other) in determining the ratio of the electro-motive force to the strength of the current produced by it in a given conductor; and then, since—

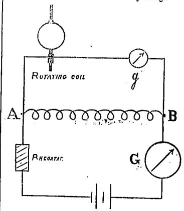
$$\frac{E}{C} = R,$$

the resistance of the conductor is determined.

For this purpose a large coil of covered copper wire, like a hoop placed vertically, is made to rotate about a vertical axis, so as to have a certain electro-motive force E generated in it by the horizontal component of the earth's magnetic force. During each half-revolution beginning and ending with the plane of the coil at right angles to the magnetic meridian, the mean value of E is—

$$\frac{2aH}{t},$$

where a is the effective area of the coil, t its time of revolution, and H the earth's horizontal intensity; but during successive half-revolutions the sign of E is alternately positive and negative. The ends of the wire of the coil are connected with a commutator on its axis (as in an ordinary Delezenne's circle) which causes the current in all external portions of the circuit to flow in only one direction. This being arranged, all that would be wanted, in order to know the resistance of the wire of the coil, would be to measure the strength of this current, and calculate the electro-motive force by observing the speed of rotation. But it is plain that the resistance so calulated would include the resistance of the commutator, which is variable and wholly irregular, so some modification is necessary which shall entirely eliminate this source of error. Prof. Foster manages this by applying Poggendorff's method of measuring E.M.F., that is, by stopping all current in the coil with a branch of an auxiliary stronger



current. A constant battery (shown in the diagram) has its circuit completed through a Siemens unit, a standard coil, or other conveniently-mounted resistance, A B, which it is desirable to know in absolute measure. A certain difference of potential exists between the ends of the wire A B, and this can readily be altered by changing the resistance of other parts of the circuit till it is precisely equal to the electromotive force generated in the coil when revolving at some constant rate. There is a delicate Thomson's galvanometer, g, in the coil circuit, which shows when the two differences of potential are equal by the absence of all current through it: and when this point has been attained, the battery circuit is totally unaffected by its connection with the coil. The strength of the current in A B is now to be very carefully measured in absolute measure by an accurate absolute tangent-galvanometer, G; this current is produced by an electro-motive force E (which we have arranged to be equal to the difference of

Over

8 14

Electrical News

July 22 1875

Journal de Physique, June, 1875.

Note on the Pressure of Electricity and on Electric Energy.—M. Blavier.—Hardly suited for abstraction.

On the Flow of Liquids.—M. Isarn.—The author shows, by some experiments, that in the phenomenon of contraction of a liquid vein, one cause is, superficial tension acting like an elastic ring round the jet where it quits the vessel. In one experiment he varies the superficial tension by action of electrolysis. A vein of mercury is made to flow through a narrow tube which is immersed in acidulated water, connected with one pole of a battery, while the mercury is connected with the other pole. With suitable pressure, the flow being *nil* in normal conditions, it appears either in drops, or with a limpid portion when the current passes so that the vein is positive. On breaking the circuit, the flow ceases, as if one had turned a cock. Again, if the liquid already flow with a limpid portion, this portion is suddenly elongated when the vein becomes positive. Lastly, if the vein be made negative, the phenomena are reversed, so that the limpid portion contracts successively, in the passage from + to zero, and from zero to −; and we may have continuous flow when the vein is positive, flow by drops when it is in a neutral state, and complete cessation of flow when it becomes negative. These phenomena show that the positive mercury, *i.e.*, oxidised superficially, has a weaker superficial tension, and that this tension returns to its normal value when the mercury is deoxidised. M. Isarn has noticed the same thing in the sinking and rise of an areometer plunged in mercury, when the surface of the latter, covered with a layer of acidulated water, is made successively positive and negative by the passage of a current.

On the Hughes' Electro-magnet, and some of its Applications.—M. Lartigue.—Will appear in a future number.

Electrical News

Aug 19 1875

Experimental Determination of the Dielectricity Constants of some Gases.—M. L. Boltzmann.—The dielectric constant of vacuum is taken as unity. The square root of the constant of a gas is, according to Maxwell's theory, equal to the index of refraction of the gas. The following table gives M. Boltzmann's figures obtained from experiment, with a pressure of 760 m.m.:—

	$\sqrt{D}$.	i.
Air	1·000295	1·000294
Carbonic acid	1·000473	1·000449
Hydrogen	1·000132	1·000138
Oxide of carbon ..	1·000345	1·000340
Protoxide of nitrogen	1·000497	1·000503
Olefiant gas	1·000656	1·000678
Marsh gas	1·000472	1·000443

The dielectric constant of sulphur changes, conformably to Maxwell's theory, when taken in a different direction relatively to the optic axes of the crystal.

Electrical News

Aug 19 1875

An Experiment on the Electro-Dynamic Action of the Polarising Current.—MM. Schiller and Colley.—The authors' object was to find whether a liquid conductor exerts electro-dynamic action while the electrodes in it are polarised. In a Wiedemann galvanometer, which has two movable wire-coils on the two sides of the magnet, one coil was removed, and a spirally wound caoutchouc tube substituted. In this were put distilled acidulated water and two platinum electrodes. A current of four Daniells, which, notwithstanding the great resistance, wrought considerable decomposition of the water, was sent in opposite directions through the liquid and the metallic spirals, and these were moved till they compensated each other in action on the magnet. Then one Daniell was substituted for the four Daniells. Neither at closing the circuit nor afterwards, on closing the wire, with the battery excluded, was the least movement observed in the magnet. Hence it follows that the process going on in the liquid is, in its action on the magnet, perfectly equivalent, both qualitatively and quantitatively, to the galvanic current passing in the metallic part of the circuit.

Telegraph Journal

Sept

Electrical Length.

The term "electrical length" has been employed in contradistinction to the ordinary or physical term by which the idea of length is conveyed. Electrical length is of course synonymous with electrical resistance. In the laboratory, and even in our handbooks, the expression "a wire of so many ohms" is common, and it is necessary that the student should dissociate the idea of physical length from such an expression. To the electrician the expression "a wire of 10 ohms," or "10 ohms of wire," conveys as distinct meaning as "10 yards" or "10 miles" laid out by ordinary physical measurement. Given a definite electrical unit of resistance, it is always as easy to measure by electrical appliances the value of that resistance as it is to put a rule or tape by the side of a wire, and to say how long is the wire. A circuit, then, of ten ohms, electrical length does not necessarily include that it should be greater in physical length than one of five ohms, or just half the amount, because if the ten ohms' wire be a very thin wire only a short piece will interpose twice as much resistance as a mile of the five ohms' wire if the latter be very thick or coarse.

But in telegraphic or other work where one gauge of wire is principally employed, it is not unusual to speak of the actual length of the wire in terms of the resistance-coils. Thus, instead of saying that the line from London to Birmingham is so many miles in length, we may say it is so many ohms or units long, meaning that the line-wire between London and Birmingham has so many ohms or units of resistance, and our meaning is as clear and as true as if it had been expressly stated.

This idea of electrical length will bear great extension, and will be so extended during the discussion of electrical principles with our students. It is better, therefore, now to lay down clearly the difference between electrical and physical length.

Electrical News

July 1 1875

Researches on Interrupted and Interverted Currents, and their Thermal and Electrodynamic Effects.—M. Villari.—An iron wire is heated more by an interrupted current than by a constant one, and still more, if the direction be reversed at each interruption. The *augmented resistance* increases (M. Villari finds) with the thickness of the wire; also with the intensity of the current, but only to a certain limit. It further increases with the rapidity of the interruptions and the number of reversals per second.

15

the action of the electro-magnet than when it is fixed, and naturally so, because the rotating disc remains too short a time with each of its diameters in the axial direction of the magnetising magnet to receive all the magnetism it is capable of receiving when allowed a longer time.

Professor Villari describes a series of researches springing out of those described. The general results obtained are thus summed up:—

1. The action of rapid rotation of a flint glass disc between the poles of an electro-magnet has the effect of lessening the magnetism produced in the disc.

2. This diminution is greater the more rapid the rotation.

3. In order to make a weak diamagnetism disappear, a less rapid rotation is required than to destroy a stronger.

4. In order to call forth such a diamagnetic intensity in flint glass as can be observed through the rotation of the plane of polarisation, a space of time not less than 0·001244" is necessary.

5. The time is not always the same, and it decreases with the increase of the magnetising force. Hence the diamagnetic motions in flint glass are the more rapid the greater the demagnetising force.

6. In order to produce in flint glass the whole diamagnetism which it is capable of receiving under the action of a strong electro-magnet, a time not less than 0·00241" is necessary, this being nearly three times as much as is required for the first symptoms of diamagnetism to show themselves.

7. The diamagnetism in flint glass, under the conditions of experiment described, continues for a space of time which is less than 18 hundred-thousandths of a second.

THE SELECTION AND NOMENCLATURE OF DYNAMICAL AND ELECTRICAL UNITS.*

We consider that the most urgent portion of the task entrusted to us is that which concerns the selection and nomenclature of units of force and energy; and under this head we are prepared to offer a definite recommendation.

A more extensive and difficult part of our duty is the selection and nomenclature of electrical and magnetic units. Under this head we are prepared with a definite recommendation as regards selection, but with only an interim recommendation as regards nomenclature.

Up to the present time it has been necessary for every person who wishes to specify a magnitude in what is called "absolute" measure, to mention the three fundamental units of mass, length, and time, which he has chosen as the basis of his system. This necessity will be obviated, if one definite selection of three fundamental units be made once for all, and accepted by the general consent of scientific men. We are strongly of opinion that such a selection ought at once to be made, and to be so made that there will be no subsequent necessity for amending it.

We think that, in the selection of each kind of derived unit, all arbitrary multiplications and divisions by powers of ten, or other factors, must be rigorously avoided, and the whole system of fundamental units of force, work, electro-static, and electro-magnetic elements, must be fixed at one common level—that level, namely, which is determined by direct derivation from the three fundamental units once for all selected.

The carrying out of this resolution involves the adoption of some units which are excessively large or excessively small in comparison with the magnitudes which occur in practice; but a remedy for this inconvenience is provided by a method of denoting decimal multiples and sub-multiples, which has already been extensively adopted, and which we desire to recommend for general use.

On the initial question of the particular units of mass, length, and time, to be recommended as the basis of the whole system, a protracted discussion has been carried on, the principal point discussed being the claims of the gramme, the *metre* and the second, as against the gramme, the *centimetre*, and the second; the former combination having an advantage as regards the simplicity of the name *metre*, while the latter combination has the advantage of making the unit of mass practically identical with the mass of unit volume of water; in other words, of making the value of the density of water practically equal to unity. We are now all but unanimous in regarding this latter element of simplicity as the more important of the two; and in support of this view we desire to quote the authority of Sir W. Thomson, who has for a long time insisted very strongly upon the necessity of employing units which conform to this condition.

We accordingly recommend the general adoption of the centimetre, the gramme, and the second, as the three fundamental units; and until such time as special names shall be appropriated to the units of electrical and magnetic magnitude hence derived, we recommend that they be distinguished from "absolute" units otherwise derived, by the letters "C. G. S." prefixed, these being the initial letters of the names of the three fundamental units.

Special names, if short and suitable, would, in the opinion of most of us, be better than the provisional designations "C. G. S. unit of . . . . . ." Several lists of names have already been suggested; and attentive consideration will be given to any further suggestions which we may receive from persons interested in electrical nomenclature.

The "ohm," as represented by the original standard coil, is approximately 10^9 C. G. S. units of resistance. The "volt" is approximately 10^8 C. G. S. units of electromotive force, and the "farad" is approximately $\frac{1}{10^9}$ of the C. G. S. unit of capacity.

For the expression of high decimal multiples and sub-multiples, we recommend the system introduced by Mr. G. J. Stoney—a system which has already been extensively employed for electrical purposes. It consists in denoting the exponent of the power of 10 which serves as multiplier, by an appended cardinal number if the exponent be positive, and by a prefixed ordinal number if the exponent be negative. Thus:—

10^9 grammes constitute a *gramme-nine*,

$\frac{1}{10^9}$ of a gramme constitutes a *ninth-gramme*,

* First Report of the British Association Committee on Units.

8 16

NOTE.—All degrees of temperature are Centigrade, unless otherwise expressed.

Comptes Rendus Hebdomadaires des Seances de l'Academie des Sciences. No. 23, December 6, 1875.

Distribution of Magnetism in the Interior of Magnets.—MM. Trève and Durassier.—In this paper, which cannot be intelligibly abstracted without the accompanying diagrams, we find the interesting observation that those parts of a magnet where its force is greatest are less readily attacked by acids than its neutral or central parts.

We have pleasure in calling the attention of our readers to a course of fifty lectures, on Electricity and Magnetism, which are being delivered by Prof. Foster at the University College, and which are advertised in our first page.

Terrestrial Magnetism.

To the Editor of the Scientific American: Oct 75

In an article entitled "Terrestrial Magnetism" on page 164 of our current volume, I notice a statement which may mislead, and beg leave to correct it. "That the earth is not a great magnet, but that the phenomena of the magnetic needle are due to the electric earth currents which flow at right angles to the earth's axes." These two statements are contradictory. "The earth is a great magnet, and the phenomena of the magnetic needle," etc., is the way it ought to have been put. For all our most recent knowledge tends to confirm Ampère's theory that a magnet is merely a closed circuit of electric currents acting parallel and in sam direction, and not necessarily a mass of iron, nickel, or cobalt. So that the earth, being surrounded by such curren ts, is as much a magnet as the magnetic needle. I. B. M,

Hoboken, N. J.

OCTOBER 23, 1875.]

Electric Force and Molecular Motion.

To the Editor of the Scientific American:

Mr. W. E. Sawyer, in his letter on "What is the Electric Force?" in your issue of October 9, says: "When one pulls a bell cord, and instantaneously a bell is rung in a distant room by the molecular transmission over or through the bell wire of the force applied at the cord, does not one realize that he is as veritably, as wonderfully, and by a similar molecular motion, transmitting that signal as though he were transmitting it by applying a battery to a telegraph wire, and thus setting the atomic particles in motion?"

I propounded the above question to myself, endeavored to realize it, and failed signally; therefore I apply to you for help, and trust it will be given, for Mr. Sawyer's explanations of the electric force seem so clear and forcible as to enable almost any one to form a good idea of the subject.

When one pulls a bell rope, causing a bell to ring at a distant point, one can readily realize the disturbance of the atomic particles from ocular demonstration. He sees the movement of the cord where the force is applied, and also where the bell lever receives it, and the only rational explanation is that of molecular transmission.

In the case of the telegraph, he sees no motion, either where the force is applied, or where it is taken off, even when the force so applied is very powerful. However, this may be deduced by reasoning, as Mr. Sawyer so ably shows, but the real difficulty is at the end, where it is utilized. The wire terminates in a coil, and inside of this coil, entirely separated from it, is a bar of metal, and entirely separated from this is the bell lever. Now it is difficult to conceive how the mere molecular disturbance of the wire causes a like disturbance in the bar, which again causes the same in the bell lever or armature. If the motion were transmitted directly to the bell lever by a material connection, as in the first case, then there would be no difficulty in understanding this application of the theory.

Philadelphia, Pa. THOMAS C. MARCKLEY.

17

Electrical Science in English and Foreign Journals.

(In addition to our usual abstracts, there will be found under this heading the titles of papers on electrical science which have appeared in English and foreign journals from the commencement of the present century up to the date of the establishment of this journal).

Poggendorff's Annalen der Physik und Chemie.

VOL. XVI. (1829).

The Experiments and Remarks on the Polar Behaviour of the Liquid in the Galvanic Battery, with Reference to Communications on the Subject from MM. Marianini, Pfaff, and De la Rive. M. Pohl. P. 101.

On Irregular Movements in the Daily Action of the Horizontal Magnetic Needle. M. Kupffer. P. 131.

Observations by Dr. Erman of Terrestrial Magnetism in Russia. P. 139.

The Magnetising Power of the Violet Rays. M. Zantedeschi. P. 187.

The Production of Chemical Compounds through Electro-Chemical Forces. M. Becquerel. P. 306.

The Magnetising Property of Sunlight. MM. Riess and Moser.

VOL. XVII. (1829).

The Crystalline Form of Tourmaline, Zinc-Silicate, and Boracit, with reference to the Electric Polarity Produced through Change of Temperature. M. Köhler. P. 146.

On Decomposition of Sulphide of Carbon by Electricity. M. Becquerel. P. 183.

Dr. Erman's Measurements of Terrestrial Magnetism in Russia (Continued). P. 328.

Influence of Heat on Magnetism. MM. Moser and Riess. P. 403.

Hail and the Electric Phenomena of our Atmosphere. M. Ideler. P. 435.

The Thermo-Electric Power of Metals. M. Becquerel. P. 535.

VOL. XVIII. (1830).

The Daily Change of Intensity in the Horizontal Portion of the Magnetic Forces. M. Reich. P. 57.

The Production of Chemical Compounds through Electro-Chemical Forces. M. Becquerel. P. 143.

Measurement of the Intensity of Terrestrial Magnetism. MM. Moser and Riess. P. 226.

The Analogy Presented in the Propagation of Light and of Electricity, and on the Constancy of Actions of Electric Currents which are Compelled to Pass through Spaces which have been Already Traversed by Other Electric Currents. M. St. Marianini. P. 276.

Observations of the Inclination of the Magnetic Needles During a Journey to Ural, Altai, and the Caspian Sea. M. von Humboldt.

VOL. XIX. (1830).

Ether-Formation through Contact-Electricity. M. Lüdersdorff. P. 77.

The Daily Variation of Magnetic Force and Extension of Poisson's Method for Measuring the Intensity of Terrestrial Magnetism. MM. Riess and Moser. P. 161.

The Regular Hourly Variations and the Perturbations of the Magnetic Deflection in Central and Eastern Europe. M. Dove. P. 357.

Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences, Vol. lxxviii., No. 16.

An Improved Thermo-Electric Battery.—M. C. Clamond.

No. 17.

On the Elemental Law of Electro-dynamic Actions.—M. J. Moutier.—A purely mathematical paper, being an investigation of Ampère's "Theory of Electro-dynamic Phenomena," with the object of formulating Ampère's views having regard to the idea of electricity as the result of a vibratory movement of the ether.

No. 18.

On the Depth of the Magnetised Layer in a Steel Bar.—M. J. Jamin.—Having previously shown that magnetisation penetrates to a finite depth into steel, M. Jamin experimented upon the limit, and the law of the decrease of the intensity from the surface to that limit. It suffices to quote the experiment of the breaking of a magnet to affirm that a bar is composed of threads, or elementary chains, of small magnets, which succeed and join one another by their contrary poles. Granted that these threads are all equal to one another,—that is to say, they are grouped in bundles of the same strength,—he assumes that in their whole length the contrary poles which are in juxtaposition are entirely concealed, in such a manner that the threads are inactive excepting at each extremity, where a single free pole is found. Being inactive, they extend parallelly to the axis in the prismatic bars, as far as the extremities; but, as there are there free poles which repulse each other, they expand by diverging, and terminate at the various points of the free surface, where they develope reactions. Upon each superficial element the intensity is proportional to the number of poles found there, and to the square of the force with which its attraction is overcome. The total number of the threads, or the total quantity of magnetism, is equal to the sum of the intensities on each element,—that is to say, the sum of the square roots of the detaching forces. M. Jamin quotes four points which he set himself to examine:—(1) the sum total of the threads which cross the middle zone of the magnet; (2) the law of distribution in this zone; (3) the sum total of the intensities distributed over the free surfaces; (4) the distribution of these intensities. Four series of steel plates were prepared with thicknesses of 1, 2, 3, 4 millimetres, and each 1 metre long by 50 m.m. broad. After saturating them with magnetism by means of a powerful coil, the magnetism developed on their surfaces was measured. First, the plates were divided into five bands by four equidistant lines running parallel to their length; then on each line, at certain distances, the detaching forces of a small trial contact-piece, suspended to the scales of a balance, were measured. The square roots of these forces represent, at each point touched, the magnetic intensity. The mean of five drawn curves, representing the intensities as measured, was taken, and the author stated—"It is clear that the area of this curve measures the whole of the magnetism, or the number of elementary threads, contained in a longitudinal slice of the magnet perpendicular to its thickness." The results of his calculations to discover this area led him to conclude that the magnetic threads are less numerous in proportion as one removes from the perimeter of the middle zone, and in proportion as one penetrates into the substance. That was evident *a priori*, but the author argues further that during magnetisation the force of the coil exerts itself directly upon the surface; but, experiment proving that it is not transmitted through a bed of steel of sufficient thickness, we can but admit that its action on a core rapidly diminishes with the depth. Call F the intensity in the exterior points: it will be $\frac{F}{a}$ at a distance 1, $\frac{F}{a^2}$ at a distance 2, and $\frac{F}{a^y}$ at a depth y. Now the quantity of magnetism developed in a slice whose thickness is dy

8 | 18

Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences, Vol. lxxviii., No. 20. May 18, 1874.

On Magnetic Bundles Formed by Plates Separated by Intervals.—By M. J. Jamin.—Coulomb, in his study respecting magnetised bundles, contented himself with measuring their magnetic moment. He found that this moment increases less rapidly than the number of plates. The problem was badly put, for it was to measure the force of a bundle by the product of two factors—the totality of the magnetism and the distance of the pole from the centre. Now these two factors vary at once and in opposite direction. It was far simpler to seek the law which governs one only of these two factors, and it was that which led M. Jamin to estimate the total magnetism, and to prove that in a bundle it is rigorously equal to the sum of the magnetism of the elements. He now demonstrates how the laws of bundles modify themselves without ceasing to be very simple, when the plates, instead of being rigorously attached and close to one another, are pur...

[20030.]—**Electrical Strength.**—I am afraid that this will be rather a difficult thing to answer, but I am of opinion that a person in good health cannot take so much as a person in bad health. I have seen a little girl about six years old taking more than three grown up persons could bear.—Tele. Lineman.

[20030.]—**Electrical Strength.**—From reading the replies given in last Saturday's number, I am tempted to contribute my iota of explanation. How very few people understand the expression so frequently used about having strong nerves or the reverse. First of all, the "strength" does not lie in the nerves at all, but is merely an impression or influence resident in the brain or other nerve-centres, and on occasion it stimulates the nerves and thereby excites the contraction of the muscles. Now the action of a current of electricity does the same thing—it excites a powerful contraction of the muscles, independently of the brain or of the nerves, except that the latter act as conductors, as may be seen in a frog, by making the legs twitch after the remainder of the body has been removed, and it must be noted that it (the strength) depends more on the power of will (the influence referred to) conveyed by the nerves than absolutely on the size of muscles, and a weak person under the influence of powerful excitement, has performed feats which a much stronger person without the impulse would fail to achieve. A phrenologist would probably say that the strength would depend on the development of the bump of endurance (I forget the scientific cognomen), as any one by a preformed determination can sustain a much more severe shock than he could generally. To make a fair test of relative endurance of the electric current the hand must be soaked in water slightly salt before seizing the conductor, as it does away with the resistance of the epidermis.—Alfred.

Comptes Rendus Hebdomadaires des Seances de l'Academie des Sciences, tome lxxx., No. 25, June 28, 1875.

Distribution of Magnetism in a Thin Plate of Great Length.—M. J. Jamin.—The author has been engaged in studying the distribution of magnetism in a bundle of rods, commencing with the most simple case, that of a single broad plate, so long that it may be regarded as infinite, and of an equal thickness of 1 millimetre. He has experimented upon various pieces taken from a long and very homogeneous band of steel.

— Les *Mondes* publient une correspondance du R. P. Lafond, sur l'*Observatoire météorologique et magnétique* établi à Zi-Ka-Wei (Chine).

Notre observatoire, dit-il, est dans ses commencements, puisque les observations magnétiques ne datent que de deux ans; nous construisons en ce moment la salle qui doit contenir le grand appareil enregistrant par la photographie les variations des éléments du magnétisme terrestre tel qu'il est installé et qu'il fonctionne régulièrement à Kiew depuis longtemps : ces phénomènes magnétiques sont ici d'une régularité surprenante; aussi j'ai tout lieu d'espérer de notre appareil une ample moisson de faits pour l'étude de ces phénomènes intéressants.

June '76

...ments on Rotatory Magnetic Polarisation.—M. H. Becquerel.—It results from these researches that the molecules of bodies submitted to the action of magnetism interfere by their specific action with the phenomenon of the rotation of the plane of polarisation of light, and that for highly magnetic bodies this action varies with the mutual distance of the active molecules.

MANCHESTER

Literary and Philosophical Society, Nov. 2.—Mr. R. Angus Smith, F.R.S., vice-president, in the chair.—Mr. Peter Spence, F.C.S., &c., exhibited a piece of 2 to 3-inch lead pipe in which the metal had been entirely transformed into galena, the crystallisation being visible through the whole of the specimen. The pipe had been used for the conveyance of gas ammoniacal water, and was sunk under ground. A considerable leak of gas-water having occurred, a constant atmosphere of sulphide of ammonium would surround the pipe, and this seems to have been the cause of the conversion of the lead into sulphide, as only that part of the pipe which was in the vicinity of the leak was found to be transformed.—On the principle of the electro-magnet constructed by Mr. John Faulkner, by Prof. Osborne Reynolds. The magnet which forms the subject of this paper consists of a soft iron bar with a flat plate attached to one end, and surrounded by a coil of wire in the same way as the ordinary electro-magnet. Outside this coil is placed a tube of soft iron of the same length as that portion of the interior bar which projects beyond the plate; this tube has flat ends, one of which is in contact with the plate, while the other comes up flush with the end of the bar, so that a plate or keep placed over the end is in contact with both the bar and the cylinder. The magnet is excited in the ordinary way, by connecting the ends of the wire which forms the coil with the poles of a battery. When thus excited this magnet exhibits certain peculiarities as compared with a common magnet. The object of the paper was to suggest explanation of these phenomena.

[23814.]—Potential.—To "Sigma."—"Beacon Lough" appears to be in the muddle which is the very common result of the use of the Shibboleth "potential." The word has so many meanings given to it and is so constantly used improperly that such confusion is inevitable. Because I have objected in my book to the constant use of the word where it is not truly applicable, the reviewer, in *Nature* is good enough to say I do not understand the term. This may be the case, as I have never yet met two people who could give the same definition of potential, and it is quite impossible to get any intelligible explanation from the various electrical books, which all use without explaining it, or give definitions entirely inconsistent with each other. It is, to begin with, unmeaning to speak of "potential" at all, or to talk of two bodies being at the *same* potential; potential has no existence, the term has meaning only when used in the form of *difference of potential*. Potential is relative only, and the use of the term in the form which "B. L." adopts (and as nearly every one does, in fact) tends only to confusion and delusion, just as does the equally common and equally absurd term "putting to earth." The earth has nothing to do with a charged condenser, except that, in making the so-called "earth connection," a derived inductive circuit may be set up, withdrawing part of the charge from the condenser. The two plates form mere surface connection to the really charged body, the di-electric; you may connect either one of the plates singly to "earth" or to the universe at large, or even to a body in a condition of vehement + or − charge, and you will produce no effect whatever upon the condenser (ignoring, that is, the question of derivation). Therefore to talk about the earth and this plate being at the *same potential* is merely to construct a wholly useless mathematical "bogy," which produces alarm and confusion in those who do not see that it is a pure imposture. Mathematicians choose to say they are at the same potential *because* no current passes, and because they have defined potential as the cause of current or electric action; but the simple fact is that there is no relation whatever, and the expression is a mere empty symbol for that fact. It is just the same when the second plate is separately connected; there is again no relation to earth, but there is a discharge of the derived inductive circuit set up at first in some cases. Relations of potential can exist only where there exist relations of circuit, and in the case put these exist only in the di-electrics—1, The material of the condenser; 2, The air between the condenser and the surrounding objects, if connection has been made to these, or to "earth" according to the commonly taught fables. In electricity "earth" means simply zero or a common conductor; the actual globe or earth has no part to play in our operations except when we use it as a large wire of scarcely appreciable resistance.—Sigma. E. M. Oct 75

[23818.]—Suspension of the ...

19

THE TELEGRAPHIC JOURNAL.

VOL. II.—No. 31.

PRELIMINARY EXPERIMENTS ON A MAGNETISED COPPER WIRE.*

By Prof. BALFOUR STEWART, M.A., LL.D., F.R.S., and ARTHUR SCHUSTER, Ph.D.

1. The following experiments were made in the Physical Laboratory of Owens College, Manchester. The copper wire employed was found to contain no perceptible trace of iron, nor was it sensibly magnetic, behaving quite in a neutral manner when tested by the highest magnetic power at our disposal. It was covered with gutta-percha. The diameter of the wire was 0·0487 inch. The wire was wound fifty-three times in one direction round the poles of a powerful electro-magnet, the length of wire encircling these poles being about 12 metres. The direct distance of the magnet from the galvanometer was about 12 metres.

A Wheatstone bridge was employed, and a very delicate Thomson's reflecting galvanometer by Elliott Brothers, of which the resistance was 5540 B.-A. units. A circuit-breaker was placed in the circuit close to the bridge. On some occasions we used one consisting of a solid key which might be removed, thus breaking the circuit; but on other occasions a fluid or mercurial circuit-breaker was employed.

When the left-hand pole of the electro-magnet was made north the arrangement was called (1), and when the other pole was made north the arrangement was called (2). It will thus be seen that the current went round the magnet in the same direction as the molecular currents of arrangement (2).

Experiments were made at intervals of two minutes; and on each occasion the current was allowed to pass through the bridge for ten seconds, the measurement being taken by the first swing of the galvanometer, which lasted for about eight seconds. Three cells of Grove's battery were used for producing this current, but on the other hand six similar cells were employed for magnetising the electro-magnet. The distance of the magnet was too great to affect the galvanometer-needle so as to alter its sensibility, the average deflection causing a difference in the zero of about four divisions of the scale.

2. In the first experiments made the key was not taken out before the magnetism was put on or off, in consequence of which the induction-current due to the wire coiled round the magnet affected the galvanometer on these occasions; but after December 12th the key was taken out, so that no induction-current passed.

The table at top of next column is a specimen of the observations made.

It will be seen from this experiment that the *first effect* of putting on the magnetism was a marked increase of resistance; but with this exception the resistance, when the magnetism was on, was less than the mean of the two resistances on both sides of it, representing the magnetism off.

Time of Putting on Current.	December 17, 1873. Whole Deflection observed (increasing deflection denotes increasing resistance in A, B, C, D).	Condition of Magnet.
11h. 11m.	312	off
13	317	off
15	311	off
17	345	(1)
19	328	off
21	306	(1)
23	303	off
25	293	(1)
27	300	off
29	290	(1)
31	307	off
33	283	(1)
35	292	off
37	288	(1)
39	302	off
41	292	(1)
43	309	off

3. The arrangement remained untouched, as far as we know, from December 15th, when it was finally made, until December 19th, when the experiments were interrupted during the Christmas holidays; and in all cases the *first effect* of putting on the magnetism was a marked increase of resistance. For instance, we have—

Date.	First Off.	First Effect.	Second Off.
Dec. 16	0	+36 on (2)	+ 3
„ 17	0	+34 on (1)	+17
„ 18	0	+54 on (1)	+24
„ 19	0	+33 on (1)	−18

It was soon seen that this *first effect* had some reference to the time elapsing since the last experiments were made. For instance, in the above table we see for December 18th a marked increase of resistance when the magnet was first put on; but on the afternoon of that day the experiments were repeated, and there was no apparent increase of resistance in this *first effect*. Next, with regard to the *average effect* on Dec. 16th, 17th, and 18th, this *average effect* of magnetism was a decrease of resistance; but on Dec. 19th there was an apparent increase of resistance when the magnetism was on. We cannot say that nothing had been done to the arrangement between the 18th and 19th of December that might account for this change, but whatever was done must have escaped our recollection. Undoubtedly a good many experiments were made during the time between the 15th and 19th of December, and the direction of the magnetism was frequently changed. This curious anomaly occurring unexpectedly induced us to limit our future experiments to a definite set each day.

4. The experiments were resumed on January 7th, the arrangement having remained untouched during the holidays. From this date until January 10th inclusive the key was taken out before beginning experiments in the morning; there was no peculiar *first effect*; while, on the other hand, an *average effect*, denoting a decrease of resistance, came out very prominently. On January 12th and 13th the key was only taken out before magnetising, and on these occasions the *first effect* denoting increased resistance was sufficiently marked.

* A paper read before the Royal Society May 7, 1874.

8 18 20

to address such an audience, either with the pen or the voice, and gave as an illustration a great meeting convened by his fellow-citizens to welcome him back to Canada after he had been knighted. He was, of course, expected to say something of himself and of his visit to Europe. He tried his best, he said, but soon grasping a long pointer, turned round to some maps and diagrams illustrative of the geology of Canada, and only recovered his peace of mind and command of language when he found himself once more among Laurentian, Huronian, gneiss, limestone, and the rest of his beloved rocks. Nevertheless, he kept copious journals of his various expeditions, and illustrated them with most admirable pen-and-ink sketches. A selection from these could hardly fail to be of great interest, both in relation to the man himself and to the way in which geology has to be carried on amid the wild life of the backwoods.

By those who were privileged with his friendship, Sir William Logan will be affectionately remembered as a frank, earnest, simple-hearted man, ever gentle and helpful, enthusiastically devoted to his profession, and never happier than when discussing geological questions in a *tête-à-tête*, full of quiet humour, too, and showing by many a playful sally in the midst of his more serious talk, the geniality and brightness of his sunny nature. Peace to his memory! He has done a great work in his time, and has left a name and an example to be cherished among the honoured possessions of geology.

ARCH. GEIKIE

TREVANDRUM MAGNETIC OBSERVATIONS

Observations of Magnetic Declination made at Trevandrum and Agustia Malley in the Observatories of his Highness the Maharajah of Travancore, G.C.S.I., in the Years 1852 *to* 1869. Vol. i. Discussed and edited by John Allan Broun, F.R.S., late Director of the Observatories. (London: Henry S. King and Co.)

WE have heard a great deal lately about the native rulers of India, and the worst features of one of them have been brought very prominently before us; but it is a pleasing reflection that they are not all like the potentate of Baroda, while some of them might even read a lesson to the paramount power. Let us hear what Mr. J. Allan Broun, a magnetician of great eminence, has to say of the late ruler of Travancore.

"The Trevandrum Observatory," he tells us, "owed its origin in 1836 to the enlightened views of his Highness Rama Vurmah, the reigning Rajah of Travancore, and to the encouragement given to them by the late General Stuart Fraser, then representing the British Government at Trevandrum. His Highness, desirous that his country should partake with European nations in scientific investigations, sanctioned the construction of an observatory, named Mr. Caldecott its director, and gave him power to furnish it with the best instruments to be obtained in Europe."

The peculiar position of Trevandrum, not far from the magnetic equator, induced Mr. Caldecott, with the Rajah's permission, to procure from Europe a complete equipment of the best instruments for magnetic and meteorological observations, and to build a magnetic observatory, which was completed in 1841.

Mr. Caldecott died at Trevandrum in 1849, and the observatory was in January 1852 placed under the direction of Mr. John Allan Broun, who had previously directed with well-known success the observatory of Sir T. Brisbane at Makerstoun, in Scotland.

Mr. Broun began his office with the conception of an interesting and important problem in terrestrial magnetism, which he was determined as far as possible to work out. This would render it necessary that the observations should not be limited to a single station. He wished, among other things, to determine how far the physical constants of terrestrial magnetism and their various changes depend on differences of height, of latitude, and of longitude.

The Agustia Malley, the highest mountain in the neighbourhood, was chosen as affording the best means for determining the effect of height, and accordingly Mr. Broun resolved to erect an affiliated observatory on this nearly inaccessible rocky peak, surrounded by forests, the inhabitants of which were elephants and tigers. These and all other difficulties connected with this formidable undertaking were, however, completely vanquished, and the Agustia Observatory was completed in 1855.

We learn from Mr. Broun that his labours were not entirely confined to these two observatories. "Other observations," he tells us, especially of magnetic declination, were made simultaneously "during short periods at different stations in Travancore, as nearly as possible on the magnetic equator, 90 miles north of Trevandrum, and also 40 miles to the south. Observations connected with meteorological questions were also made simultaneously to the east and west, and about 5,000 feet below the Agustia peak, on the peak itself, and at Trevandrum; while on one occasion hourly observations were made during a month at five different stations, varying gradually in height from the Trevandrum Observatory (200 feet) to 6,200 feet above the sea-level, in which fifteen observers were employed."

In this first volume Mr. Broun has confined himself to the magnetic declination, and one of the chief objects sought has been to determine every possible action of the sun and moon upon the magnetic needle. The observations extend from 1852 to 1870, and embrace in all nearly *three hundred and forty thousand readings.*

A considerable portion of the introduction is devoted to the discussion of a question which has, we think, been somewhat too much overlooked. When a magnet is suspended by a thread and enclosed in an appropriate box, it does not necessarily follow that all its movements are due to magnetic causes, for changes in temperature and humidity may affect the zero of torsion of the thread, and thus cause slight changes in the position of the suspended magnet. It is perhaps unlikely that such changes could seriously affect the character of the daily variation, but it has been thought that they might perceptibly affect the annual variation, since in this case the magnetic change is comparatively small, while the range of temperature and humidity is generally great.

Mr. Broun overcame this source of error by observations of an unmagnetic brass bar suspended in the same way as the magnet, which thus afforded him the means of estimating, and hence eliminating, the error due to these causes.

Besides all this, several declinometers were used and

... to discuss those by themselves, and the result has ... the most interesting and important discovery of the law of storms. And if it be asked what right meteorologists had to separate a body of disturbed observations, the reply will obviously be that they are justified by their success. Deny the right, and a cyclone becomes an ...ogether false and illegitimate scientific conception.

Now, a large and increasing number of magneticians are of opinion that the phenomena of terrestrial magnetism can bear a similar treatment. They believe that the sun has a daily and yearly influence on the magnetism of the earth just as it has upon its meteorology, and they also believe that it is the cause—the indirect cause, it may be—of an abnormal magnetic influence, just as in meteorology it is the indirect cause of the cyclone. Some even go so far as to say that these two abnormal influences, the one in magnetism, the other in meteorology, are intimately connected together. This assertion, however, is not now the point in question. The point is ...at we have in magnetism certain abnormal distur...es which may be compared to abnormal meteoro...ical disturbances. Now, it is held by Sir E. Sabine ...d those who share his views, that it is expedient to separate out these disturbed magnetical observations, just as we separate out the meteorology of a cyclone. This ...chool assert that we may thus arrive at a series of pheno...ena obeying very different laws from those of the un...isturbed observations, and that we are therefore justified in making the separation, inasmuch as we are thereby led to a clearer knowledge of the various ways in which ...e sun affects the magnetism of the earth. And they ...nsist very strongly upon the point that both these mag...etic actions of the sun have diurnal and annual varia...ons different from one another, so that if treated to...ther we obtain a result much more complex than if they ...e treated separately.

We have little doubt of the policy of this method of treatment, and we cannot, therefore, but regard it as a misfortune that Mr. Broun has not unmistakably adopted it. He has, however, given us all the individual observations, so that, if it be thought desirable, those magneticians who advocate a somewhat different method of reduction may make it for themselves. We need only add, in conclusion, that the appendices will be found to be very interesting reading, and that all who are interested in terrestrial physics must look with great interest to that magnificent series of researches of which the volume before us forms the first instalment.

B. STEWART

Faraday's experiment is well known, which consists in placing between the poles of a strong electro-magnet a cube of copper or silver suspended at the end of a twisted cord: the cube being left to itself quickly rotates; then a current is sent into the electro-magnet, and the cube is instantly arrested. Foucault produced a similar effect on a rotating copper disc. A pretty way of exhibiting this effect to an audience has been described by M. Bourbouze to the French Academy. He fixes the copper disc to the axis of the moving plate of a syren. A blast of air being sent into the syren produces the rotation, with gradually rising sound. On making the electro-magnet the disc stops, and the sound is suddenly extinguished.

DISTRIBUTION OF MAGNETISM IN BUNDLES OF VERY THIN PLATES OF FINITE LENGTH.

ELECTRICAL NEWS, August 26, 1875. 21

By JULES JAMIN.

MY previous researches have had for their object the determination of, first the "Distribution of Magnetism in a Thin Plate of Great or Infinite Length," * and then the distribution in a bundle composed of several such plates.† I now propose to study the general case in which the bundle has a *finite* length *l*.

air take place freely through the extremity of the section. At the instant when the carrier clears the space separating arrival line from the departure line, he closes behind it the departure line, and opens a stop-cock communicating with the reservoir of compressed air, which drives it through the following section of the line. He also keeps the cock open until communicated with by the operator at the next station.

Such an apparatus, we are informed, worked regularly for some months in France. The escapement of air took place in front of the relay, through a piece of tube perforated in every direction, and affording a passage equal to twice the section of the line. The closure of the line behind the carrier, and communication with the compressed air, was effected by a sort of trigger upon which the carrier acted as soon as it cleared the relay. The period of "blowing" was measured with a piston raised in a cylinder by means of the inner pressure; the law of this ascension being regulated by counter pressure in such a manner that the "blowing" lasted as long as the desired time. Directly the carrier reached its destination or entered into the continuing section, the pressure in the line fell, and the piston dropped.

The objection to the apparatus was its susceptibility. It encloses a delicate valve to close the line, and if a foreign body even partially opposes its working, the relay becomes itself an obstacle to the efficiency of the line.

To remedy this state of things it was necessary to suppress the valve, which, after the description just given, appeared to be the chief piece of the instrument. It could not be suppressed unless the escapement were suppressed; and the escapement could only be abolished at the expense of the counter pressure. This series of observations led to a project which has completely solved the question. The line is of double effect; by means of special apparatus which are really relays, it is constantly maintained empty of air, and consequently, the more compression, the more valves in the pressure relays.

The line, which we will suppose of illimited length, is escorted by two secondary pipes uniting with the suction and pressure reservoirs designed to supply the relays placed at convenient spots on the line.

These relays are of two kinds. Those whose object is to empty the line of air are placed at distances of 5 kilometres in those cases where the line will be traversed by carriers spaced by a quarter of an hour's interval. They are, moreover, extremely simple: a piston rising in a cylinder carries with it a valve closing the line and a slide opening the exhausting reservoirs. The piston is raised on the passage of a carrier by the action of the counter-pressure which follows it; it closes the line behind it, and immediately begins the exhaustion of the section just traversed. The valve borne by this relay is not subject to any of the inconveniences met with in those first invented.

The pressure relays are distant from each other 1 kilometre, and are simple "blowers," being opened on the carrier's passage, and blowing all the time the carrier is in their sections. They are merely formed of a piston carrying a counterpoise acting against a slide. The air enters the line through a kind of lantern (*lanterne*) studded with holes having twice the section of the line; and notice for blowing is given by the carrier itself, which, striking a detent, causes a counterpoise placed upon the piston and commanding the slide to fall. The blowing is instantaneous. It is suspended by the regulating piston's action, which closes the communication to line, and confines compressed air in a small chamber placed between this closer and slide. The effect of this compressed air at the moment when the pressure is lost in the line, *i.e.*, when the carrier has cleared the section, is to lift up the piston acting upon the slide and to put it in position for the arrival of the next carrier. This apparatus, which is the soul of the new system, is extremely simple and needs no supervision. It is accompanied by a reservoir of compressed air sufficient to serve its section.

22

There now remains but to examine the speed of a line furnished with these relay instruments. Let the line be 100 m.m. diameter, the suction-pressure be 50 centimetres of mercury, and the driving pressure be 76 centimetres of mercury. The comparison will be made between a line as above and the Parisian net-work, where a pressure of 40 centimetres of mercury gives a speed of 20 metres a second in a line 1000 metres long and 65 m.m. diameter.

The increase in diameter will augment the speed thus:—

$$\sqrt{\frac{100}{65}}\times 20 = 25 \text{ metres per second.}$$

The consideration that the line is constantly empty of air will reduce the friction-length of the sections of 1000 metres to a mean of 600 metres maximum; for, on entering each of the sections, *i.e.*, at the moment when the train clears the pressure relay, no column of air follows it, only at the end the column of air attains a length of 1000 metres. If exhaustion were absolute, the mean length of the friction column would be 500 metres. This diminution of the friction column gives a further increase of speed in the proportion of—

$$\sqrt{\frac{1000}{600}}\times 25 = \frac{33}{24}\times 25 = 34\frac{9}{24} \text{ metres per second.}$$

In addition to this, there is the augmentation resulting from the difference of pressures, which is likewise as the proportion of the roots—

$$\sqrt{\frac{76\times 50}{40}}\times 34\frac{9}{24} = \frac{115}{65}\times 34\frac{9}{24} = 61 \text{ metres per second.}$$

This speed is enormous, and probably might create inconveniences. The observation of trains proceeding under analogous conditions, with speeds of 40 to 50 metres, has shown that these speeds are practically quite admissible in regular working. It is only necessary to have a material extremely solid, and so arranged as to wear itself out without wearing out the line; this has been provided for by furnishing the rubbing parts of the carriers with a much softer metal than that of the line.

Pneumatic relay lines will certainly eventually become valuable communicating engines for correspondences at distant spots. The facility with which trains or carriers may be multiplied on lines without considerable expenses, the rapidity with which they are capable of progressing, will render them grand systems if applied to the postal service, for their speed of translation is triple that of the most rapid locomotive, if stoppages on railways are taken into account.

Scientif. Am. Aug. 29 1874
Scientif. Am. Aug 29 1874

Magnets.

M. Jamin describes experiments which support these three propositions: (1) The number of elementary magnetic threads, and so the quantity of magnetism a magnet may contain, depend only on the middle section. (2) The opening (*épanouissement*) of the poles of these threads, or the distribution of intensities, is regulated by the form and extent of the exterior surfaces of the magnet. (3) If the surfaces diminish, the tension increases till they become insufficient to allow of the elementary poles opening out, and a portion of the two contrary magnetisms disappears, reproducing the neutral state.

On combining 22 magnetized plates (each 0·01 inch long, 0·04 inch thick, and 2 inches broad) in a bundle, with pasteboard 0·032 inch thick between adjacent plates, each plate lost magnetism, and so the bundle, the loss of the latter being 50 per cent, which is less than in the case (first experimented on) of superposition without intervals; the loss was then 66 per cent. In this first mode all the magnetism retained was carried to the exterior; there was none, or almost none, between the plates. In the other mode the quantity remaining (151·1) was divided into two portions:—(1), 85·5, which was expanded on the exterior; and (2), 65·6, which remained in the intervals. With wider intervals the exterior magnetism diminished, the interior increased; and gradually the plates act as if they were independent.

...nied with the same electrical changes as those which ...cur in the contraction of muscle and in the functional ...citation of nerve has never yet been investigated by ...getable physiologists. Mr. Darwin, who for many ...ears has devoted much attention to the animal-like ...nctions of *Dionæa* and *Drosera*, kindly furnished ...lants for the purpose of the necessary experiments, ...hich have been made by Dr. Sanderson in the ...boratory of University College, London. The result ...as been that the anticipations he had formed have ...een confirmed as to the existence of voltaic currents ...n these parts, and particularly in the leaf of *Dionæa*. ...y a most remarkable series of experiments (which ...ill be published subsequently) made with the aid of ...ir W. Thomson's galvanometer, he has shown that ...hese currents are subject, in all respects in which they ...ave been as yet investigated, to the same laws as those ...f muscle and nerve.

...OCIETE D'ENCOURAGEMENT POUR L'INDUSTRIE NATIONALE.

At a meeting of the Council of Administration of ...his Society, under the presidency of M. Dumas, a ...etter from Sir Charles Wheatstone was read, who said,

... is the coefficient of magnetic induction. This coefficient in the four above mentioned substances cannot be very different from air, which is taken as = 1. So that we have the index of refraction equal to the square root of the constant of dielectricity. M. Boltzmann accordingly compares the square roots of these constants as found by his method with the refractive indices as determined by Wollaston's method; and the differences may be attributed to errors of observation. He considers these results, though not so accurate as to lead to the identification of light and electricity, furnish strong support to Maxwell's theory.

Bulletin du Musée de l'Industrie de Belgique. September, 1873.

Report on the Systems of Pneumatic Tubes Employed in England for the Transport of Telegraphic Despatches to Short Distances.—By M. F. Delarge, Telegraph Engineer.—(A Review, by M. Gauthy.)—Given elsewhere.

The Journal of the Franklin Institute. Vol. lxvi., No. 3.

The American District Telegraph Company.—The apparatus employed by this company is described in another portion of this journal.

Lightning and Lightning-Rods.—By John M. Mott. —Continued in our next number.

...nomena the term *meta-electrolytic* ... researches on the absorption of hydrogen by palladium, the author has made known—1. The quantity of heat (about 9000 calories) due to the formation of the alloy of hydrogenium and palladium; 2. That the condensation of hydrogen by palladium, and the condensation of gas by carbon are not in the least compatible. The method of condensation of hydrogen by platinum-black differs from that of hydrogen by palladium in plates. When the gas is introduced in successive portions into contact with the platinum-black until saturation is attained, the heat developed is not constant for the weight of gas absorbed, as takes place with palladium. Hydrogen indeed appears to form a true alloy with palladium, whilst with platinum-black it seems to form only layers of less and less density as it enters the metal. The action of platinum-black upon hydrogen appears to fall under the head of capillary affinity. The author repeats that he has been led to the conclusion that *oxygen* is not an immediate product of elec...

over

What is the Electric Force?

...Editor of the Scientific American:

...continuing the explanation of my views on this sub... commenced by me on page 100 of your current volume, ...ow me to say:

...the point of sound force, we have accurately deter... the number of vibrations of matter per second neces... to the production of a certain sound; in that of light ... we have approximately estimated the number of vi...ions, waves, or molecular motions per second necessary ... production of the various colors. In the point of heat ... we have determined that it exists in a certain violent molecular motion; and in the point of electric force, we have determined that it also exists in a certain molecular motion. And I may here mention, as being one of the strongest proofs, the fact that a current transmitted through a bar of iron will not disturb it, the fact that a current transmitted around it will not disturb it, and the fact that a current transmitted simultaneously through it and around it will cause it to twist in a very appreciable degree, which would not be the case unless the electric force consisted of molecular motion. If we were in possession of no other proof that the idea of a fluid flowing through an electric wire is a myth, we might easily be assured of it by the fact that molecular motion alone is the necessary condition of all other forces. This motion, beyond doubt, varies in intensity and form in different forces, but that it is the one condition of force there can be no doubt: and that the only difference between the forces is the difference between molecular actions may be accepted as a truism. To my mind the force of attraction of gravitation, and perhaps the more remarkable orbital motions of the planets, are forces to which the electric force bears no comparison. The electric force, in fact, is no more mysterious than is any other force. When one pulls a bell cord, and instantaneously a bell is rung in a distant room by the molecular transmission over or through the bell wire of the force applied at the cord, does not one realize that he is as veritably, as wonderfully, and by a similar molecular motion, transmitting that signal as though he were transmitting it by applying a battery to a telegraph wire and thus setting the atomic particles in motion? Cannot one realize that, if there are bells at different places upon a long wire, the nearest bell will ring first and the most distant last? But no one would speak of a subtle fluid as the cause of the ringing, although there is just as much subtle fluid passing over the bell wire as there is when a telegraph operator in New York makes a signal in Chicago by applying the battery to the line of wire connecting the two distant places.

As in this force, so in electricity, nothing flows through the wire. There is, in fact, the most striking analogy between the molecular transmission of electricity and the molecular transmission of all other forces. The stronger and more rigid the lever, the larger and firmer the belt, the larger the tube for water or air, the better the transmission of the forces applied. The larger the conducting wire, the more perfect the transmission of the electric force: because the larger conductor we have, the more perfect must be the molecular motion.

We are now brought to consideration of one of the most important facts bearing upon the question of molecular motion and the theory of a subtle fluid. The force of the electric current is as the square of the distance or length of the

conductor. A battery is a constant generator of electric force. These are our premises, and it is not difficult to understand that if, as according to the subtle fluid theory, a wire have a certain capacity to hold that fluid, just as a tube has a certain capacity to hold a liquid, it cannot matter what the length of the wire may be. It is well known, also, that the resistance of a wire varies as the square of the diametric amount of metal. Therefore, in considering the electric force as a fluid, we are bound to consider the wire as a reservoir for that fluid. Now an immense quantity of electricity passes over a very small wire in a certain period of time; and a wire ½ of an inch in diameter, the battery being of proper dimensions, will charge a condenser up to a certain point in one half the time that a wire of less diameter, composed of ¼ the diametric amount of metal will charge it, and in one fourth the time that a wire composed of one fourth the diametric amount of metal will charge it; but the smallest wire will charge it to its full capacity as well as the longest wire, merely requiring more time in proportion. Therefore, if a battery be attached to a wire 100 miles in length, the subtle fluid theory would, as soon as the battery should have sufficiently charged the wire, make it necessary that the strength of the electric force in the 100 miles of wire should be as great as though the wire were but a mile, or a few feet, even, in length. This statement cannot be controverted.

Very far from this, however, is the case. We may have our battery upon the wire for any length of time, and we shall find that the force of the electric current still varies as the square of the length of the wire. This, alone, utterly disproves the theory that, in transmitting a signal by telegraph, the wire is charged by a subtle fluid, and proves beyond doubt that the action of the battery is to impart a certain force to the atomic particles of the conductor, which act, each in turn, upon the next and the next, losing force in each successive action, just as we behold every day in the operation of all the forces surrounding us, as, for instance, the ripples occasioned by the dropping of a pebble into a still pond, widening and widening and decreasing in force and intensity as the square of the distance. In the molecular action, there must be a loss of force every time one atomic particle imparts the electric force to another. This we know is the case. According to the subtle fluid theory, this could not be the case.

Again, if we can prove, as in the case of light, that one transparent substance will transmit certain rays of light and not others, we prove that the transmission of the light force is due to molecular action, that the light force itself, in fact, is a certain molecular action. This will be conceded; and I suppose I need not at this point endeavor to prove that such is the case, as the facts have been set forth by students in this line of science, among them Professor Tyndall, in far weightier terms than I am able to command. The one and only deduction to be made from the results attained is that certain atomic conditions are necessary to the transmission of certain forces, and that certain substances are incapable of assuming the atomic conditions necessary to the transmission of certain forces. The same general law holds good in respect of the electric force.

Without entering into all details of the subject, it may be asserted that the very fact that one metal is a better conductor of electricity than another proves conclusively that the propagation of the electric force is dependent upon the atomic structure of the metals; that as its propagation is dependent upon this atomic structure, the propagation of the electric force is by the atomic or molecular action of the metals; and that as this is true, so the electric force is a certain molecular action. The conductivity of the metals is expressed by their resistance, the metal offering the least resistance to the propagation of the electric force being the best conductor. Thus with the resistance of silver expressed as 107,

224

the resistance of quicksilver is 5,650, the latter metal, which is almost without tenuity of the atomic particles, being the poorer conductor, as would inevitably be the case under the molecular theory, and so would not be the case upon any other hypothesis. There are other causes, however, for the difference in the conductivity of different metals. Heat, we know, is a violent molecular motion. The electric force, being or consisting of a certain molecular action, should therefore be disturbed by the molecular action which constitutes heat; and we find that the resistance of a metal to the propagation of the electric force is increased by increase of temperature in the metal. The violence of the molecular action which is the electric force must be apparent to any one who witnesses the wonderful deflagrating effects of that force. Intense, we know, is the molecular action which constitutes heat; and it is a remarkable fact, as pointed out by Forbes, that the order of the metals as regards their conductivity for heat is the same as their order in conductivity of the electric force.

I will conclude the present article with one more argument in proof of the assertion that electricity is nothing more nor less than a certain condition of the atomic particles of matter.

The majority of the readers of the SCIENTIFIC AMERICAN have doubtless witnessed the discharge of electricity from a condenser, such as a Leyden jar, or from a battery or induction coil. They have beheld the brilliant sparks, and very many are cognizant of the fact that every spark is a particle of the metal of the discharging point heated to the state necessary to the production of the light witnessed. The electric light is not something which has passed over or through the wire, or something partaking of the nature of many metals which may compose the wire, but it is confined in kind to the properties of the metal composing the discharging point. Thus of platinum, silver, iron, copper, or which the discharging points may be composed, each gives its own peculiar light, no matter of what metal the greater length of the conducting wire may be composed: as, for instance, we may transmit the electric force through a hundred miles of copper or iron wire, and finally, when we get the discharge, it passes through a film of platinum $\frac{1}{10000}$ of an inch in thickness: but we get the same result in the kind of light produced as though the whole of the wire were platinum. Yet the electric force is the same no matter of what the conductor may be composed; and no reasoning can account for the projection of a flaming atom of matter from the discharging points, oftentimes with force sufficient to penetrate a piece of glass several inches in thickness, beyond the theory of intense molecular action.

The simple fact that the electric light which we witness is composed of the atomic particles of the conductor, heated to the state in which we observe them, and projected or following from the mass of the conductor, from one electrode to another (atomic particles which we know never have passed through the conducting wire, but have existed at and are wearing off from the terminal alone), proves beyond doubt that nothing that we witness in electrical phenomena has passed over the conducting wire in the sense of a current; that as this force is manifested at the distant end of the conductor in the shape of projected atomic particles of matter, it is clear that the electric force is a certain intensely active condition of the molecules of matter, which activity is set up by the violent action of acids upon metals or chemicals, by heat, or by friction, and transferred from one atom to another with inconceivable rapidity; and that as no heat can exist except by combustion or by friction (unless imparted heat, which is itself sustained by combustion or friction), the voltaic arc, the most intense heat, which is not sustained by combustion but exists in all its intensity in a vacuum, can only be the result of friction; and inasmuch as the mass of the metal is not subjected to friction, the friction can only exist in a violent action of the atomic particles of the metal,

Knowledge is of two kinds, positive and negative, namely, that which we know is, and that which we know must be, because it can be nothing else. It is more by the negative than by the positive reasoning that we can determine the nature of electricity. Deschanel, recognizing the crudities of the electric fluid theories, said of the positive and negative currents: "It is conceivable that the two electricities, instead of being two kinds of matter, may be two kinds of motion, or in some other way may be opposite states of one and the same substance." The reasoning by which we establish the verity of this conception is both positive and negative, and the reasoning of analogy.

Washington, D. C. W. E. SAWYER.

Sections 9 and 10, Magnetism and Electricity, are likely to prove two of the most attractive, as they are certainly among the most important. All departments of these subjects—and how varied they are even scientific men may be astonished to learn—are illustrated with great fulness; the number of entries in the Catalogue is 650, commencing with the greatest natural magnet yet known, weighing, with armature, 152 kilograms, sent by the Teyler Foundation, Haarlem, and concluding with a minute description of the Polar Light Apparatus, by Prof. Lemström. Of apparatus connected with Electricity the variety is astounding. Friction and Induction Machines, Galvanic Batteries (there are 32), Thermo-Electric Batteries, Induction Coils, Magnetic-Electric Machines, and other modes of producing Electricity or Electric Currents, are abundantly represented. So, also, apparatus for producing, collecting, observing, regulating, and measuring electricity; of Galvanometers alone there are 43. In the Electrical Section, no doubt the most attractive department to the general public will be that devoted to apparatus for the application of Electrical principles to practical purposes, illustrating, as it does, every stage in the progress of the Electric Telegraph. The Catalogue in this department contains 204 entries of Telegraphic apparatus alone, not to mention the various other applications of electricity to military and other purposes. Nature May 76

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A NEW RELATION BETWEEN ELECTRICITY AND LIGHT: DIELECTRIFIED MEDIA BIREFRINGENT.

By JOHN KERR, LL.D., Mathematical Lecturer of the Free Church Training College, Glasgow.

(*From the Philosophical Magazine.*)

The thought which led me to the following inquiry was briefly this:—That if a transparent and optically isotropic insulator were subjected properly to intense electrostatic force, it should act no longer as an isotropic body upon light sent through it. Faraday was often occupied with expectations of this kind; and he has mentioned in his memoir on the Magnetization of Light, and elsewhere in his "Researches," how he experimented in this very direction, upon electrolytes as well as dielectrics, at different times and in many ways, but always without success.* As far as I remember, I have not read or heard of an attempt in this field by any other naturalist. I proceed to offer a few notes of some recent experiments of my own. The investigation is not so complete as I should wish it to be; but it has been carried forward as far as my limited time and means would allow. At present I confine myself to solid dielectrics, reserving the case of liquids for a second paper. The principal results given in this first paper are stated apart, in articles 11, 17, 23.

1. *Dielectric of Plate Glass.*—A piece of good plate glass, ¼ inch thick, is formed roughly, before it leaves the shop, into a rectangular block 6 inches long and 2 wide. In this and subsequent operations, the original polish of the plate is carefully preserved. Two holes, about 1-10 inch wide, are drilled into the block from its opposite ends; they lie exactly as in continuation of each other, in a line parallel to the longest edges of the block, and midway between opposite faces; and they terminate in well-rounded bottoms at the centre of the block, with a short extent (a quarter inch or less) of clear glass between them. Two fine pillars of glass rise from a stand on the table, distant an inch or two from each other. The block is placed across the pillars (at about a foot from the table), its plate-faces vertical, and the line of borings horizontal; and in this position it is tied securely to the pillars by coils of silk thread. Two thick wires of copper, sheathed in guttapercha, have their bare extremities inserted in the borings, down to the ends. As a provision against the strongest electric action applied in any case, these wires are coated very deeply with lac or sealing-wax at their junction with the glass, and an inch or more outwards. The whole surface of pillars and block is well varnished with lac—except a small space which is left clean upon each of the plate-faces, to allow distinct vision through the centre of the block.

When the dielectric has been thus prepared, its transparency is all that can be desired. Objects bright or faint are seen horizontally through the central parts of the plates (between and around the ends of the borings) quite as well as through a fine window.

2. The electricity is obtained from a Ruhmkorff's induction apparatus, which gives a spark of 20 to 25 centimetres. The dielectric just described stands upon the table close to the inductorium. The outer ends of the wires from the dielectric are screwed into the knobs of the secondary coil. From the same knob two wires are led to the other side of the instrument, and are connected with two insulated metallic balls, which act as spark-terminals. The distance of these balls, or the actual spark length in air, is under the observer's control at every instant.

The ends of the secondary coil are separated thus at one place by so many inches of air, and at another place by a quarter inch of glass. When the primary circuit is closed in the usual way, through the oscillating rheotome of the instrument, the air between the spark-terminals is broken by a sensibly incessant discharge, while the glass between the induction-terminals is traversed by a strong electric force. By simple increase or diminution of the distance between the spark-terminals, the intensity of electric strain thus produced at the centre of the glass block may be raised or lowered at once and in any degree, as the observer pleases. I may mention that on several occasions, when the instrument was working at full power, and the spark-terminals were drawn 7½ or 8 inches apart, strong discharges burst across between the two induction-wires, at the rate of about one per second, without cessation of the principal discharge. The insulation was so good that the dielectric was not in any way damaged. The discharges took place through the air in dense white sparks, from end to end of the block, a distance of 7 or 8 inches. In these circumstances, the part of the glass block between the induction-terminals must have been subjected to a strain little short of the utmost it could bear. Electric forces of such intensity were hardly ever applied in the experiments—were not, indeed, required.

3. The polariscope consists of two Nicol's prisms. A flat paraffin flame, presented edgeways, is used as a source of light. Next to the lamp, and close to it, comes the first Nicol; then, at a distance of two feet or more, comes the dielectric of plate glass; then, at a like distance, comes the second Nicol. The pieces are so arranged that the observer, looking horizontally through the polariscope, and keeping the first Nicol at the centre of the field of vision, sees the flame through the centre of the dielectric, midway between the induction terminals. The light crosses the dielectric at right angles to the plate-faces, and therefore at right angles to the lines of force.

4. *Neutralizing Plate.*—Every very thick plate of glass which I have yet worked with exerts most of its points a slight depolarizing action upon transmitted light. When such a plate is inserted between the two Nicols without compensation, anything like perfect extinction is generally unattainable, and the sensibility of the polariscope is lost.

The principal section of the first Nicol being in any desired position, and that of the second Nicol perpendicular to it, the dielectric (still unexcited, though connected with the coil) is inserted properly between the Nicols, and the light reappears well in the polariscope.

The neutralizing plate, a piece of glass about six inches square, taken from the same original plate as the dielectric, is then placed upon a stand immediately in front of the second Nicol, and is moved by trial into such a position that the restored light is again extinguished perfectly by a very small rotation of the analyzer. The apparatus is now ready for work.

The highest powers applied in the experiments are sufficiently indicated thus: Battery in the primary circuit, a series of six Grove's or Bunsen's elements; corresponding spark length, 9 or 10 inches; actual spark-length, or thickness of air between the spark-terminals, 6 inches, rarely 7; thickness of glass between the induction-terminals, 3-16 inch. But powers a good deal lower give effects distinct enough.

6. *First Experiment.*—The pieces are arranged in the order and manner just described (2, 3, 4). The spark-terminals are fixed at a distance of 5 or 6 inches; the polarizing Nicol is laid with its principal section at 45° to the horizon; and the analyzer is turned, with the help of the neutralizing plate into the position of perfect extinction. No piece of the apparatus is now touched, except the commutator, till the end of the experiment.

Looking through the polariscope, the observer closes the primary circuit. In about 2 seconds the light begins to reappear through the dielectric, at its old place between the induction-terminals, very faintly at first; but it brightens continuously for 10, 20, even 30 seconds, till it is almost brilliant. When the primary circuit is now broken by the commutator, the light fades away continuously, at first rapidly, then more slowly, to perfect extinction. The time that elapses (in the latter part of the experiment) between the opening of the primary circuit and perfect extinction in the polariscope depends very noticeably upon the intensity and duration of the electrification, increasing as these increase.

7. The light thus restored by electric action cannot be extinguished again, at any stage of the experiment, by any rotation of the analyzer either way.

8. *Second Experiment.*—The polarizing Nicol is laid with its principal section either horizontal or vertical; the analyzer is turned into the corresponding position of perfect extinction; all the other arrangements and the procedure are as in the first experiment. There is now no regular effect ob-

*Faraday's "Experimental Researches," 2216, p. 951, or Maxwell's "Treatise on Electricity," vol. ii. p. 399.

is not a very great effort required for extinction at any time during the whole hour of observation.

19. *Ninth Experiment.*—The analyzer is mounted in such a way that it may be moved in different directions at right angles to the beam, without rotation; the other arrangements are as in the fifth experiment. When a good effect has been obtained through the centre of the electric field, the second Nicol is moved about so as to receive the light through different parts of the dielectric.

Keeping first to the perpendicular bisector of the line joining the terminals, the intensity of the optical effect diminishes as the distance from the centre of the field increases; and this is particularly noticeable at first, while the effect is rising; but the action has always the same character, is always neutralized by horizontal tension of the compensator. As far as my means would allow, I have assured myself of the fact that, as soon as there is a good virtual compression of the dielectric at the centre of the field, there is an effect of the same kind, a virtual compression in the same direction, beginning to manifest itself all along the equator, but more faintly as the distance from the centre of the field increases. Out of this equatorial line, and well back from the wires, the direction of apparent compression of the dielectric changes from point to point of the field, and is at some points vertical, perpendicular to the line joining the terminals. Only at points very close to the induction-wires does the compensator fail decisively to extinguish or greatly weaken the restored light.

20. In connection with the preceding facts, I may mention that under certain conditions, in the fifth experiment, the compensator does not extinguish the restored light all at the same time, but produces a very dark broad band, which descends from the outer parts of the field towards the centre, as the tension of the compensator increases. This happens for instance, though not very regularly, when the electric force is very intense from the beginning, and the optical effect is just beginning to show itself; it happens also when the lines of force are inclined to the horizon, so that the fine vertical band of flame seen through the centre of the dielectric crosses the equator of the field at about 45°. In these cases there appears to be an unusually rapid variation of birefringent action through the part examined of the electric field.

I have now done with the dielectric of plate glass. Half-a-dozen other solids were tried; and I will conclude with a short account of the only two of them which gave results worth mentioning. The great difficulty was to get a sufficiently strong superficial insulation, the masses being too small. In only one case, that of Iceland spar, was the dielectric perforated by discharge without giving a clear effect; but I think the crystal had received a predisposing flaw in the operation of boring.

21. *Dielectric of Resin.*—This is a piece very similar to the dielectric of plate glass in form, size, and adjuncts. A quantity of clear amber resin is kept at a gentle fusion for some time till it is free from air-bubbles; it is then poured into a suitable mould and left to cool. Two thick stocking-wires of steel, previously fixed into the mould, along one line through its ends, remain imbedded as induction-terminals in the solid resin, leaving less than one-quarter of an inch of clear dielectric between them at the centre of the block. The polarized light enters and leaves the central part of the block through small squares of thin plate glass, which are in optical contact with the resin, and parallel to each other.

This dielectric, even the best specimen of it, is far inferior to the dielectric of plate glass. It gives evidence of permanent and irregular strain in the neighborhood of the terminals; it exerts a pretty strong photogyric action in the polariscope, separating the blue and red by a small angle; it is also imperfectly transparent for very faint light; but its chief defect is, that it allows a spark-discharge over its surface, a length of 7 inches, before the distance of the spark-terminals has much exceeded 2¼ inches. With all these deficiencies, the dielectric of resin gives a definite and regular effect; and the action is contrary to that of glass.

All the arrangements are essentially as in the fifth experiment (14). The block is tied to two insulating pillars of glass; the induction-wires of the dielectric are connected with the knobs of the secondary coil; and the light is seen through the centre of the block; midway between the terminals. A pretty good initial extinction is obtained in the polariscope between the blue and red; the light is then well restored by electric action, and the compensator is introduced between the dielectric and the second Nicol. By tension of the compensator in a direction parallel to the lines of force, the restored light is constantly and distinctly strengthened; and by compression parallel to the lines of force, it is regularly and greatly weakened, though never quite extinguished.

To test the value of these indications, I repeated the illustrative optical experiment (12) with the block of resin put in the place of the large block of plate glass; and the results were satisfactory. I varied the experiment also by manipulating the block of resin itself as a compensator against the small square of compressed glass, the resin being simply pulled or pushed gently at both ends; and the results were equally distinct. The lines of stress being parallel, compression of glass and compression of the resin always reinforced each other, compression of glass and extension of the resin always counteracted each other, but never down to perfect extinction. It is true that these last results might be due more or less to the thin plates of glass which limit the resin. From all the observations, I infer that dielectrization of resin is optically equivalent to tension of the resin along the lines of force.

22. *Dielectric of Quartz.*—This is a plate perpendicular to the axis, made as for ordinary experiments in the polariscope, thickness 3 millims., length 20. Two fine holes are drilled into the plate as in the dielectric of plate glass, their bottoms flat, and with one-sixteenth of an inch of clear crystal between them. Wires of copper are inserted in the borings, and are fixed along with the crystal to simple bearings made of glass rods; and the whole piece is coated very deeply with fused lac, a narrow window being left at the centre of the plate. The action of the crystal in the polariscope is well neutralized by a contrary plate of equal thickness; the other arrangements are as in the fifth experiment. With my rough apparatus, the adjustments are so troublesome that I have executed only one short series of observations, of which I append all the notes preserved.

Distance of spark-terminals ½ inch; a faint but clear restoration of the light from almost perfect extinction; the compensator not working distinctly; the insulation perfect.

Distance 1 inch; the light clearly restored by electric action, and then well extinguished by tension of the compensator parallel to the lines of force. The insulation is now failing, sparks passing occasionally over the service of the lac near the crystal.

Distance ¾ inch; the insulation still defective; the light well restored by electric action and, then well weakened by horizontal tension, and strengthened by compression. From what I have seen in some other experiments, I think that the effects in this case and the preceding may have been produced wholly or partially by slight changes of temperature, due to occasional spark-discharge over the surface of the crystal.

Distance again ½ inch: the insulation again good. In this case it is noticed that, before the electric force is applied, while the body of the light is barely perceptible in the polariscope, there is a short length of it from the apex downwards (due exactly through the center of the electric field) which is perfectly extinguished. By electric action this upper part of the light is restored very clearly, and is then as clearly extinguished by tension of the compensator parallel to the lines of force.

23. Upon the whole, though better experimental results are desirable, I consider it proved that dielectrified quartz (like glass) acts upon transmitted light as if compressed along the lines of force, while dielectrified resin (unlike glass) acts as if extended along the lines of force.

24. *Theory.*—Faraday's views as to the constitution and function of dielectrics apply here very aptly.

When the induction-terminals are charged, the particles of the dielectric throughout the field are electrically polarized, and tend accordingly to arrange themselves end to end, and to cohere in files along the lines of force, just as iron filings do in a magnetic field. As far as this tendency of the polarized particles towards a file arrangement along the lines of force takes effect, there is a new molecular structure induced in the dielectric.

If we neglect the influence of ordinary strains transmitted from point to point of the solid, and assume, as a good first approximation warranted by facts (19), that the change of molecular arrangement at each point is determined solely or principally by electric force at the point, we cannot easily suppose the new structure in a dielectric, originally isotropic, to be anything else than uniaxal symmetrical at each point with reference to the line of force through the point. And, even in the case of an æolotropic body, we may assume, as a simple and sure approximation to the truth, that the effect of electric force is to superinduce a uniaxal structure upon the primitive structure.

The uniaxal structure thus induced by dielectrization has been experimentally detected and characterized by birefringent action in three cases. As a matter of fact, it appears to be negative in glass and quartz, but positive in resin.

The electric force has probably a certain resistance to overcome, something analogous to coercive force in the case of magnetism. A sensible time is therefore required for the development of the uniaxal structure by electric action, and for its disappearance after the electric action has ceased. Under an intense and long-sustained electric force, the new structure of the dielectric may assume the character of a very stiff, and, perhaps, permanent set, analogous to permanent or subpermanent magnetism (18). We shall see afterwards, as might indeed be expected, that there is nothing similar to this in the phenomena presented by dielectrified liquids.

Contrary electrizations rapidly succeeding one another exert contrary actions of electric polarization, but conspiring actions of molecular arrangement; they are therefore as effective as a continued electrization in one direction; and Rhumkorff's coil is as effective as an electrical machine of equal strength.

28

29

Eng — May '76

Magnetism and Electricity. By FREDERICK GUTHRIE. *Collins' Advanced Science Series.* London and Glasgow: W. Collins and Son. [Price 2s. 6d.]

THE study of physics is now receiving a greater share of attention than formerly. We have happily grown out of the idea—or are fast growing out of it—that young men should leave college with a marvellous stock of Greek and Latin and a no less marvellous ignorance of the laws that govern the world around them. Of the various branches of physics, few are more attractive than magnetism and electricity. In the hands of an able teacher, they may become an excellent means of mental discipline by awaking a spirit of inquiry and stimulating the powers of observation. To such a teacher, Professor Guthrie's work will be a most valuable aid. The leading principles of the subject-matter are unfolded in plain concise language. There is the felicity of expression and lucidity of idea that at once denote thorough mastership. Nothing really essential is omitted; and but little that may be thought superfluous is introduced. Upwards of three hundred figures are scattered throughout the book, and are what they purport to be, real illustrations. It is, however, to be regretted that some of the more important are not made to scale. Nothing but a long experience with the difficulties generally felt by beginners could have led to such a series of diagrams.

We might instance those illustrating the electrophorus, in which by a simple arrangement of the signs + and —, the successive changes that occur in the electrical condition of the resinous plate and the metallic disc are clearly placed before the eyes of the student. In some other text-books a similar plan is adopted; but in none that we have hitherto seen is this important principle propounded with such sequence and completeness. As another instance, we would mention the explanation given of the development of frictional electricity. By means of arrows, and the usual algebraic signs, the course of the positive and negative electricities is clearly shown.

We believe that a great deal is to be learnt from good diagrams on the twin subjects of magnetism and electricity, just as well as in the various branches of natural history. If Ganot's "Physics" was so popular in France some years ago it owed its popularity in great measure to the excellence of its illustrations, and when a better text with equally good illustrations, made its appearance, Ganot retired into honourable obscurity. We have several text-books that contain finer specimens of the art of the engraver than the one before us, but we do not know another in which so much is done by ingenious diagrams to render tangible—we might say—those points which are the least easily realised by youthful minds.

The work is divided into three books. Book I. treats of Frictional Electricity; Book II. of Voltaic Electricity, and Book III. of Magnetism. The name of the book would therefore more aptly be "Electricity and Magnetism" than *vice versâ*.

In Book I. we think a little too much importance has been given to a few subjects, *e.g.*, the relation of heat to discharge, discharge by flame, by evaporation, &c. We would suggest as a substitute for these pages as many paragraphs elucidating the experiments of velocity based upon the rotating mirror. Electrophorus is spelt in this part electrophoros. So long as phosphorus obtains in chemistry and cryophorus in heat, &c., it seems unnecessary to break the analogy even for the sake of introducing a purism.

Chapter III. in Book II. contains 21 pages; too much stress seems to be here laid on the electrolysis of various salts. If this chapter were reduced to four pages, and the balance used to supplement the rather succinct treatment of telegraphy and magneto-electricity, we believe the book would not be less valuable.

We also regret that the author adheres so strictly to the self-imposed rule of avoiding historical references. The names and labours of such men as Ampère, Oersted, Faraday, Wheatstone, Sir William Thomson, Professor Morse, &c., ought to be familiar to every student.

There is an appendix of nine pages of closely-printed matter, in which directions are given to enable the student to construct for himself a large number of the most ordinary pieces of apparatus both of static and dynamic electricity. This novel feature will be found to serve the twofold purpose of economy and of practical instruction. Indeed there is no better means of getting at the rationale of the science than this.

As this book deserves to be extensively used, we think that another chapter might be added in a future edition. It is not enough to know principles, but we must know how to apply them. For this purpose we would recommend a short collection of numerical problems on the laws of quantity, inverse squares, the method of oscillations, resistances, &c. Such problems are being constantly set at examinations for the requirements of which this book seems admirably adapted. Besides this service such a chapter would evidently lead to a more thorough comprehension of the laws it illustrates.

SPECTRUM OF THE ELECTRIC SPARK IN A COMPRESSED GAS.

M. A. CAZIN.

THE electric spark in a gas is analogous to the ordinary flame of a hydrocarbon. In each of these luminous sources there are gaseous particles which produce a spectrum of lines, and solid or liquid particles which produce a continuous spectrum. These are derived in case of the spark from the electrodes and the sides of the vessel when very near. When the pressure is increased these particles are more abundant, their continuous spectrum becomes more brilliant, and, finally, causes the disappearance of the linear spectrum of the gaseous particles. It is in the flash of fire that things take place thus: the paler luminous halo or aureola is formed of gaseous particles whose linear spectrum is more or less visible; it is to the entire spark what the blue base of the flame of a candle is to the entire flame. At ordinary pressures, in nitrogen, the spark is pale and furrowed with small flashes of fire. We see in the spectroscope the grooves ascribed to nitrogen, and in their intervals the characteristic lines of this gas. On compressing we see the grooves disappear little by little, whilst the continuous ground of the spectrum becomes more brilliant. When the pressure exceeds two atmospheres there are only six lines of nitrogen from the orange to the blue, and five diffused bands beyond. At 10 atmospheres there only remain the two nitrogen lines $\lambda = 567$ and $\lambda' = 500$, and then a very brilliant line in the violet $\lambda'' = 424$, which first appears at 5 atmospheres. The sodium line is very distinct, whilst it is not to be distinguished at ordinary pressures. About 15 atmospheres the spark becomes dazzling; upon the continuous spectrum are seen the four lines above mentioned, and certain brilliant points due to platinum. In air compressed above 30 atmospheres the spark produces intense reddish vapors, and the spectrum showed the absorption spectrum of hyponitric acid.

28 30

Jan 76

MR. EDISON'S ELECTRIC DISCOVERY.

On the evening of Thursday, December 16, Mr. Edison brought his discovery, of what he supposes to be a new force, before the Polytechnic Club of the American Institute. Dr. Beard gave a very lucid account of the phenomena, observed by himself as well as by Mr. Edison; and he pointed out in what particulars the new spark is similar to some forms of electricity and in what it appears to differ from the various known forms of that force. Like a true scientist, he pointed out that only such phenomena as every competent experimenter is able to verify at any time are worth consideration; and he spoke of the sources of illusion and delusion which misled Reichenbach, and afterwards others who asserted that they had verified his alleged discovery of the so-called odic force.

Some writers who gave the first reports of Mr. Edison's discoveries to the daily papers, with more enthusiasm than discernment or knowledge, said that, in their opinions, there was identity between Mr. Edison's discovery with the so-called results of Reichenbach's experiments. But the difference is that in the first case we have a reality, and the experiments have results which any one can see and verify; while in the other case we have alleged results which nobody can see but the mediums, so that all belief in the reality of Reichenbach's phenomena rests exclusively on outside testimony.

Dr. Beard also pointed out a feature to which we referred in an article in our issue of December 25, namely, the dissimilarity of the experiments of Reiss, with what he calls weak sparks, and Mr. Edison's discovery. They differ in origin as well as nature. Reiss' experiments were made with static electricity, while Mr. Edison obtains his results from the contact breakers of electromagnets. Dr. Reiss' weak sparks have polarity, while those of Mr. Edison show none, and in that respect the latter differ from all other known forms of electricity: at least neither Dr. Beard nor Mr. Edison have been able to discover any trace of polarity, but, as this is only a negative proof, and we do not know what future investigations may reveal, it is as yet premature to give a decided opinion.

After considering Dr. Beard's elaborate and masterly exposition of the phenomena thus far observed, and seeing the experiments which Mr. Edison kindly exhibited before the members of the Polytechnic Club, with his apparatus of three vibratory sounders, charged by six chromic acid battery cells, we see no reason to change the opinions we have already expressed: That, after all, the phenomena may be due to a peculiar form of induction. They prove that the inductive power of a coil, when charged or discharged by a sufficiently strong voltaic battery, extends all around to a distance of one or more inches, and can not only induce currents in other coils, but also in straight wires or, better, in metallic bars, kept within the range of this influence, which influence may be called an inducing atmosphere surrounding the coils. Dr. Beard also appears inclined to the view that the phenomena are due to electricity; while Mr. Edison differs from him on this point, and is strongly inclined to consider the phenomena to be due to a new force, as distinct from electricity as light or heat is. Mr. Edison would rather prefer to consider it as a new form of heat or light than of electricity, and gives, as his principal reason for this view, the absence of polarity, which absence exclusively belongs to heat and light, while electricity without polarity is (to use one of Herbert Spencer's expressions) unthinkable. We fully agree with him in this respect; and according to Mr. Edison's invitation, we will assist him in a new course of experiments, laying the results before our readers at an early opportunity.

(24) A. H. T. says: I have constructed a Jamin magnet, but have failed in magnetizing it on account of its peculiar shape and form, not having been able to apply the electro-magnet to the surface of the steel ribbons. Wishing to construct a magnet of great power, I ask your advice how I am to proceed in magnetizing it. What power of battery, and what form of magnet am I to use? A. We think you should be able to charge it with a bar electro-magnet. Two or three large sized cells will magnetize the latter strongly if the cells are properly constructed.

MAGNETIC OBSERVATIONS IN CHINA

THE first annual report of the magnetic observations at this new observatory has just reached Europe, and it contains results of considerable interest to those engaged in the study of terrestrial magnetism.

The position of Zi-ka-wei is 31° 12' 30" N., and 8h. 5m. 45s. E. of Greenwich, being rather less than four miles to the S.W. of Shang-Hai. The observatory is in possession of an excellent set of instruments for determining the absolute values of the magnetic elements, procured by the kind assistance of the Director of Kew Observatory, and a set of self-recording magnetographs by Adie, verified at Kew, have just been erected in a suitable building. The observer, the Rev. M. Dechevrens, S.J., spent a considerable time at Stonyhurst Observatory previous to his departure for China, in order to make himself thoroughly acquainted with the methods of observation, and with the use of the instruments.

The observations in the report extend from April 1874 to March 1875, and furnish the following data for the epoch Oct. 1, 1874:—

Declination	1° 54'.72 W.
Dip	46° 15'
Total Force...	10.04850

The value of the declination is very reliable, as it depends on observations taken every half hour from 6 A.M. to 6 P.M. on four days each month in 1874, and on eight days a month in 1875. The dip results from six complete observations, and the horizontal component of the intensity was determined twice a month in 1874, and every week in 1875.

Previous dip observations at Shang-Hai, by Sir E. Home in 1843, and by Capt. Shadwell in 1858, give − 2'.2 and − 3'.4 as the secular variation for 1851 and 1862, the latter differing but slightly from the present variation in England.

Comparing the monthly means of the horizontal force for the winter and summer of 1874-75, we find an excess of 0.00074 in favour of the winter, when the sun is nearest the earth. The extreme variation is only 0.00577, and both maximum and minimum occur in the summer months.

From a limited number of night observations it appears that the range of the declination needle is much more confined, whilst the sun is below the horizon than during the day hours. The diurnal variation is regular throughout the year, but the daily changes in winter are less simple than those of summer. The following are the mean results for the separate seasons:—

	Mean.	Min. at		Max. at	
Spring	1 50 49	... 9 A.M.	1 47 33	... 2 P.M.	1 54 3
Summer... ...	1 49 39	... 8 ,,	1 45 45	... 2 ,,	1 53 3
Autumn	1 59 35	... 9 ,,	1 58 9	... 1 ,,	2 1 10
Winter	1 58 51	... 9 ,,	1 57 32	... 1 ,,	2 0 5

The time of the principal minimum is more constant than that of the maximum, the latter being anticipated by one hour in winter.

A sudden change from 1° 50' 13" on Sept. 21 to 1° 56' 51" on Sept. 26, 1874, seems to require further confirmation (which it did not receive in 1875) before it can be considered as more than accidentally connected with the passage of the sun through the autumnal equinox.

The monthly mean value of the declination is greatest in November and least in June, and the absolute maximum and minimum were:—

2° 3' 49" at 11h. 15m. A.M. on November 8,

and

1° 41' 58" at 9 A.M. on June 29.

giving a yearly range of only 21' 51", whilst the secular variation amounts to + 5'.85. The value on Nov. 8 was also evidently increased by some irregular disturbance.

The comparison of the yearly means for the different hours with the hourly means for each season, shows that the sun's position with regard to the equator has a decided effect on the magnetic declination, as increase and diminution in summer invariably correspond with diminution and increase in winter.

In discussing the hourly velocity of the needle, it is found that the acceleration is greatest between 10 and 11 A.M., when the magnet is near its mean position, and that the A.M. maximum velocity is an hour earlier, and the P.M. maximum an hour later in summer than in winter, the greatest velocity being about 1'.5 per minute.

The mean amplitude of the daily excursions of the declination magnet is 7'.88 in summer against 3'.68 in winter, June giving the maximum mean amplitude of 9'.06, and December the minimum of 2'.95. The value of 1'.92 in February appears to be exceptional. The greatest extent of a daily oscillation in the course of the twelve months was 11'.05 on June 1, and the least 1'.13 on Feb. 20, giving a maximum yearly variation of 9'.92.

The changes of the magnetic elements appear to be remarkably small throughout, and very free from irregular disturbances. The care with which the observations are taken, and the efficient way in which they are discussed, are an earnest of the plentiful harvest we have every reason to expect from this land once so famous, but hitherto so neglected by modern science.

Stonyhurst Observatory, April 13 S. J. PERRY

31 33

THURSDAY, FEBRUARY 17, 1876

THE LISBON MAGNETIC OBSERVATIONS

Annaes do Observatorio do Infanto D. Luiz. Magnetismo Terrestre. Lisbon Imprensa Nacional. (1870, 1874.)

THAT in 1858 Portugal entered into "the Magnetic Union of Nations, founded by Gauss and by Humboldt in 1832," was due to the enlightened solicitude of the King Luiz I. for the progress of science. The observatory founded by him at Lisbon, and placed under the care of the late Mr. de Silviera, has during the last years been directed by Mr. de Brito Capello, who had previously the oversight of the magnetic department, and to whom we believe the results in the two parts of Annals before us are chiefly due.

The value of the Lisbon observations and of these results is so much the greater that the neighbouring country, Spain, has done nothing for terrestrial magnetism, and even France, which stands so high in science, has given us no such series of observations since Arago originated them by the devotion of years to the movement of the magnetic needle.

The first part of the Annals before us (1870) treats of the results for the magnetic declination derived from direct observations made at 8 A.M. and 2 P.M. (1858-1868), and for the diurnal variations (1864-1868) from a photographic registering apparatus similar to that at Kew. The secular variation is first investigated. This mysterious movement, which we can attribute to no known cause, as it has no known period, is shown at Lisbon by a mean approach of the north end of the needle to the north at the rate of 5'.9 a year during ten years, but varying from a minimum of 4'.8 in 1858-9, to 8'.2 in 1866-7. An annual law has also been found consisting of an oscillation of 1'.5, the needle being nearest the north in June, and farthest from it in December and January.

The diurnal variation at Lisbon resembles to a considerable extent that obtained at more northern stations in Europe. The periodic variation of the mean range of this oscillation, first discovered by Dr. Lamont, which occupies from ten to twelve years, has also been found at Lisbon. This investigation has its importance increased by the fact that the greatest and least mean oscillations happen at the same times as the maximum and minimum frequency of solar spots. The coincidence first indicated by Sir E. Sabine, with reference to magnetic disturbances, was remarked independently by Dr. Rudolph Wolf, of Zurich, who has made it the subject of an extensive and valuable series of investigations. Dr. Lamont, commencing with Cassini's observations, has found the mean duration of the magnetic period to be 10.43 years, while Dr. Wolf obtains 11.11 years from a longer, though perhaps less certain, series of solar spot observations. Since there can be no doubt that the yearly variation of sunspots and of the amplitude of the diurnal oscillation of the magnetic needle follow the same law and depend on the same cause, every new determination of the epochs of maxima and minima is of value, fixing points which will determine the mean duration and variable length of the period, and thus probably lead us to a knowledge of the common cause. The Lisbon observations give 1859.9 and 1867.0 as epochs of maximum and minimum, agreeing very nearly with those derived from the Munich and Trevandrum observations. In the determination of the mean duration, everything depends on where we commence. If we begin with Arago's magnetic observations, the mean duration is about 10.7 years; if we take the most accurate results for the sunspot area from Messrs. De la Rue, Stewart, and Lœwy, we find 11.2 years, nearly that deduced by Dr. Wolf. Evidently a much longer series of accurate observations is required to determine the length of a period which has varied between 8 and 12.3 years within the last half century; though we believe Dr. Lamont's result to be nearly true.

As the Observatory establishment was not sufficient for the long calculations required for the investigations connected with the lunar diurnal variation, the latter was sought approximately from the effects of the lunar action in diminishing or increasing the solar diurnal oscillation at different days of the moon's age. It was thus found that the diurnal oscillation from 8 A.M. to 2 P.M. was greatest when the moon was three and eighteen days old, while it was least when she was ten and twenty-four days old. This indicates a semi-diurnal oscillation due to the moon's action, with an amplitude of 1' nearly, having the maximum westerly positions when the moon is near the upper and lower meridians.

It is remarked by Mr. Capello, with reference to disturbances, that in many cases the observations taken as disturbed (those differing from the normal position by 2'.26 or more) were, properly speaking, not disturbed observations, but belonged to very regular curves, in which the morning minimum was more marked or the afternoon maximum was less so than usual. Whereas disturbances are shown by serrated curves. This remark is quite exact, and the fact becomes even more marked in lower latitudes. The investigation for the lunar variation just noticed will show one cause for this variation of the amplitude of the diurnal oscillation which is greater the greater the lunar action.

The second part of the Annals before us (1874) contains the discussions for the other magnetic elements. Mr. Capello finds, from nine years' observations, that the horizontal force of the earth's magnetism was greatest in July, least in September, with a secondary maximum in November, and minimum in February. This result depends on few observations, but approaches considerably to that obtained first at Makerstoun. The very marked minimum found for the month of September induced Mr. Capello to examine whether this might not be due to the action of disturbances, which in general diminish the earth's magnetic force; it results from this discussion that though the disturbances have a considerable effect in increasing the amplitude of the annual oscillation, yet the maximum in December is best marked in years of least disturbance. This result he confirms by an examination of the Kew observations, and it agrees with that deduced from each of a series of years' observations of the bifilar at Makerstoun. Mr. Capello also finds that the Munich observations show the most marked minimum in September and October, in years of least disturbance. It is an important fact, confirmed by the results from many observatories, that the horizontal force of the

Lisbon Magnetic Observations

Mr. de Brito Capello, Director of the Lisbon Magnetic Observatory, having addressed to me several interesting results having reference to the notice of his observations which appeared in Nature, vol. xiii. p. 301, I am anxious to communicate them to your readers.

With reference to the movement of the declination magnet from 8 A.M. to 2 P.M. Mr. Capello gives me the following mean values for each year from 1858 to 1875:—

1858	8′·74	1867	6′·15
1859	10·34	1868	7·17
1860	10·11	1869	8·42
1861	9·00	1870	10·83
1862	7·84	1871	10·60
1863	7·65	1872	9·45
1864	6·94	1873	8·22
1865	6·61	1874	7·23
1866	6·19	1875	6·09

These quantities, Mr. Capello remarks, show the maxima 1859·8 and 1870·9, and the minimum 1867·1, agreeing very nearly with the epochs of maximum and minimum sun-spots.

It also appears as if the minimum had been reached again last year, the mean oscillation (6′·09) being less than in 1867. This agrees with the conclusion derived by me from the Trevandrum observations, and communicated to the French Academy of Sciences last year. Dr. R. Wolf had previously (as I now find [1]) concluded from his sun-spot observations that the minimum would probably appear in 1875–6; and he considers we have now one of the short periods, which his tables of sun-spots show may be expected every 80–90 years. My own conclusion to the same effect (that we have now a short period) was founded on a consideration of the magnetic observations. The last short period was that from the maximum 1829·7 (shown by Arago's observations) to that of 1837·5 (shown by Gauss's observations), an interval of rather less than eight years. If we may take 1875·5 as the epoch of the present minimum, then the interval from the last is nearly nine years. As the interval from the minimum of Arago (1824·2) to the next was nearly 9·2 years, we find a space of nearly forty-two years from the last short period to this one. Should this hold for the next maximum it will occur about 1879·0.

Mr. Capello has obtained the interesting result that the curve showing the mean diurnal disturbance of the vertical magnetic force is the exact inverse of that for the mean diurnal disturbance of declination at Lisbon; a movement of the north pole of the declination magnet towards the west corresponding to one downwards of the south pole of the balance needle. It appears also that the difference of sign in the temperature coefficient for the balance magnet due to changes of the compensation bar from brass to zinc and zinc to brass, on which a remark was made in Nature, vol. xiii. p. 302, does not affect the results for the diurnal variation, each year giving the same mean law of a minimum vertical force between 11 A.M. and noon, and a maximum near 5 P.M. whatever the sign of the temperature coefficient. It appears also that the results at Lisbon are confirmed by those obtained at Coimbra, ninety miles to the north.

John Allan Broun

THE EFFECTS OF THE SUN'S ROTATION AND THE MOON'S REVOLUTION ON THE EARTH'S MAGNETISM

When the mean horizontal force of the earth's magnetism for each day of the year has been deduced from well-corrected observations of the bifilar magnetometer, and the results have been projected in the usual way, the curves thus obtained show successions of maxima and minima occurring in some instances at nearly equal intervals and in others abruptly and apparently without law. It has been found that these changes are experienced similarly at all stations where observatories have been placed on the earth's surface; they are therefore variations of the magnetic force of the whole earth. The results now considered, though derived from the observations at a single station, may thus be accepted as true generally for all places.

In the projection of the daily mean forces observed at Makerstoun in 1844, the first and last quarters of the year showed large oscillations of the earth's magnetic force, the maxima occurring near the times of new moon and the minima near those of full moon; the ranges of the oscillations were not equally great, and the oscillation disappeared in the months near midsummer. The mean result for the whole year seemed to show that great changes of the earth's magnetic force were due to the moon's position relatively to the earth and sun; but no explanation could be offered for the apparent irregularities in the lunar action. Eleven years later (in 1857), while discussing observations made near the equator, I became persuaded that the variations in question were really due to the sun's rotation on his axis. The result of a re-examination of the Makerstoun observations gave a mean period of nearly twenty-six days for the most probable duration of the magnetic oscillation.

Astronomers who till then had occupied themselves with the determination of the time of the solar rotation had found for it from 27·3 to 27·7 days. It was difficult, in the face of this result, to suppose that the magnets were better acquainted with the true time of the sun's rotation than the eminent observers, who, with the best telescopes, had watched the movement of the solar spots; and it was suggested that a movement of the sun's magnetic poles might explain the difference of the periods obtained. More recently, however, it has been found that the spots give considerably different times for the sun's rotation, and especially that those nearest the solar equator indicate, as Spoerer has shown, a period of 26·3 days, thus approaching nearly to that obtained previously from the magnetic observations. Dr. Hornstein, director of the Prague Observatory, discovered, independently, nearly the same period from his observations in 1870.

There still remained for explanation the irregularities already noticed in the lengths and ranges of single oscillations. I, on a reconsideration of all the discussions previously made by him, arrived some time ago

Feb. 24, 1876] NAT.

at the conclusion that the results obtained for the solar and lunar actions did not exclude each other, but that both sun and moon were concerned in the changes of the earth's magnetic intensity; and that possibly the variations in the character of the single oscillations were due to the sun and moon sometimes acting in the same and sometimes in opposite directions; just as in the case of the oceanic tides, for which the differences would be even greater were the solar more nearly equal to the lunar action.

This conclusion is put to the test; the mean variations derived from the observations for each of two successive years are calculated for periods of 26, of 27·3, and of 29·53 days, the two latter being the times of the lunar, tropical, and synodical revolutions respectively. The variations for each of these three periods corresponding to the positions of the moon and of a given solar meridian for each day of the year are then added together; the sums should represent the total actions of the two bodies for each day, and if no other causes are in question, they should agree with the observed variations.

I have shown that when the calculated results are projected so as to form a red curve, on the same mean line as a black curve representing the observations, the two agree very nearly with each other throughout the two years. The different durations and ranges of single oscillations, and the total disappearance of the latter in certain months, are found to be produced, as was supposed, by the greater or lesser agreement or opposition of the three actions.

These results demonstrate, I think, not only that the sun's rotation and the moon's revolutions produce variations of the earth's magnetic force, but that all the marked variations are really due to these causes.

There appears to be one exception to the generality of this conclusion, in sudden great changes, generally diminutions, of the earth's magnetism, which appear of variable magnitude and apparently at irregular intervals. I have examined these cases, and find that if a considerable diminution of intensity happen suddenly when a given solar meridian is in the same plane with the earth, that a similar sudden diminution generally occurs twenty-six days or some multiple of twenty-six days after, when the same solar meridian and the earth are again in the same plane. In one case the sudden loss of force begins five times in succession at the exact interval of twenty-six days.

If we examine these cases of successive disturbance when a given solar meridian arrives opposite the earth, we are induced to conclude either that the solar action exists only for this position, that is to say, that the earth is its cause; or that the action is continuous, but, unlike light and heat, is propagated only in one direction (or plane); or, which seems more probable, that the medium through which these actions are transmitted proceeds from the sun, is not uniformly distributed around it, nor always distributed in the same way. This idea may aid in explaining many facts in terrestrial magnetism for which hitherto no clue has existed.

We arrive then at the conclusions that the variations of the daily mean magnetic force are due to causes external to the earth, depending on the sun's and moon's motions; that all the principal variations of this force can be calculated approximately for each day in twelve months, on the hypothesis that the actions of these bodies are constant throughout the year for the same positions relative to the earth; and that the great magnetic disturbances (accompanied by the aurora borealis) are due to actions proceeding from certain parts of the sun's surface, since so many of them repeat themselves at intervals of twenty-six days, when the same solar point returns opposite the earth. It appears from other investigations that the sun's rotation produces marked effects on our atmosphere.

J. Allan Broun

20. *Des grandeurs électriques et de leur mesure en unités absolues*, par E. E. Blavier. (Ann. télégr., tome I, page 9, 287. Tome II, page 149, 256).

La publication de cette importante étude n'était pas encore terminée avec la dernière livraison de 1875 des Annales télégraphiques. L'auteur part des travaux qui ont été entrepris en Angleterre pour déterminer l'unité absolue de résistance électrique et dont le résultat était la « B. A. Unit » ou l'« Ohmad ». Après un résumé historique, il discute la question du potentiel électrique et celles de la condensation, de la capacité électrostatique des différents électromètres et de leur emploi ainsi que des condensateurs étalons.

25. *Théorie des galvanomètres*, par H. Weber. (Ann. de Poggendorff, vol. CLIV, page 239).

On est arrivé par l'expérience et la pratique à construire des galvanomètres extrêmement sensibles; mais cet instrument étant indispensable pour toutes les observations et les applications de l'électricité, il mérite bien qu'on en approfondisse le plus possible les conditions théoriques. C'est ce que M. H. Weber a cherché à faire dans l'article sus-mentionné qui ne forme que la première partie d'une étude dont la suite n'a pas encore paru. (Nous rappelons à cette occasion les articles de M. Schwendler sur le même sujet publiés par notre Journal, dans les numéros 15 et 16 du 25 Mars et du 25 Avril 1873).

245

Les recherches théoriques de M. Weber l'amènent à cette conclusion que pour qu'un galvanomètre atteigne son maximum de sensibilité, il doit être établi de façon que sa résistance soit, par rapport à la résistance extérieure du circuit, dans la même proportion que le diamètre du fil nu de son manipulateur au diamètre du même fil recouvert. Un cas spécial dont l'examen [illegible] présenterait serait l'établissement d'un galvanomètr[illegible] avec une pile thermo-électrique comme source d'éle[illegible]tricité. La première partie du travail de M. Weber ne fait qu'indiquer cette question dont l'examen paraîtra sans doute dans la continuation.

How can I make a conductor to draw off frictional electricity? A. Brush some gum water over the outside of a base ball. When this is almost dry, roll the ball on gold leaf so that the ball will be covered with a smooth layer of gold; then mount the ball on a stick of sealing wax, set in a little wooden disk or base. Then on one side of the equator of the ball insert five or six cambric sewing needles, so that they will be about ⅛ inch apart; these needles act as a comb to conduct the electricity to the gold leaf on the ball, from which the electric sparks may be drawn. In some establishments where leather belts are run at a very high speed, electricity is produced on the belts. If the conductor that we have just described be placed with its row of needles near to, but not touching, one of these belts, the electricity of the belt will be accumulated, and will manifest itself in the form of the bright blue sparks, several inches in length, that pass from the conductor to the knuckle of the hand that is presented to it.

Influence of Heat upon Magnetisation.—M. J. M. Gaugain.—M. Favé had pointed out that when a bar of steel is magnetised at about 350°, allowed to cool, and heated again, the quantity of magnetism augments, and may reach triple the value which it had preserved after cooling. M. Wiedemann maintains that a bar magnetised at an elevated temperature loses on cooling a part of its magnetism: it loses a further portion when heated again, but on cooling it resumes a part of what it had lost. The author believes that this contradiction is due to the circumstance that M. Wiedemann experimented only with bars heated to 100°, whilst M. Favé operated with bars magnetised at a far higher temperature. 77

334

Notices of Books.

Magnetism and Electricity. By FREDERICK GUTHRIE, Professor of Physic at the Royal School of Mines: William Collins, Sons, and Company, 1876.

WHETHER or not there is an opening for another text-book of a purely theoretical nature upon the

subject of "Magnetism and Electricity" is a question upon which different opinions may be entertained, more especially since it is borne in mind that a twelve month has scarcely elapsed since Mr. Fleeming Jenkins' work was published in Messrs. Longmans' series. Still the demands of rival publishers appear to over-ride every other consideration, and we have here in Messrs. Collins' Advanced Science Series, as an extra volume too, "Magnetism and Electricity," by Professor Guthrie.

In the preface, which is written apparently on the "brevity being the soul of wit" principle, we are informed that "this work is intended for the general student." The wants of the "general" student are now-a-days well looked after, and there is a plethora of manuals and text-books. The publication of a new book, if an indication of a demand, is a healthy sign of the times.

In a text-book we do not look for any new facts in connection with the subject: what we do look for, and have a right to demand from whoever undertakes the work, is that the existing facts shall be made as clear as possible that the diagrams shall be such that they can be followed with ease, and that some show at least of logical treatment should be made in the arrangement of the various branches of the subject. Departing from the general custom, Professor Guthrie postpones the subject of magnetism until that of electricity is dealt with. We do not object to this, provided any apparent advantage is to be gained by it. So far, however, from this being the case, the reverse is true, for some knowledge of magnetism on the part of the general student must be assumed before it can be expected that he will successfully grapple with the intricate problems of the electrical relations between currents and magnets, or the measurement of the strength of currents; and on this ground alone, if on no other, we are of opinion that magnetism ought first to be brought under his notice.

The treatment of the work, regarded as a whole, might be improved. At the very commencement we are referred to "Appendix 1" for an explanation of the manner in which shell-lac varnish is to be made; frequent reference is then made throughout the book to "Appendix," although the fact has been apparently overlooked in these foot-notes, that there is an appendix and an appendix; so much so, that after being referred to on the sixth page to "Appendix Y." for the steps to be taken "to make a balanced glass tube," we are, on turning thither, simply advised to "see Appendix B 1 (b)." An appendix of any kind is an objectionable feature in a text-book like this. If it contains matter of any value, then that ought to appear in its proper place in the text; if the matter is superfluous, and not considered worthy of a place in the text, then it should be dismissed from the work altogether, and not tacked on in this fashion to the end of it.

In a scientific text-book no point should be more carefully attended to, although, strange to say, none is more generally neglected than the employment of new terms only after they have been thoroughly defined and their meaning made clear to the reader. This does not form an exception to the general rule, and the student very soon finds himself landed in the midst of a mass of "electro-inducible" matter, "equipotent," "electrogens," and the like. Why "insulators" again have to make way for "isolators," or the term "commutator" to be sacrificed for "rheotrope," we are at a loss to understand, and we had as soon expected to find Mr. Frank Buckland writing of the hippopotam*oi* in the Zoological Gardens as to find Professor Guthrie writing of "continuous electrophor*oi*."

The first part of the book deals with frictional or static electricity.

The second part on voltaic electricity, opens with an account of the "Sources of Voltaic Electricity," and the origin of the current is dealt with at some length. We cannot say that Professor Guthrie has been altogether successful in placing clearly before the student the rival contact and chemical theories. Galvanic batteries form the subject of one chapter, and they are treated in what we may now regard as the stereotype fashion. Daniell's battery occupies the position to which it is in every respect entitled. It is first brought under notice, and the arrangement is described at some length. Why Groves' and Bunsen's should next be brought forward, and in company with Daniell's, regarded as *the* batteries in preference to all others, we are at a loss to understand, unless it be that in this case it was deemed undesirable, from the usual method which has hitherto been adopted, of handling the subject. Under the "Other forms of Battery," which, "though not new or yet in general use, are either of historical interest or involve ideas which may hereafter be developed, or which are applicable for special purposes," are included the Leclanché, which is now in general use for telegraphic work in England and France, and the Gravitation which in one or other of its numerous forms are more or less employed in many parts of the globe; the Minotto, is in general use in India, and Messrs. Siemens' and Halske's modification is all but universally adopted in Germany and on the Indo-European lines. Professor Guthrie, in the short allusion to Leclanché's battery, falls into the mistake, by no means uncommon, of speaking of "the elements being zinc and carbon, and the liquid a solution of chloride of ammonium." Mons. Leclanché, writing of his battery, says: "The peroxide of manganese in possessing a certain conductivity of a considerable amount, and analagous to that of the metals, caused me to think of the probability of constructing a constant one-liquid battery by employing a plate of that material as the positive element," and further on, he adds, "In practice, I replaced the plate of peroxide of manganese by pounded peroxide, which I enclosed in a porous pot; the positive electricity of that mass is gathered by means of a plate of carbon." The battery is a one-fluid battery, and is practically a zinc-peroxide of manganese couple, immersed in a solution of the chloride of ammonium.

We turned with interest to the section on the "Amalgamation of the Zinc Plates," for the purpose of learning what opinion so high an authority as Professor Guthrie entertained on this oft-vexed question. We cannot do better, perhaps, than give in full the explanation which is put forward. In Section 163, page 141, we read: "In fig. 133, E represents an easily, and D a difficulty (*sic*) attackable piece of zinc forming one piece. The arrows represent the direction of the current. *A coasting trade.* Such a heterogeneous piece of

335

Si l'on suspend un barreau d'acier à un aimant, l'on peut, en chauffant le barreau et en le laissant refroidir ensuite, tout en maintenant toujours son contact avec l'aimant, augmenter le magnétisme permanent que l'on a produit. Si, par contre, le refroidissement a lieu quand le barreau est éloigné de l'aimant, alors le magnétisme permanent est moindre que si l'on n'eût point du tout chauffé. Ce phénomène correspond très-bien avec l'idée généralement répandue de la force coërcitive du fer.

6. *Sur les quantités de magnétisme et sur la situation des pôles dans les aiguilles minces*, par E. Bouty. (Comptes-rendus, tome LXXX, page 879).

Les vrais pôles des aiguilles minces se déplacent avec l'augmentation du magnétisme; ils s'approchent de plus en plus de l'extrémité de l'aiguille, mais ce déplacement s'accomplit entre des limites très-étroites.

7. *Expériences sur l'imitation artificielle du platine natif magnétipolaire*, par Daubrée. (Comptes-rendus, tome LXXX, page 526).

Entre autres métaux, le platine de l'Oural contient souvent du fer et se comporte alors comme un aimant, ayant fréquemment des pôles multiples. Le prince Nicolas de Leuchtenberg possède une pareille pépite magnétipolaire du poids de 3,833 grammes. L'auteur a essayé, par la fusion du platine avec du fer, de produire des masses magnétiques analogues aux aimants naturels et il y a réussi en donnant à la masse la forme d'une barre et la direction du méridien magnétique et en la laissant refroidir dans cette position. Il est probable que tous les aimants naturels ont une origine semblable.

8. *Sur une nouvelle source de magnétisme*, par Donato Tommasi. (Comptes-rendus, tome LXXX, page 1007).

Lorsqu'on fait passer un courant de vapeur d'eau sous une pression de 5 à 6 atmosphères à travers un tube de cuivre ayant 2 à 3 millimètres de diamètre et roulé en spirale autour d'un cylindre de fer, celui-ci s'aimante tellement qu'une aiguille de fer, placée à quelques centimètres de distance de l'aimant-vapeur, est attirée vivement et reste magnétisée pendant toute la durée du passage du courant de vapeur d'eau à travers le tube de cuivre.

9. *Observations sur la nouvelle source de magnétisme signalée par M. Tommasi*, par Maumené. (Comptes-rendus, tome LXXX, page 1138).

L'auteur ne croit pas à une nouvelle source de manétisme. Il croit que dans l'expérience de Tommasi, magnétisme est développé par l'électricité thermique se forme dans le tube de cuivre, par suite de la érence de température de ses deux surfaces.

GRAVITATION AND ELECTRIC ACTION.

M. A. PICART.

the phenomena of the universe may be explained by and motion *alone* without *forces acting at a distance.* s purpose it is sufficient to imagine infinite space filled ernal matter consisting of a mass of atoms animated erpetual movement in all directions. This matter, the utum of the world, is what is commonly called *ether.* t has been hitherto regarded as a fluid whose molehave in a state of equilibrium fixed relative positions, xerting upon the neighboring molecules a repulsive which give rise to vibratory movements whenever quilibrium is disturbed by any cause whatsoever. rding to the new theory of gaseous fluids (Clausius) ay henceforth conceive the ether as formed of *elastic* s moving with considerable speed in all directions, producing at each point by their impacts upon an elemental plane a determined pressure. From this conception of the ether, which in nowise contradicts ancient view, and which even includes it as a corollary *orie mécanique de la chaleur*, de M. Briot), gravitation ice follows, *i. e.*, the mutual attraction of two material ts in the ratio of their masses, and inversely as the re of their distance. As to electric actions they may explained in an analogous manner. The material cules in arranging themselves by their mutual attracso as to form bodies must condense around thems the ethereal atoms as atmospheres more or less e, the elasticity of which must vary according to the ive positions of the molecules of the body. These the atmospheres whose increases or diminutions of ity or of elastic force constitute the electric condition sitive or negative—of the body. Between these atmores and the material molecules situate at a distance must be exerted a gravitation like that of two rial molecules. Between two condensed atmospheres ther a repulsive action must be exerted, resulting from necessary increase of the speed of the atoms which ve in both directions from the one atmosphere to the ier, and which produce upon each of them, on the side ere they strike, an augmentation of pressure tending to nove them from each other. From these reactions we sily arrive at Coulomb's law of attraction or repulsion; e basis of all electrical theory.—*Comptes Rendus.*

[20274.]—Speed of Electricity.—This is a question to which it is scarcely possible to give even an approximate answer, because so much depends upon the kind of circuit employed. In his celebrated experiment with a Leyden jar, Wheatstone found the velocity of static electricity to be 288,000 miles per second (greater than that of light), while at the other end of the scale we have the speed of maximum current in deep-sea cables, which is under 1,000 miles per second, owing to the enormous amount of lateral induction. Almost any speed between these two extremes could be obtained by suitable conditions of circuit, so "J. G. B. H." may choose which he likes the best, and calculate the time of traversing 25,000 miles for himself.—BEACON LOUGH.

[30540.]—Magnetising Endless Ring.—You could permanently magnetise a steel ring in the way you describe, but you need not press very hard or you would spoil your magnet. Also notice that the poles would be on the two outside edges of the ring—that is to say, suppose the ring were lying flat on a table, the part in contact with the table would be one pole, and the part looking upwards would be the other, while the inside and the periphery would be neutral and powerless. Such a magnet would, I think, soon lose strength.—DU FAY.

[30540.]—Magnetising an Endless Ring.—About twenty years ago I had a steel ring forged, to which a wooden case was fitted; this case consisted of a circular groove into which the steel ring dropped freely; the outer edge of the case was graduated to spaces of $22\frac{1}{2}°$. When this apparatus was finished the ring, with a distinguishing mark on it, was tested by being placed on a tripod, the mark successively brought to each graduation, and the deviation of the needle of a small mariner's compass noted. On projecting the readings in a curve a weak magnetism was detected; on bringing a somewhat large horseshoe magnet near the ring, not in contact, the magnetism of the ring was exalted, and a much bolder curve obtained. By operating in this manner changes of magnetism in the ring may be observed.—W. R. BIRT.

Eng Sept 77

Après avoir fait l'historique de la machine depuis son invention en 1865 par Holtz, ainsi que de la première modification en 1866 apportée par l'inventeur lui-même, celui des machines de Töpler et de Bertsch, de la machine à deux disques tournants de Holtz, des modifications consécutives de l'inventeur, de Kundt et Carré, des machines doubles de Kaiser et Poggendorff et des modifications ultérieures de Leyser et Musaeus, l'auteur donne le compte-rendu des résultats qu'il a obtenus avec des disques en ébonite, tant avec la machine simple qu'avec la machine double. Il arrive aux conclusions suivantes, que l'ébonite se recommande comme matière pour former les disques des machines de Holtz, parce que la masse en est bon marché, facile à travailler, non cassante et moins influencée par l'état hygroscopique de l'air que ne l'est le verre, tandis que le pouvoir électrique est à peu près le même pour les deux substances.

5. *Quelques essais pour le perfectionnement de la machine de Holtz*, par W. Holtz. (Poggendorff Ann., vol. CLVI, page 627).

6. *Transformation de l'étincelle de la machine de Holtz*, par A. Demoget. (Comptes-rendus, tome LXXXI, page 140).

Lorsqu'on place, dans le courant de la machine une bobine de résistance dont les doubles spires sont bien isolées, on obtient des étincelles entourées d'une auréole, comme celles de la bobine de Ruhmkorff.

7. *Sur les étincelles faibles*, par P. Riess. (Poggendorff Ann., vol. CLVI, page 378).

On obtient avec la machine de Holtz les étincelles faibles en donnant aux électrodes différentes longueurs ou en approchant une pointe de charbon de l'électrode positive ou en suspendant tout simplement un fil de cuivre recourbé à son bout libre sous forme ovale. Tous ces procédés ont pour résultat de rendre l'électricité positive plus faible que l'électricité négative. Le passage de faibles étincelles ne produit pas une augmentation de la température et ne développe pas non plus de magnétisme, tandis que les étincelles ordinaires sont accompagnées de ces deux effets.

Note. La machine de Holtz se charge très-facilement si l'on frotte la plaque d'ébonite avec de l'amalgame. L'ébonite devient électrique positivement. (Poggendorff Ann., vol. CLIV, page 643).

Lois de l'électricité.

1. *Sur les mouvements de l'électricité dans les corps de constitution moléculaire*, par W. Weber. (Poggendorff Ann., vol. CLVI, page 1).

Développement des lois établies par l'auteur en 1846 sur les phénomènes électro-dynamiques. (Voir aussi les travaux de Zöllner, etc.).

Cet article peut se résumer ainsi:

a) observations sur les lois fondamentales électro-dynamiques;
b) identité des parties mobiles des corps dont le mouvement constitue la chaleur, le magnétisme et le galvanisme;
c) identité de la force vive produite par la force électro-motrice avec la chaleur développée dans le conducteur par le courant;
d) mouvement de l'électricité dans les conducteurs;
e) propagation en double sens de la chaleur dans les corps pondérables;
f) théorie de Kohlrausch sur la thermo-électricité;
g) résistance et maximum de l'intensité du courant;
h) distribution de l'électricité dans les conducteurs.

2. *Sur les phénomènes électro-dynamiques*, par F. Zöllner. (Poggendorff Ann., vol. CLIV, page 322).

Helmholtz a cherché à remplacer la loi d'Ampère par une autre loi qu'il désigne sous le nom de loi des potentielles. Zöllner croit cette loi défectueuse au moins en ce qui concerne son application aux phénomènes de la rotation d'un conducteur électrique autour d'un aimant. Il appuie cette opinion par les résultats de nombreuses expériences faites avec des conducteurs solides et liquides que le courant électrique qui les traverse entraîne dans un mouvement rotatoire autour d'un centre magnétique.

3. *Sur quelques objections faites contre la loi de Weber*, par C. Neumann. (Poggendorff Ann., vol. CLV, page 211).

C'est la discussion des objections faites à la loi électro-dynamique de Weber par Tais, Thompson et Helmholtz. L'auteur arrive au même résultat que Zöllner (voir art. précédent) à savoir: que la théorie de Weber est encore aujourd'hui la seule qui soit en rapport avec les faits expérimentals.

4. *Sur les constantes diélectriques des liquides*, par P. Silow. (Poggendorff Ann., vol. CLVI, page 389).

Examen expérimental de la théorie de Helmholtz: « si deux masses électriques E et E' se trouvent dans un milieu diélectrique dont la constante diélectrique est D, ils s'influencent alors comme $\frac{E}{\sqrt{D}}$ et $\frac{E'}{\sqrt{D}}$ le feraient dans l'air ».

5. *Réfutations de deux objections faites contre la théorie unitaire de l'électricité*, par E. Edlund. (Poggendorff Ann., vol. CLVI, page 590).

L'auteur défend sa théorie contre les objections faites par Messieurs C. Neumann et G. Baumgartner d'après lesquelles l'induction unipolaire ne pourrait s'expliquer que par l'existence de deux fluides électriques, tandis

…er granulé ou en faisceaux.

38

échantillons dont la résistance spécifique variait entre 75 et 4000 fois celle du mercure.

3. Sur la résistance électro-chimique de l'aluminium, par E. Ducretet. (Comptes-rendus, tome LXXX, p. 280.)

Si un voltamètre a pour électrodes une plaque de platine et une d'aluminium, le courant passe facilement quand l'aluminium est l'électrode négative, tandis qu'il devient très-faible dans le sens inverse. Le voltamètre est ainsi en quelque sorte une soupape électrique qui laisse passer l'électricité dans un sens, mais pas dans l'autre.

4. Sur le passage de l'électricité dans les électrolytes, par E. Budde (Poggendorff, Annalen, vol. CLVI, page 618).

Développement de la théorie de la propagation de l'électricité dans les électrolytes.

5. Résistances et leur mesure, par H.-R. Kempe (The Telegraphic Journal, vol. III, pages 158 et 222.)

Quoique d'une valeur et d'une application générales, les développements de cet article se rapportent plus particulièrement aux câbles.

ÉLECTRO-MAGNÉTISME ET MAGNÉTO-ÉLECTRICITÉ.

1. Note sur le magnétisme, par Th. du Moncel. (Comptes-rendus tome LXXX, page 532.)

Il s'agit des électro-aimants à noyaux tubulaires au lieu de cylindres massifs. Ces aimants atteignent la même force que les derniers, si le pôle est bouché ou couvert d'une plaque en fer; mais ils présentent quelques avantages vis-à-vis des cylindres massifs, en ce sens que la désaimantation s'opère plus vite et plus complètement; il reste après l'aimantation moins de magnétisme rémanent.

2. Note sur les électro-aimants tubulaires à noyaux multiples; par J. Camacho et Th. du Moncel. (Comptes-rendus tome LXXX, pag. 312 et 1572, et tome LXXXI, page 17.)

Ces électro-aimants ont été construits pour la première fois par M. Camacho. Les expériences faites par M. du Moncel se rapportent à un électro-aimant à 3 noyaux tubulaires de 6,5 centimètres de longueur et 2 millimètres d'épaisseur. Au centre, il y a un noyau solide de 6 mm. de diamètre. Le tube extérieur a un diamètre de 3 cm. Chaque noyau intérieur est revêtu de deux couches de l'hélice magnétisante, le noyau extérieur de cinq. Quand le courant passe par toutes les hélices, le magnétisme est beaucoup plus intense qu'il ne le serait si la masse du fer des noyaux formait un seul noyau solide. Quand le courant ne parcourt que l'hélice d'un seul noyau, les autres noyaux deviennent aussi très-faiblement magnétiques, les noyaux intérieurs avec des pôles du même nom, les noyaux extérieurs avec des pôles de nom contraire. Quand les noyaux sont munis de semelles ou de bagues en fer qui remplissent le vide aux pôles entre les différents noyaux, l'effet magnétique est toujours amoindri. Pour atteindre le maximum de force magnétique, il faut par conséquent laisser les pôles ouverts de façon qu'ils présentent des anneaux concentriques.

3. Sur les courants d'induction produits dans les fils télégraphiques, par M. Lagarde. (Ann. tél. tome II, page 285).

Si deux fils télégraphiques sont posés sur les mêmes poteaux, toujours parallèlement et à grande distance, le courant d'un fil produit des courants d'induction dans l'autre fil. L'appareil Morse n'est pas assez sensible pour accuser l'existence de ces courants, mais il n'en est pas de même de l'appareil Hughes. Sur les câbles souterrains, où les âmes sont beaucoup plus rapprochées l'une de l'autre (distance seulement 8 mm.), ces courants d'induction peuvent même être observés à des distances ne dépassant pas quelques kilomètres. L'auteur a fait des expériences sur un câble entre Paris et Juvisy et sur des fils aériens entre Paris et Mâcon et entre Lyon et Marseille.

4. De l'influence du magnétisme sur l'extra-courant, par Trève. (Comptes-rendus tome LXXX, page 1587.)

Quand on produit dans un œuf électrique un extra-courant, la température à l'intérieur de l'œuf augmente de quelques degrés et la pression atmosphérique de 25 à 30 centimètres (en employant 15 éléments Bunsen); mais si l'œuf est placé entre deux pôles d'un électro-aimant puissant, cette élévation de température et de pression atmosphérique est beaucoup moindre.

5. Phénomènes magnéto-chimiques produits au sein des gaz raréfiés dans des tubes de Geissler, illuminés à l'aide de courants induits; par J. Chautard. (Comptes-rendus tome LXXXI, page 75.)

Compte-rendu d'expériences sur la séparation des éléments de différents corps composés. Les changements chimiques se manifestent par les variations de teinte du tube, ainsi que par l'apparition de raies spéciales.

6. Influence de matières diélectriques sur les courants d'induction; d'après J.-J. Muller par A. Kleiner. (Poggendorf, Annales, vol. CLVI, page 564.)

Comme une masse de fer à l'intérieur d'une bobine d'induction augmente le courant d'induction, mais qu'en l'enveloppant sous forme de cylindre, elle affaiblit ce même courant, il y avait lieu de présumer que des matières électriques, telles que le soufre ou la paraffine, produiraient dans les mêmes conditions des effets contraires. Le professeur Muller dont la mort a interrompu les expériences, a pu obtenir des résultats de nature à faire penser que cette thèse sera probablement vérifiée par les faits. Il faut observer toutefois que, s'il y a une influence de la part des matières diélectriques, elle est extrêmement faible.

7. Décomposition d'un électrolyte par l'induction électro-magnétique; par J.-A. Fleming. (Electrical News, vol. I, page 124.)

On sait que des courants électriques se produisent dans un conducteur solide quand il se meut dans un champ magnétique. Est-ce aussi le cas pour un électrolyte et dans l'affirmative l'électrolyse aura-t-elle lieu? L'auteur a fait couler dans des tubes en verre de l'acide sulphurique dilué entre deux pôles d'un électro-aimant puissant et il a constaté qu'un courant traverse le liquide perpendiculairement à la ligne qui joint les deux pôles. Le courant de polarisation a montré, en outre, que l'électrolyte est décomposé par ce courant.

(A suivre.)

THEORIES OF ELECTRICITY.

[13134.]—THE letters which have appeared in your last three or four issues on the "Earth as a Reservoir," &c., show how little the mechanical theory of electricity is understood, even among those who have a very considerable knowledge of electrical facts. Your correspondent, "Sigma," both in his letters and in his invaluable work, evinces a perfect mastery of the mechanical theory; but, with all due respect to him, I do not think his work makes the theory clear to the beginner. Prof. Felice Marco, of Turin, is perhaps the only one who has taken the trouble to explain every known phenomenon by this theory; his latest contribution in this direction being a pamphlet on the zodiacal light. If it meets your views I shall be happy to give a series of translations from the Italian physicist's excellent work, "Teoria Meccanica dell' Electricità." I may state, however, in reference more especially to letters 12993 and 13037, that the earth has no more right to the denomination "reservoir of electricity" than it has to be called reservoir of force when a ball thrown on its surface bounces up again. A. F. J.

39

SOCIETY OF TELEGRAPH ENGINEERS.

AN ordinary general meeting of this society was held in January at the Institution of Civil Engineers, Great George Street, Westminster, London. The first business done was to pass a hearty vote of thanks to Mr. C. W. Walker, F.R.S., the retiring President of the Society, under whose auspices, it was said, it had gone on increasing in numbers and importance.

Professor Abel, F.R.S., the President for the ensuing year, then proceeded to deliver his inaugural address, which he commenced by observing that the prominent position to which the Society had attained among the associations in applied science must in a great measure be ascribed to the wisdom which had hitherto been exercised by its members in the selection of the men to whom had been intrusted the management of its affairs. He, however, who had contributed nothing to the pure science of electricity or to the advancement of telegraphy could hardly have hoped in the wildest flight of his imagination to succeed to a position which had been occupied by such men as Siemens, Scudamore, Thompson, Clark, and Walker, and he could only attribute his selection for the post of President of the Society to a desire on the part of its members to testify their recognition of the special importance of chemical science in its application to the work of the telegraph engineer. So strong was his conviction that it was to that consideration he owed the privilege of addressing them that evening that he felt confident he was only rightly interpreting their wishes in endeavoring to illustrate some of the principal directions in which chemical science bore importantly upon that work. And there could, he thought, be no better illustration of the value of combining chemical with electrical research than that which was furnished by the investigations of the late Dr. Matthiessen, relating to the causes of the differences in electrical conductivity exhibited by different kinds of commercial copper. By a systematic series of experiments, that accomplished chemist ascertained, in the first instance, the influence exerted upon the conducting power of pure copper by the principal metalloids and metals known to be naturally associated with it, and afterwards determined the conducting powers of important varieties of commercial copper. The conducting power of pure copper he found not to be susceptible of increase by alloying the metal with any other substance, while certain non-metallic elements occurring as very frequent impurities in the copper of commerce exercised a very prejudicial influence on its conducting power. Thus, the conductivity of pure galvanoplastic copper being fixed at 100, the addition of only traces of arsenic to the metal reduced its conductivity to 60. Some further experiments of Matthiessen elucidated the cause of the good effects produced upon the working qualities of refined copper by the addition of small quantities of lead, which operated in removing some impurities which were detrimental to its toughness and ductility. A sample of pure copper after fusion in contact with air had a conductivity of only 87·25; 0·1 per cent. of lead was added to the metal, the two being fused together in a current of carbonic acid, and by that treatment conductivity was raised to 93. The analysis, Professor Abel went on to say, which Dr. Matthiessen made of a series of commercial coppers, the conductivity of which ranged from 14 to 92, and of six specimens of the core of the Gibraltar cable, the conductivity of which ranged from 67·4 to 90·7, afforded interesting confirmation of the results of his investigations upon the conductivity of pure copper, and contributed in a very important degree to indicate to the wire manufacturer the sources whence he should obtain, or the conditions as regarded purity to be fulfilled, in preparing metal of a quality best suited to the purposes of a telegraph engineer. But while chemical science had unquestionably facilitated the selection of fitting materials for the conductors of cables, it had also been usefully applied in connection with the substances available as dielectrics in cable manufacture, and it was in that direction especially that important benefits from the labors of the chemist were to be looked for in the future. The Submarine Telegraph Committee, the result of whose inquiry was published in a valuable Blue-book in 1861, requested Professor W. A. Miller to investigate the causes of the decay of gutta-percha and india rubber, and he arrived at the same conclusion as that to which Professor Hoffman had previously come—that decay was due to oxidation, through atmospheric influence, of the gum, which became transformed to a more or less considerable extent into a brittle resinous substance. Professor Miller also pointed out that an intermittent exposure of moisture, particularly if solar light had access, was rapidly destructive of gutta-percha, while if kept continually immersed in water it remained practically unchanged for indefinite periods. Now, the mechanical processes of preparation of gutta-percha had doubtless undergone considerable improvements since the date of the Marine Telegraph Committee's Report, but, judging by the results of some chemical examinations which he himself had recently made of samples of new gutta-percha, it did not appear to him that there was much improvement in the quality of the material as indicated by its chemical composition, for although a high-priced sample contained just below 13 per cent. of resin, it contained even more inclosed water than two somewhat lower priced samples, while in several samples offered at about the same price, by different well-known makers, the resin ranged from 20 to 27·5 per cent., and the water from 8 to 12 per cent. Professor Abel, after dwelling at length upon this part of his subject, went on to give some illustrations from his own experience of the imperfect nature of existing knowledge regarding the chemical and other conditions to be fulfilled in the application of vulcanizing processes to the preparation of telegraph cables. It was scarcely necessary, he added, to impress upon the Society the importance of the application of chemical research to the more complete study of the causes of the defects in the dielectrics at present in use, and to the production of insulating preparations suitable for cable covering which should possess the chemical as well as physical qualities essential to permanence. The efforts which had been made from time to time to produce new insulators or to improve the existing ones might be said to have served until lately chiefly to clear the ground for future experiments; but there was one direction in which, after repeated efforts, an important success appeared to have been achieved. One of the most absolutely permanent materials of organic origin was the solid product of the distillation of peat and of certain descriptions of coal or bituminous minerals which also existed in many varieties of petroleum or mineral oils, and which was known as paraffin or as fossil-wax. That substance, which during the past 30 years had passed from the obscure position of a chemical curiosity to the foremost rank among important chemical products, thanks to the practical development of the results of pure chemical research, was possessed of high insulating power, and had consequently received some useful applic..

simple costume of the goddesses, passes before the car of Apollo, the god of the sun, while Science observes the phenomenon on the earth and records the results. The legend is the composition of a member of the Academy of Inscriptions. On the obverse of the medal is the following inscription :—

INSTITUT DE FRANCE
ACADÉMIE DES SCIENCES
PASSAGE DE VÉNUS SUR LE SOLEIL
8-9 DECEMBER, 1874.

THE EFFECT OF INAUDIBLE VIBRATIONS UPON SENSITIVE FLAMES

DURING a recent visit to Birmingham my friend and host, Mr. Lawson Tait, showed me some interesting experiments with one of Mr. Galton's whistles, capable of yielding vibrations beyond the limit of hearing. This led to the suggestion of trying a sensitive flame with these whistles, and in fulfilment of my promise to select and send to Mr. Tait a burner sensitive to very high notes, I was yesterday led to make the following experiment, the result of which is, I believe, new, and I think sufficiently interesting to put on record. A sensitive flame was obtained just two feet high when undisturbed, but shrinking down to seven inches under the influence of the feeblest hiss or the clink of two coins. Adjusting the Galton whistle, which Mr. Tait lent me, so as to yield its lowest note, little effect was produced on the flame; a shrill dog-whistle produced a slight forking of the flame, but that was all. Raising the pitch of the Galton whistle, the flame became more and more agitated, until, when I had nearly reached the upper limit of audibility of my left ear, and had gone quite beyond the limit of my right ear, the flame was still more violently affected. Raising the pitch still higher, until I quite ceased to hear any sound, and until several friends could likewise detect no sound, even

DIAGRAM A

quarters which leads us to believe in the existence of these peculiar relations.

About fift[...] Schwabe, of [...]

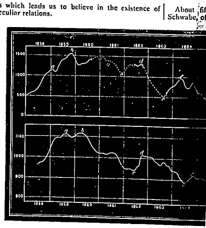


DIAGRAM B.—The upper curve denotes sun-spot fluctuations, the lo[...]

himself to observe the sun's surface day after day, and as the result of forty years' observations, he was rewarded by

the discovery [...] will be seen [...]

vibration number of these high notes, and thus with greater exactitude fix the upper limit of hearing.

The flame giving the effect here described was produced by coal gas contained in a holder under a pressure of ten inches of water, and issuing from a steatite jet having a circular orifice 0·04 inch in diameter.[1]

W. F. BARRETT

SOUND-VIBRATIONS OF SOAP-FILM MEMBRANES

THE vibration-forms of membranes agitated by their fundamental and upper tones, have usually been studied by means of thin bladder or india-rubber stretched on a ring or frame (see Helmholtz "Sensations of Tone," chaps. iii. and v.; Pisko, "Die Neueren Apparate der Akustik," p. 75). While I was lately trying with Mr. R. Knight the capabilities of various membranes of taking impressions from vocal sounds for phonautographic purposes, the idea occurred of using soap-film. This was at once carried into effect by dipping the end of a lamp-chimney into some soap-solution, strengthened in the usual way with glycerine and a little gelatine. On singing near the open end of the chimney, the series of forms belonging to the various notes became plainly visible, those produced by the upper tones being as it were engine-turned in their complex symmetry, in a way to which the sand-lines on so coarse a material as caoutchouc can bear no comparison. To exhibit these forms at a popular lecture here last night, the light of an oxyhydrogen magic lantern was simply reflected off the vibrating film upon the screen in a disc of some three feet in diameter, so as to show its patterns on a large scale when set in movement by talking, singing, and playing a cornet in its neighbourhood. The effects were of singular clearness and beauty. To lecturers who may use this new and easy means of making the more complex sound-vibrations appreciable by the eye, I would mention that by slightly thinning the soap-solution, and adding a few drops of ammonia, they may obtain a film more free from interference-colours, so as to display the vibration-figures on an almost clear ground. But if this is done, the thicker mixture should be used afterwards, for the gorgeous scenic effect of the masses of prismatic colour whirled hither and thither by the musical vibrations.

EDWARD B. TYLOR

Wellington, Somerset, April 20

THE OTHEOSCOPE[2]

I COMMUNICATED to the Royal Society in November last, an account of some radiometers which I had made with the object of putting to experimental proof the "molecular pressure" theory of the repulsion resulting from radiation. Continuing these researches I have constructed other instruments, in which a movable fly is caused to rotate by the molecular pressure generated on fixed parts of the apparatus.

In the radiometer, the surface which produces the molecular disturbance is mounted on a fly, and is driven backwards by the excess of pressure between it and the sides of the containing vessel. Regarding the radiometer as a heat-engine, it is seen to be imperfect in many respects. The black or driving surface, corresponding to the heater of the engine, being also part of the moving fly, is restricted as to weight, material, and area of surface. It must be of the lightest possible construction, or

[1] The conditions necessary for obtaining the utmost sensitiveness of the flame are described in an article I published on the subject in the *Popular Science Review* for April, 1867.

[2] On Repulsion Resulting from Radiation. Preliminary note on the Otheoscope, by William Crookes, F.R.S., &c. Read before the Royal Society, April 26, 1877.

Velocity of Electricity.

Dr. Sabine has devised a method of measuring the contour of electric waves passing through telegraph lines. It is probable that in this sense alone electricity may be said to have a velocity. The early experiments on the time elapsing, between starting electricity into one end of a conductor and receiving it at the other end, gave totally contradictory results. This interval would depend on the electromotive force employed, the resistance and capacity of the conductor, and the sensitiveness of the receiving instrument. It would therefore by no means be proportionate to the length. By the following method the electrical condition of any point of the line may be examined quantitatively at intervals of 0·001 of a second or less after starting the electric impulse. It thus becomes possible to measure the form and speed of a wave. Suppose one end, A, of a conductor, A B, is placed to earth, and that the other, B, is connected with one pole of a battery whose second pole is put to earth. Then any point of the conductor, as C, will assume a potential which will be proportional to the resistance of A C. This potential may be measured by connecting C for an instant with a condenser or accumulator, and then discharging the latter through a delicate galvanometer. When the circuit is first closed, a minute interval of time is required before C will attain its full potential measurements made of the relation of these quantities, showing the form of the electric wave passing the point, C. The only mechanical difficulty is to construct a chronograph which will allow C to be connected with the condenser, a small but accurately determined time after A is connected with the battery. A heavy wheel of brass is set in motion by a steel spring so that it shall revolve exactly twice a second. The interval through which the spring acts being always the same, a nearly constant velocity is always imparted. The disk is divided into 500 equal parts. A movable index serves to regulate the angle through which

through the exhaust pipe. The exhaust steam itself lowers in temperature as its pressure decreases, and the live steam on the back of the valve is comparatively constant in temperature: as a result, then, the valve is continually changing in form from the expansion due to the high temperature of the exhaust steam during the early part, and the lower temperature during the latter part, of the exhaust. Now comes another and more important question, and that is: How far will the spring of the valve, from the pressure of the steam upon its back, affect the fit to its seat, and will it so spring as to permit of a fine film of steam finding its way beneath the wings of the valve, thus relieving, to a certain extent, the amount of its pressure to its seat?

If we take a pair of the plates shown in Fig. 1, and get them so closely together that it requires, say, 340 lbs., to slide one upon the other, and then take hold of the plates by

40 42

THE LAWS OF THE PASSAGE OF ELECTRICITY THROUGH GASES.

77

A PAPER by M. G. Wiedemann on this subject is published in *Pogg. Annal.* An abstract of it will be found in the December number of the *Journal de Physique.* The apparatus employed by M. Wiedemann was a Holtz machine, one of the conductors of which was in connection with the earth. The other communicated with one of the electrodes between which the discharge took place, the other electrode being connected with the earth by a circuit of which a galvanometer formed a part. Without going into the facts observed by M. Wiedemann, we may state some of the conclusions which he drew from them: The discharge, or rather the series of discharges, taking place between the two electrodes cannot be assimilated to an electric current; the more or less rarefied air or vapors offer no resistance in the electrodynamic sense of this word. A certain charge is necessary on each electrode before discharge can take place. This limit attained, the gaseous molecules are driven far from the electrodes, carrying with them the electricity with which they are charged. The differences noticed by observers in the luminous appearances at the two electrodes, as also the differences in the intensity and number of discharges between two electrodes of different forms, when the direction of the current is reversed, are attributed by M. Wiedemann to the fundamental fact that the positive discharge only commences when the potential of the positive electrode has attained a value superior to that for which the negative discharge takes place.—*Academy.*

77 *Depolarization.*—M. Lippmann.—The depolarizing power of certain salts has long been known. The first constant current battery constructed in 1829 by M. Becquerel depends on the use of copper sulphate, while zinc and cadmium sulphates have been utilized by MM. Du Bois-Reymond and J. Regnault for the construction of impolarizable electrodes and of constant elements. This property, however, has not been studied. The author's experiments reveal an essential condition of the phenomenon. In order that an electrode may be depolarized it must be formed of the metal which is contained in the solution. Thus copper is the only metal which is depolarized in copper sulphate, while gold, silver, and platinum are polarized in this solution. On the other hand, copper is polarized in zinc and cobalt sulphates, etc. A salt depolarizes only its own metal. This principle may be applied to the detection of a metal in a solution. Taking, for example, copper: if a wire of this metal be plunged in a solution under examination, and taken as the negative electrode of a feeble current, it will not be polarized if the liquid contains 1-5000 of copper sulphate. The presence of copper may thus be detected in a mixture of metallic salts. With a silver wire silver may be detected in like manner.

Diamagnetism of Condensed Hydrogen.—R. Blondlot.—Graham had found hydrogenium-palladium more magnetic than palladium. Wiedemann ascribes this result to iron present as an impurity in Graham's palladium and reduced by the hydrogen. Blondlot agrees with Wiedemann, and finds that condensed hydrogen is powerfully diamagnetic. 77

ELECTRICITY AND THE EARTH.

[12926.]—"NO SIRRAH" (12915, p. 440) considers I am wrong in objecting to the commonly taught doctrine that electricity is pumped out of the earth by friction machines, and runs away into it again like waste water into the drains. He brings up the old statement that, "after a few turns, we cannot get any more sparks, the quantity of positive electricity in the rubber having been exhausted." Now, this statement, though made in all the paste and scissors "textbooks," is absolutely a falsehood as to the fact, and a ridiculous absurdity as to the explanation, and the mischief of it is that it results in false conceptions of the nature of electricity, and of its actions, and necessitates a whole series of equally erroneous corollaries as to charge, bound, and dissimulated electricity, &c.

If "No Sirrah," and other believers in these old tales, will read my articles in Vol. X., "Electricity: Its Theory, Sources, and Applications," or the second chapter of my book of the same title, they will find these notions fully dealt with, and their absurdity exposed. They date from the early days of electrical discovery, when its frictional sources were alone known, and when people had a fashion of inventing "a fluid" at pleasure, or devising some kind of explanation of facts before they had any extended knowledge of the facts; but all this "earth" elaboration, however it may be adapted to mere frictional electricity, is a mere incumbrance directly we deal with electricity derived from any other source, and the necessity of making later knowledge agree in some degree with the old infantile theories produces confusion.

It is not true that it is necessary to connect either the rubber of the machine or the sole of the electrophorus to "earth," as the textbooks say. We can get as many sparks as we please, and keep them going for years if we please, with the apparatus as perfectly insulated as possible—that is to say, without either a means of drawing positive electricity from the earth, or a drain pipe to run off the negative to the earth, both of which the old theory (or any theory which treats "earth" as an electrical source) pronounces absolutely essential.

How, then, does the erroneous notion arise? Very simply. A chain is dropped from the rubber to the floor, or somewhere where it will find some conducting body, and without this but little electricity can be obtained. But let us try to bottle off a little of the fluid we suppose we pump up through this chain, and put it into a Leyden jar; we find we must drop another chain from this also to earth, and a new explanation is devised which constitutes this into a drain pipe for the negative electricity to run off by. It never seems to have occurred to the inventors of this complex notion that these two chains, by both being connected to earth, were simply connected to each other; but in actual fact, if we insulate all the apparatus perfectly, and just join these two conductors, we get all the effects without the "earth" having anything to do with the matter, so proving that it is not the source of the electricity.

But this does not appear so evident in the seemingly simpler case of charging an insulated surface with positive electricity, requiring only one chain to earth. But the erroneous theory has shut the eyes of observers to the facts, and led to nearly universal misconception as to what occurs in this case. No such charge of positive electricity really occurs. The phenomena are exactly identical with the case of the Leyden jar. Whatever positive electricity is found on the prime conductor or surfaces connected to it, an equal quantity of negative electricity is to be found on surrounding surfaces. The brass chain forms no connection to earth, but it does form a connection to these surrounding surfaces. It does not act as conduit for positive electricity (from the earth as a source) to be packed upon bodies to be charged, but it does connect the opposite side of the insulating medium—*i.e.*, the air of the room, so as to permit an electric charge to accumulate in that air, just as under other circumstances it does in the glass of the Leyden jar.

July 77 Sigma.

43

ELECTRICAL VORTICES.

From observations made on the escape of steam from kettles and railway engines, and of smoke from tobacco pipes and cannon, I was led to believe that many of the evolutions performed by the discharged vapors arose from their being in a different electric condition to that of the surrounding media, that they were in a spheroidal state, that the rings and various forms of radiation they assumed were due to this condition, and that the particles of vapor and smoke were involved in electric vortices.

Mr. Robert Hunt's experiments on the influence of magnetism on molecular arrangement* favor this view; and, as they are important and may not be readily accessible to some of our readers, the following extract may perhaps be admissible:

"12. A plate of copper with an edging of wax was placed on the electro-magnet, over it a very weak solution of nitrate of silver was quickly poured; the plate immediately blackened from decomposition of the silver salt by the copper. In about a minute the finely-divided silver arranged itself into curves which were after a few minutes again destroyed. By using a sheet of chemically pure copper obtained by electrotype deposit I found a permanent impression of these curves could be obtained owing to the oxidation of the copper along the spaces, which the finely-divided silver, when distributed in curved lines, did not occupy.

"13. A plate of hard copper, such as is used by engravers, was placed in precisely the same circumstances and covered with a tolerably strong solution of nitrate of silver. It was left in contact with the electro-magnet for a night. On washing off the deposit of silver which covered it, it was found that the acid of the silver salt had bitten deeply into the plate over an oval space around the poles, leaving a small space between them quite bright. The copper over this etched space was covered with an immense number of minute holes, and, beyond this, the oxidation of the surface had proceeded in curved lines. We thus have permanent evidence of the influence of magnetic force in determining chemical action.

"14. Into one of the glass troughs before named—a plate of glass with an edge of clay—placed on the electro-magnet, a weak solution of sulphate of silver was poured, and into this an equally weak solution of sulphate of iron. In about five minutes precipitation of silver commenced. This precipitate arranged itself over the glass in curves from and around the poles in the same manner as it distributed itself over the copper plate. In a short time precipitation increasing, two curious curved spaces were formed by the fine deposit, proceeding from one pole toward the other in opposite directions, increasing in width as they proceeded, until they were abruptly checked at little distance from the poles towards which they were directed, these spaces being very distinct from the first formed curved lines.

* *Philosophical Magazine*, third series, Vol. XXVIII., page 1.

Thus far as regards the effects of electro-magnetism on chemical action in progress. But there seemed something wanting between it and the effects of the poles of an electro-magnet on loose particles of matter not immediately involved in chemical action. While I was studying a means for supplying this want, M. Gaston Planté's very simple and ingenious experiments were made known, which meet what is required. It is unnecessary to repeat them here, as they have been already noticed in these columns.*

These experiments indicate most distinctly the existence of electrical vortices. In M. Planté's experiment the fluid passing from the electrode involves the metallic particles and renders the vortex visible. The explanation I gave twenty-seven years ago of the behavior of the electric fluid when passing along a wire† shows that it arises from the latitudinal and longitudinal action of the fluid upon itself, owing to which it moves corkscrew fashion, the principle involved being that of two forces propelling a body on the diagonal of the direction of those forces. The paper referred to was an explanation of the cause of the magnetic needle assuming its peculiar position in Ampere's experiments when a current is passed along a wire. This paper would not admit of being abstracted, and would seem too long to insert here. But M. Planté's experiments confirm what was there said, and show the current passing off into loose and liquid materials, continuing, as far as these can hold together, the vortex established on the wire.

This is very noticeable when he illustrates the formation of waterspouts, producing in a mixture of salt and water similar gyrations to those witnessed in that meteoric phenomenon, and showing the tendency of the liquid to rise in the vortex.' The direction of gyration in these experiments is also found to agree with that of waterspouts in nature, the reversal of the experimental electric current changing the direction of gyration, as waterspouts revolve in opposite directions in two hemispheres, which M. Planté considers may be attributed to the flow of the electric fluid under the magnetic influence of the globe.‡

Another form of vortex appears in M. Planté's experiments. The immersion of the positive wire into a liquid conductor, such as salt water, determines the aggregation of the aqueous molecules about the electrode in the form of a luminous spheroid in consequence of a double simultaneous effect of flowing and suction—*d'écoulement et d'aspiration*—"or of transport in two directions that seems peculiar to the electric fluid."§

The whole universe develops vortices or centres of force *en rapport* with electricity. Amongst animals it appears in the ganglions and other nerve centres; in the vegetable world in the deposition of cells, in the roots, in the joints, the corollæ, and the fructification; and in the inorganic world in every centre of chemical change; in the planets, in the solar system, in the Milky Way, and those still more distinct centres, the casual messengers from which occasionally visit our system.—JOHN J. LAKE, in *English Mechanic.*

76

ELECTRICITY.—To "Sigma." 77

[13216.]—Most willingly do I accept your gauntlet (let. 13169), and if I have departed from the original question—of whether electricity is or is not an entity—the fault, if any, I think, rests not with me. But let us now proceed to business, begin at the beginning, and taking facts in their order of date I will give a detail of the boiler experiment.

My authority has identified electricity with cold, or cold with electricity, and by letter of the 19th August, 1815, to determine the effect of electricity on red-hot iron, he solicited of the directors of the Polytechnic Institution his being allowed to put two bars of iron into the furnace of the hydro-electrical boiler, and when red hot to insulate them at a short distance from the boiler, "but so connect one of them with the boiler and the ground so that the fluid in its passage to the boiler shall pass through the bars." On his arrival at the theatre of the institution, where were Dr. Bachoffner and three or four other gentlemen standing among the benches, he was told by the doctor: "Mr. ——, you are altogether in error; the electricity does not go to the boiler, but only comes from it." "What, doctor," was the reply; "do you mean to say that the electricity that flows from the boiler with the steam has not previously gone to the boiler?" "Yes, certainly I do." After a minute or so of reflection, the doctor was requested to put the machine into action, and the request not being complied with, it was repeated, which produced the desired effect, when my authority, taking off his hat, notwithstanding the admonitions of the attendants, gradually approached the boiler, head foremost, until a vivid flash passed from his forehead to the boiler. Assuming again the upright position, he turned to the doctor and his friends, and having passed three or more flashes, he asked whether they were to or from the boiler, it being evident that, if the latter, he would not now be alive to tell the tale. Obviously, whatever may have been the idea of the doctor and his friends, the attendants anticipated fatal results, or that the flow of the electricity would have been from the boiler; and assuredly you, as an electrician, cannot require to be told "what the flashes of electricity reported prove against the received ideas that the electricity is produced by friction in the hydro-electric apparatus." That the electricity to the boiler was caused by the rushing out of the high-pressure steam from the boiler is unquestionable; but its being "produced" or generated is quite another matter. What may have been Dr. Bachoffner's thoughts I am unable to say, since he did not express them; but I think that, if inquiry be made, it will be found that the boiler ceased to be, very shortly, if not immediately, after the demonstration.

Fact 28, detailed in my letter 13014, p. 515—the flow or passage of the "intense cold" of a freezing mixture through the finest of copper wires to a hot solution of alum—is one of the subjects of the paper to Professor Faraday, and apparently escaped your notice. In that experiment there can be no friction, and I certainly should like to know what else than the electricity, "intense cold" of the decrystallisation of the ice and salt, is the cause of the crystallisation of the alum; and what it is that the rain of a heavy shower brings down that produces a similar effect. Professor Faraday, by letter of the 20th December, 1816, replied:—"I am obliged to you for the copy of the papers, and have looked them hastily through. I cannot undertake to do more, for I can hardly find time and strength to pursue my own views. You must be content to do as other philosophers do—form your own judgment, give it to the world, and then leave others to adopt it or not, according to their opinion of its value, or their ability to understand it. It often happens to me to be, as I think, misunderstood on very important points; but, having put them on record, I do not think that I have any right to press them, because, after all, I may be wrong. What I practise myself is, of course, that which I should recommend to you. I return the MS. because, as there is a good deal of it, it may save you some trouble." No doubt you could write that reply more tersely than "gentle Faraday" would have found words for; but William Henry Weekes, who, as an electrician, can be no stranger to you, stated, by letter of the 20th February, 1819:—"If I have retained your papers longer than perhaps I ought, it is because they have interested me, especially your 'statements' comparing your own views and the doctrines of the schools. Stick to your 'electrical condition.' I have well considered all, and my conviction is unchanged as well as unchangeable. Surely you will ere long bring your guns to bear direct on the enemy."

My authority, I should tell you, on account of his principles, duly went through the ordeal of persecution, and one of no small magnitude, "gentle Faraday" notwithstanding. And now as to "Heat and Motion." I should like to know how you interpret the fact that, if one end of a bar of steel, say, 30in. long, be firmly held against a revolving emery-wheel, the other end of the bar burns the skin of the hand grasping it? Diffusion to the reconstitution of the atmosphere, decomposed by combustion, &c., is one of the "doctrines of the schools." A greater fallacy could not be, and the facts of decomposition of matter are the result of a protracted inquiry. But, for the present, let us deal with electricity, the hydro-electrical boiler, freezing mixture and crystallisation, and heat and motion, which latter, my authority contends, is purely electrical.

Scholasticus.

Has Electricity Weight? 78

Mallet has come forward with an experiment, apparently corroborative of that of Pirani, described in the SCIENTIFIC AMERICAN of February 9, 1878, purporting to show that electricity has weight, or at least is under the influence of gravitation. He takes a straight copper wire three feet long, bends the ends downward, and suspends it at the middle to one of the arms of a delicate balance, while the bent ends dip in mercury. When the current of a moderately strong battery (say ten Grove cells) is passed through the wire by the intervention of the mercury, the arm to which the wire is attached, although accurately balanced by a counterpoise, will sensibly tend downward, notwithstanding the resistance produced by the buoyancy of the mercury. The conditions of the experiment, however, demonstrate that gravitation has nothing to do with it, and that it is merely due to the law of attraction of electric currents. These conditions are that the wire must be placed in an east and west direction, and that the current is sent in the same direction. According to Barlow's theory, electric currents travel in the earth's crust from east to west, and are the true cause of the direction of the compass needle, which, according to the law discovered by Oersted, places itself always at right angles to electric currents, while magnetic declination and variation are due to the direction and changes of these currents. Ampère discovered that currents passing in the same direction attract one another, and therefore that the subterraneous earth currents exert an attractive effect on all conductors through which electric currents pass from east to west; hence the conducting wire goes down, while the electric action is added to the gravitation which was balanced by the counterpoise. But Ampère also discovered that electric currents running in opposite directions repel one another; *ergo*, when the electric current is passed through the suspended conducting wire from west to east, it must be repelled and driven upward against gravitation, and this deduction is fully verified by experiment, as in this case. The counterpoise goes down, and the balance may be made to oscillate by alternately reversing the currents; which proves that the theory based on the laws discovered by Barlow, Oersted, and Ampère, offers a correct explanation, without recourse to the novel hypothesis that electricity has weight.

ELECTRICITY. 79

[13244.]—"Scholasticus," letter 13216, p. 11, informs me for the first time what was the "original question" with him. I had thought that it was an inquiry into the causes of some chemical actions produced by high-pressure steam; I conceived that the electrical notions were but an offshoot of this, and I objected to confusing our minds by the endeavour to grasp, all at once, a whole collection of perfectly dissimilar and unconnected matters. I now learn that the original question—that is, in the mind of "Scholasticus"—was "whether electricity is or is not an entity." That question I debated pretty fully some years ago in a series of articles in these pages, now before the world in the shape of a book. The arguments I used no one has yet answered; when any one does so, I am quite ready to discuss the subject, but while those arguments, showing that electricity is not an entity but a form of molecular energy and motion, remain unattacked, I do not see that I can be expected to enter upon the examination of all kinds of ideas or facts which may or may not bear upon the subject.

Thus the reported experiments upon crystallisation did not "escape my notice;" I read them with interest, but I should not think of discussing them until I had myself witnessed them—not once but several times. Meanwhile, I have on hand many much more important experiments for which I cannot find time and power. I cannot accept the "authority" on which "Scholasticus" relies because, while I do not doubt his honesty, I have no reliance on his experimental faculty. I see in numerous other cases that he misreads facts, and therefore think it probable he has done so in this case. Many points would have to be considered: one glass may have been in a draught and cooled more quickly, or it may have been in a stronger light, and I see clearly that the observer would have been quite incapable of giving a thought to such matters because he was simply looking for facts which should confirm his ideas, and any difference whatever would be triumphantly adopted as being due to electricity.

As to the hydro-electric matter, no doubt it will surprise "Scholasticus" (who says, as an electrician, I cannot require to be told it) when I again ask what the reported flashes prove? It appears they proved nothing to Bachoffner, who witnessed them, and I cannot imagine what they are supposed to prove. I do not need to see that experiment because I know that the flash would occur, and why it would do so. The insulated boiler was in a negative state, and any object which approached it would be positive and would form part of a more or less extensive inductive circuit, and at proper distance would pass a spark. The boiler, in fact, plays precisely the part of the rubber of a friction machine. "Scholasticus" must pardon my saying that I do not approve of the spirit of the concluding remark on this topic. Bachoffner it seems did not express his thoughts, probably because he came to precisely the same conclusion as I have, and saw that his interlocutor was one of those men to whom it was useless to talk, because they raise such a mist in their own minds that they can see nothing but the vague figures reflected from the mist. But when it is hinted that "the boiler ceased to be, very shortly if not immediately after the demonstration," dishonesty is implied; it means that Bachoffner and others were convinced that they had given a misinterpretation of facts, and were not men enough to admit it. Now, the fact is, that the boiler has not ceased to be—it stands, I believe, to this day in the Polytechnic Hall—but it has ceased to have any interest. Like the enormous plate machine which stands there also, it served as an attractive and an amusing scientific illustration for a time, and then it was superseded by something else. The boiler was also a novelty, and, no doubt for a time, was expected to prove important, but as soon as it had been studied and was understood, its interest passed away. One circumstance alone suffices to show the fallacy of the ideas of "Scholasticus's" authority. With perfectly dry steam (electric steam) no electricity is generated; with steam partially condensed the boiler becomes negative, and the conductor charges with positive electricity, as does a friction machine with a glass plate. Now charge the steam with oil of turpentine, and the boiler becomes positive and the conductor negative, as in a machine with an ebonite plate. Would this be possible if the steam were really electric, or if the electricity were an entity coming to the steam from the earth, from the fuel, or from anywhere? If the electricity were really a something present in the steam, which, in fact, owed to it its energy, would the presence or absence of a few drops of a foreign liquid entirely change its character? It is easy enough to comprehend this when we recognise that electricity is simply energy guided by molecular polarity, and ready at any instant to resume the form of heat or mechanical motion.

Now, for the next fact of the heat generated in an iron bar, or rather through the iron bar; the interpretation involves no difficulty whatever. The end held against the emery wheel is subject to violent friction and becomes very hot, and this heat would only be slowly transmitted along the bar; but other effects would also arise. I think it quite likely that a current of high tension electricity would be set up, resulting in a series of discharges into the hand but whether this be so or not, a powerful tremor would be set up, resulting in a rapid series of blows delivered by the end of the bar held, and these would produce heat in the hand, though the bar itself remained cold, just as the hand is heated beyond endurance by drawing a cord rapidly through it. All this is the A B C of heat science, but what "Scholasticus" means by "diffusion to the reconstitution of the atmosphere, decomposed by combustion," &c., is a profound mystery to me. He seems to assume that these cabalistic phrases form part of the "doctrines of the schools," but I should like to learn from what textbook he extracted them. I am quite willing to agree with him that a greater fallacy could not be, although I do not see what "the facts of the decomposition of matter" have to do here.

Now, a few words as to "persecution." If a man sets himself against the world, the world laughs at him, and if he gets in its way kicks him out of it; what else can he expect? If a man with an active mind thinks he has discovered something new, and proceeds forthwith to tell every one else that they are fools, and he alone knows the truth, can he complain if they in return regard him as a conceited and wrong-headed man? Can he wonder even if this opinion of him results in damage to his interests, if those interests are in any way dependent upon the opinion people form of him? But it is folly to call this persecution: it is what any man ought to expect if he sets himself, either rightly or wrongly, against the stream of life; it is what any sensible man (who ventures to think his own thoughts and endeavours to modify accepted views) prepares himself to meet, and either to conquer or endure. But the paradoxers who very freely call every one else fools, and insist that they alone know the truth, who will persist in holding forth their half-understood facts and crude ideas, and will pay no attention to the work of other people, are generally very thin skinned themselves. When people laugh at them they begin to whine about persecution, and they think themselves dreadfully ill-used when people who know their subject and see through the absurdities presented to them refuse to go seriously over and over the ground of examining and refuting them in detail.

Sigma.

INFLUENCE OF HEAT UPON MAGNETISATION. 77

M. J. M. Gaugain.

M. Favé had pointed out that when a bar of steel is magnetised at about 350°, allowed to cool, and heated again, the quantity of magnetism augments, and may reach triple the value which it had preserved after cooling. M. Wiedemann maintains that a bar magnetised at an elevated temperature loses on cooling a part of its magnetism: it loses a further portion when heated again, but on cooling it resumes a part of what it had lost. The author believes that this contradiction is due to the circumstance that M. Wiedemann experimented only with bars heated to 100°, whilst M. Favé operated with bars magnetized at a far higher temperature.

ELECTRICITY. 77

[13688.]—When I took the (perhaps unwise and needless) trouble of repeating the experiment in crystallisation, about which "Scholasticus" says so much, I endeavoured as much as possible to adopt his conditions. He now says (letter 13632, p. 289) that I have "reversed the order of things." Now, the fact is that the slight difference to which he refers, so far from reversing the order of things, would not make the smallest difference in the results. He says, "in neither of the solutions was there any wire, big or small," and yet he actually describes two wires as "bent over the tumbler, so as to just and barely touch the surface of the solution." Now, that "just touching" is the very point in which he fails; for he does it only in the one solution. An infinitesimal point of solid substance is enough to determine and modify crystallisation, as is well known in experiments with supersaturated solutions. [My arrangement was practically the same, for I secured the wire to a bar crossing the tumbler, and inserted about ¼in. of the wire, twisted up in a spiral, in the solution; but I did the same in both, and connected one only to the freezing solution. When I began I was pretty sure I was wasting my time, and that no kind of effect would be produced, and what I expected, that I found.

Here I finally dismiss that matter. If "Scholasticus" believes in it yet, he should carefully repeat his experiment, and see if he finds any effect; if he does, and will describe it, I will take the trouble to examine the matter; till then I regard the discovery as a mare's-nest, and will have nothing more to say to it.

"Scholasticus" seems to think that his lucubrations are like wine, and are to improve by keeping. He keeps on extracting and referring to papers he wrote in 1819, &c., and things he drew up for the Government, for Professor Faraday, and goodness knows who. But if those papers were rubbish when written, they are no less rubbish when quoted 30 years later, and the fact that they were written with the intention of pestering distinguished men with them, sheds no halo on their own merits. He now even quotes some unknown "S." who appears to have had nothing better to do than to write 17 papers, apparently of about equal value, based upon the discoveries (!) of "Scholasticus," and, as he has contrived to mix up this "S." and "Sigma" in his paragraph, I feel it due to myself to say that "S." and "Sigma" are not the same—indeed, very much not so. In 1819 I was in Australia, using, it is true, my pen pretty freely; but, if I had happened to write about these discoveries I feel pretty sure "Scholasticus" would not have much cared to quote my remarks.

It is quite evident, from his own account, that "Scholasticus" has all his life been afflicted with a chronic mental diarrhœa. When he has obtained some intellectual food in the shape of ideas he has not been happy enough to digest them, and use them in building up a wholesome healthy mind. They seem to have always disagreed with him, and produced a desperate attack of cacoethes scribendi, which has rendered him a nuisance to every one to whom he approached. Some sharp caustic remedies applied to his diseased vanity in earlier days (and that remedy, efficient or not, would have been administered had he come under my hands in 1819) might have cured him, and made him happy and useful afterwards. As it is, the case is hopeless. I do not write with the least idea of convincing "Scholasticus;" he has for so many years fancied he was exploring the universe, while he was only peering about with his own little glimmer of a monochromatic lantern (rose tinted), that now real light would probably be too much for his mental eyesight. If I heed anything he says, what I say is really intended for the many readers, who may think that what he says, so distinctly and with so many words, may be really of some significance.

Now it seems that the unknown "S." is apparent disciple of "Scholasticus," felt that the phrase "attraction of cohesion" has no meaning, and that the other phrase, "attraction of gravitation," might as well be gravitation of attraction. Other scientific terms, such as "energy," also have no meaning (that "Scholasticus" can discern), and "molecules" simply "conveys an indefinite idea," according to his notions. Now, in fact, the two last do convey real conceptions, and the terms molecule and molecular are most rigidly exact and definite. Those I will not trouble about; but as to the attractions of cohesion and gravitation, I, and all men of science, are so far at one with the paradoxists that we also say they do not convey an intelligible idea. We know perfectly well that they convey no explanation (nor do heat, weight, &c.); they simply express the fact that such attractions exist; they do not define or explain the causes. Now "Scholasticus" steps in triumphantly and explains it all. He says all these things are visions—they do not exist, they are effects of a cause, and that cause is electricity. Well this is a great step; but, just one moment, before we take it please, what is electricity? Well, we are told it is cold, it is crystalline energy, it is this, that, and the other thing; it causes weight, it causes heat, it is everywhere, and does everything. But surely all this does not answer the question. The fact is, that electricity so used is merely another word without meaning, used to wrap up in one comprehensive but incomprehensible bundle all the other words which are condemned. Then "Scholasticus" pathetically exclaims, "this momentous conclusion has not been tested—the experiment, simple as it is, is in abeyance." Go on, "Scholasticus," and make it. Sigma.

[31740.]—Electricity.—The querist evidently wants to do something impracticable. It would be absurd to try to work a magnet of the sort through 2 or 3 miles of wire. If to be done at all, it should be by a local battery and relays; and "Inquirer" cannot get the information he wants all ready cut and dried, but must learn something of the subject for himself.—Sigma. 78

Electrical Experiment 78

The inclosed letter gives an account of an experiment in which an electric current appears to be produced by the direct action of gravity, a result which, if clearly established, would be new and of considerable scientific interest.

In trying to repeat the experiment yesterday I observed a considerable deflexion of the galvanometer in the direction described by Mr. Pirani, but as this deflexion seemed to occur some seconds *after* the inversion of the tube, I examined the tube and found a small bubble of air working its way up through the solution, and as soon as it came to the top of the tube the deflexion occurred.

I have not yet had time to repeat the experiment without the bubble, but I mention this to show that care must be taken to secure that the electrolyte is homogeneous, and that it does not contain anything which will either sink to the bottom of the tube or float to the top, so as to act alternately on the two electrodes.

The fact that the deflexion continued for some time after the tube was placed horizontally seems to indicate the possibility of something which was shifted from end to end when the tube was inverted, but remained where it was when the tube was only laid on its side.

J. Clerk Maxwell

Cavendish Laboratory, Cambridge, December 28, 1877

"University of Melbourne, Oct. 30, 1877

"My Dear Sir,—On page 317 of vol. i. of your 'Electricity and Magnetism' it is pointed out that a greater electromotive force is required to produce a given current between zinc electrodes in a solution of sulphate of zinc when zinc is carried upwards than when it is carried downwards.

"I am not aware that it has been noticed that by the same reasoning as that by which the induction of currents is deduced from the force exerted between a circuit and a magnet and the existence of contact electromotive force from the Peltier effect, it follows that a current should exist if two zinc electrodes connected by a wire are immersed in a solution of sulphate of zinc, the direction of the current being (in the solution) from the upper to the lower electrode.

"I tested this a few days ago, using a glass tube eighteen inches long, filled with a saturated solution of sulphate of copper and closed by copper caps with wires attached.

"On connecting the wires with a very delicate Thomson's astatic galvanometer belonging to Prof. Halford, a very considerable deflection was produced (200 divisions) when the tube was held vertically, the direction of the deflection being reversed when the tube was reversed.

"If the tube, after being held vertically, was placed in a horizontal position, the deflection diminished, but several minutes elapsed before the index came to zero, which it eventually did. I cannot explain the time taken. I am now preparing to test the actual loss of weight of the upper electrode.

"I have the honour to be, Sir,

"Your obedient servant,

"F. J. Pirani,

"Lecturer on Natural Philosophy and Logic, University of Melbourne.

"P.S.—If the phenomenon has not been noticed before I shall be obliged if you will kindly communicate it to Nature.

"F. J. P."

ELECTRIC CURRENTS OF HIGH TENSION.

By M. Gaston Planté.

Comptes Rendus de l'Academie des Sciences.

For the purpose of studying the effects produced upon distilled water, I have augmented the tension of the current employed, by uniting 20 secondary batteries, each composed of 40 couples, making a total of 800 secondary couples, and giving a current about equal to that from 1200 Bunsen's elements.

When this current is caused to act upon distilled water, the effects observed by Mr. Grove with 500 of his nitric acid cells are reproduced, but much intensified. The positive electrode being previously plunged into distilled water, on bringing the negative platinum wire to the surface of the water and immediately removing it, a nearly spherical yellow flame is obtained, about two centimeters in diameter (Fig. 1). The platinum wire of two millimeters diameter quickly fuses and remains for some instants in a state of fusion to a height of 14 or 15 millimeters above the surface of the liquid. The flame is formed by incandescent rarefied air, by the vapor of the metal forming the electrode, and by the elements of the decomposed water vapor. Spectrum analysis clearly declares the presence, above all, of hydrogen.

If to avoid the fusion of the metal the intensity of the current is diminished by interposing a column of water in the circuit, the spark takes the form of a compact little globe of fire, from 8 to 10 mms. diameter (Fig. 2). Drawing away, slightly, the electrode, this globe takes an ovoid form; luminous blue points, continually varying in number and arranged in consecutive circles, appear on the surface of the water (Fig. 3). Rays of the same color soon start from the center and join these points (Fig. 4). At intervals the rays take up a gyratory motion, tracing out spirals, sometimes in one direction, sometimes in the opposite direction (Figs. 5 and 6). Sometimes the points and rays all disappear on one side, and various curves, formed by those which remain, are drawn on the surface of the liquid. Lastly, when the speed of the gyratory motion is increased, all the rays vanish, and only concentric blue rings are seen (Fig. 7). The rings are the last phase of these transformations, which, examined either with the naked eye or by means of a lens, are very curious, and may be said to form a real *electric kaleidoscope*.*

Feb 78

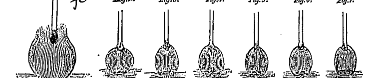


Fig. 2. Fig. 3. Fig. 4. Fig. 5. Fig. 6. Fig. 7.

PLANTE'S ELECTRICAL EXPERIMENTS.

The production of these figures is explained by the great mobility of the luminous arcs or filaments which compose the ovoid flame formed between the water and the electrode. A careful examination of this form of spark proves that there is in reality a kind of tassel or *brush*, analogous to the brushes of static electricity, but more complete by reason of the greater quantity of electricity coming into play. These luminous filaments being in a state of continual agitation, the points where they meet the surface of the liquid are constantly displaced, and form the rays observed. Their gyratory motion arises from the flow of the electric discharge. As to the rings, these are formed, in a manner visible to the eye of the observer, by the motion, more or less rapid, of the blue points, and by the persistence of the impression on the retina.

When the metallic electrode is positive, and the distilled water negative, the spark still assumes an ovoid form; but the middle is traversed by a core of violet light. When two metallic electrodes are employed, a luminous spheroid is obtained, the interior of which is traversed by a brilliant track. This appearance resembles that of the path and corona of the spark from currents of induction, except that here the corona occupies a proportionally greater space by reason of the greater quantity of electricity. In fact, if the length of the interposed column of water is considerably augmented, nothing but an arc or rectilinear track is obtained.

In these experiments it is not necessary to bring the electrode into actual contact with the water to determine the passage of the electric discharge. The tension of the battery, although the component couples are not very highly insulated, is sufficiently great to cause the spark to occur spontaneously through a distance of about 1 mm. from the surface of the liquid.

This current will also flow through rarefied air, and brilliantly illuminates Geissler tubes if not too much attenuated, producing the stratifications observed under analogous conditions by MM. Gassiot, Warren de la Rue, and H. W Müller. With a long column of water in circuit it is possible, with a single discharge from the battery, to keep a Geissler tube illuminated for upward of three hours and a half, owing to the small quantity of electricity expended in passing through the rarefied air.

These experiments form a sequel to those which I have already made known in explaining the mode of formation of the *globular thunderbolt*. They show that with electricity of sufficient quantity and tension one can obtain not only electrified liquid globules, but also the electric spark itself in the globular form. This kind of thunderbolt should, therefore, result from the production of an abundant flow of electricity in the dynamic state, in which quantity is joined with high potential. The particular case in which fulminatory globes present slow movements or become stationary is explained by the motion or repose of the column of moist air, highly electrified and invisible, which serves as an electrode. To imitate this effect it is only necessary in one of the preceding experiments to cause the electrode, previously suspended in the form of a long pendulum, to vibrate above a vessel filled with water, or a metallic surface, and to hide its lower extremity by means of a screen. A small *ball of fire* is then seen to move along the water or conducting surface, reproducing all the appearances of the natural phenomenon.

* These phenomena are comparable with those observed by M. Fernet with induction currents; they also offer a close resemblance to those which result from the falling of liquid drops upon a plane surface, and which have been examined by MM. Helmholtz, Thomson, Maxwell, Tait, Rogers, Worthington, Trawbridge, &c.

Electrical Experiment 78—We find the following in the *English Mechanic*: "If an ebonite electrophorus be whipped with a fox-tail, it is negatively excited, and the condenser gives positive sparks. If, again, the electrophorus be rubbed with leather on which is some mosaic gold, the ebonite disk is positively excited, and the condenser gives negative sparks. It is stated by M. Schlosser, however, (*Pogg. Ann.*), that if the same ebonite disk be excited on one side with the fox-tail, and on the other with mosaic gold on leather, one may at any moment obtain from the same disk positive or negative electricity, according as the one or the other surface of the electrophorus is used as the source. The most important point in this double excitation is the very much greater length of spark, as is readily observed by the eye. On the other hand, considerably shorter sparks are obtained from the same electrophorus when both sides are similarly excited—for example, whipped with the fox-tail.

We add to the above that this experiment is quite old, and perfectly conforms to the known laws of electricity. Any non-conducting disk, whether glass, shellac, or ebonite, can be made far stronger electric when charged with opposite electricities on its opposite surfaces, than when charged with the same kind, as the mutual attraction of the opposite kind favors the charged in the first instance, and the mutual repulsion of the same kind interferes in the second case.

IS GRAVITY A MODE OF MOTION?

In his 24th series of experimental researches Professor Faraday describes the experiments undertaken, the results of which, he says, though "negative, do not shake my strong feeling of the existence of a relation between gravity and electricity, though they give no proof that such a relation exists." In 1859, returning to the same investigations, he reflects upon the infinity of actions in nature, in the mutual relations of electricity and gravity, which would come in play: he pictures the planets and comets, charging themselves as they approach the sun; cascades, rain, rising vapor, circulating currents of the atmosphere, the fumes of a volcano, the smoke in a chimney, become so many electrical machines. Many more experiments were made by Faraday, but the results were still negative, and the experimenter did not accept them as conclusive. In this position the question remains to the present day; it may be, as Professor Jevons has suggested, that the effect was too slight to be detected, or it may be that the arrangements adopted were not suited to develop the particular relation which exists.

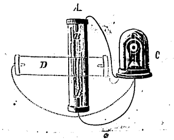
The force of gravity, while conforming on one hand to experience, is on the other a mysterious existence. We know that it is proportional to mass and utterly independent of present or intervening matter. In common with light, sound, and other influences emanating from a point, the law of decrease of its intensity is inversely as the square of the distance, yet, unlike the former, its action appears to be absolutely instantaneous.

The hypothetical ether which transmits light undulations which according to Herschel exercise a pressure of 17 billion pounds per square inch, and is harder and more elastic than adamant, is not influenced by gravitation as matter is, but its density and mechanical properties are modified by gravity in a way yet unexplained. Science thus far has stood silent before this mysterious influence, and there have not been wanting those who, like the late Professor Vince of Cambridge, have held that the force could be explained in no other way than by ascribing it to the immediate and ever present action of the Deity, an easy way of settling problems not wholly satisfactory to scientific minds.

The reader will now perceive the possible importance of an experiment which in place of Faraday's negative results has caused positive ones, and by which an electric current seems to have been produced by the direct action of gravity alone. Professor F. J. Pirani, Lecturer on Natural Philosophy and Logic in the University of Melbourne, writes to Professor Clerk Maxwell (who communicates the fact to *Nature*) with reference to the fact that a greater electric motive force is required to produce a given current between zinc electrodes in a solution of sulphate of zinc when carried upward instead of downward, testing the question whether a current should exist if two zinc electrodes connected by a wire are immersed in a solution of sulphate of zinc, the direction of the current being from the upper to the lower electrode. Professor Pirani used a glass tube, A, 18 inches long, filled with a saturated solution of sulphate of copper and closed with copper caps, B, with wires attached. This, on being attached to a Thomson static galvanometer, C, produced a deflection of 200 divisions when the tube was held vertically, the direction of deflection being reversed when the tube was reversed. When the tube after being held vertically was placed horizontally, as at D, the deflection diminished, and after several minutes the index came to zero.

Professor Maxwell has repeated the experiment, and considers that the temporary permanence of the deflection after the tube is placed horizontally indicates the possibility of something being shifted from end to end when the tube was inverted, but which remained where it was when the tube was only laid on its side.

Further verification of this experiment will be looked for with the greatest interest, as, if its present import be substantiated, the possible conversion of gravity into electricity places that force at once in the same category as light and heat, and indicates future possibilities in discovery over which now it would be idle to speculate. One, at least, may be the measurement of the velocity of propagation of the influence, and the means for determining this are probably already in existence, as will be seen by an examination of the horizontal pendulum, to the illustration and description of which we devote the first page of this issue.



(i.) That the electric currents are not produced by chemical action. (ii.) Nor by a temporary disassociation of the constituents of the liquid. (iii.) Nor by the action of gases occluded in the metals. (iv.) But that they are produced purely and solely by the heat, and that heat disappears in producing them. (v.) That they are immediate or direct effects of the heat, and that aqueous conducting liquids, therefore, possess true thermo-electric properties. (vi.) That the current is a result of a difference of thermic motion at the surfaces of the two pieces of metal. (vii.) That it is a product of a suitable molecular structure of the liquid, a change of such structure resulting from alteration of temperature, and a direct conversion of heat into electricity; and (viii.) That the circumstance which is most influential in enabling heat to produce the currents, and most determines their direction and amount, is a suitable molecular structure of the *liquid*.

Irregular molecular changes in several liquids examined have been discovered, and it is suggested that the method should be further used to prosecute researches in this direction. In the case of platinum, when immersed in some saline, alkaline or acid liquids, a slight rise of temperature takes place, and a similar rise in temperature probably takes place when other metals are immersed. The results obtained support the contact theory of voltaic electricity.

Galvanic Current Between Solutions of the Same Substance of Different Degrees of Concentration.—J. Moser has observed that, in a couple formed by the same liquid of different degrees of concentration, a current passes from the more dilute to the more concentrated solution, the liquids being in separate vessels connected by means of a syphon, and having a metallic plate in each. This currrent was observed with zinc and sulphuric acid, with zinc sulphate, nitrate, chloride, and acetate, with copper sulphate and nitrate, iron chloride, silver acetate, and nitrate, &c. The electromotive force, however, is but feeble, the largest observed being only ·027 of that of a Daniell—as estimated by Du Bois-Reymond's modification of Poggendorff's compensation method—in a couple, consisting of a solution, containing 30 parts of $CuSO_4, 5H_2O$ in 100 of water, and the same diluted with 29 times its volume of water. In this form of couple the metal is dissolved by the more dilute solution, and deposited from the more concentrated. June 78

Specific Inductive Capacities of Certain Dielectrics.—It is important that authoritative determinations of specific inductive capacity should be made. Professors Ayrton and Perry, in a paper sent from Tokei, Japan, show that certain modifications must be introduced in the fundamental notions of the mathematical theory of electricity, because Faraday's conclusion as to the specific inductive capacity of all gases being the same as that of air is incorrect. Mr. J. E. H. Gordon has carried out some experiments in this direction by a new method, the essential features of which are that it is (*i.*) a zero method, (*ii.*) the electrified metal plates never touch the dielectrics, (*iii.*) no permanent strain is produced or charge communicated, as the electrification is reversed some 12,000 times a second. The following are the results obtained with solid dielectrics in plates 7 inches square and from ¼ inch to 1 inch thick:—

June 78

Dielectric.		Specific Inductive Capacity.	
Ebonite, four slabs, ¼, ¼, ¼, ¼ in. thick	(1) 1·5593 (2) 1·5553 (3) 1·5671 (4) 1·5669	mean	1·56215
Best quality gutta percha			1·5939
Chatterton's compound			1·6080
Indiarubber (black)			1·5502
Ditto (vulcanised)			1·5988
Sulphur			1·6127
Shellac			1·6362
Solid paraffin S.G. ·9109 at 11° C. Melting point 68° C. Six slabs, each about ¾ in. thick	(1) 1·4986 (2) 1·4943 (3) 1·4920 (4) 1·5033 (5) 1·4936 (6) 1·5034	mean	1·49753
Bisulphide of carbon (probable)			1·4474
Chance's optical glass slabs nearly 1 in. thick	Double extra dense flint		1·6840
	Extra dense flint		1·6727
	Light flint		1·6677
	Hard crown		1·6872
Common plate glass, two slabs each, about 1in. thick	(1) 1·6933 (2) 1·6903	mean	1·6918

It will be seen that these figures differ considerably from those previously obtained, and we might suggest that other experimenters should spend a little time in confirming or in showing the incorrectness of these results.

Elongation of a Conductor traversed by a Current.—M. Blondlot has presented to the French Academy of Sciences an account of some experiments undertaken with a view to prove whether or not there is really an elongation of a wire when a current passes in it, as Edlund and Streintz have believed and Wiedemann has denied. This method is designed to distinguish more clearly than heretofore between the effect due to heating and that due to the current. The principle of it consists in intercalating a thin metal ribbon in the circuit, by means of stout soldered connections. Any effect due to heating will dilate this ribbon both longitudinally and transversely, so as to increase its bulk without deforming it. But the current effect, if it take place, will do so unequally in the two directions, and will consequently deform the ribbon. Any misshaping of the metallic band or of figures traced on its surface ought therefore, M. Blondlot reasons, to be due to the current, and if there be none, such a direct mechanical action of the current does not exist. With the current from ten Bunsen cells no elongation could be detected, although the arrangement was capable of showing an elongation of 0·00000025m. per metre. Ribbons of brass, German silver, and other metals were experimented on, but with the same negative result. Nov 78

Scientif. Amer. Mar 20 1880

THE ELECTRO-MOTIVE FORCE OF ALUMINUM.

Sci Am S. P. March 20 1880

This subject has been recently studied by Signor Malavasi, of the Modena Academy. In contact with zinc (he says) aluminum always appears electro-positive, though it is less oxidizable. In dilute acid, on the other hand, it is electro-negative. If an aluminum plate be cleaned with oil and pumice stone, it is, on contact with zinc, positive; but, if it be cleaned with water and pumice stone and dried in the sun, it is negative. On being immersed in water after the cleaning with oil, the aluminum plate is only positive at the beginning—very soon negative In water, the aluminum plate gets coated with a gelatinous mass (iron oxide, hydrate, and clay), the zinc plate with a crust; thus both are oxidized, with the above mentioned effects. Three elements—zinc, copper, water—have the same electro-motive force as five elements, zinc aluminum. On heating the junction, the current passes from aluminum to tin, copper, antimony; thus the behavior is somewhat like that of lead. At a higher temperature, the current between aluminum and tin is reversed. Aluminum plates are not markedly polarized in a circuit, though the positive aluminum electrode is thereby quickly dissolved. If the current is passed through after the aluminum plate has remained long in water, the polarization is more pronounced. In a combination zinc-aluminum water, or dilute acid, the current mostly rises at first, even to the double, and then slowly falls; and this the author attributes to the gradually strengthening adhesion of the water to the metals, especially the aluminum; the more so that, on carefully cleaning the aluminum plate with water and pumice, the rise takes place more quickly. This is also indicated by the increase of polarization, after long immersion, on the current being passed. This does not produce an increase of conductivity of the liquid. On alternately immersing, raising, drying, and again immersing, one of two aluminum plates, that remaining in the water, appears gradually positive, like zinc. In acid water, the change of the aluminum came out more strongly than in pure water. In copper aluminum elements, especially when the copper plate is large, the injurious polarization of the latter can be partly compensated by the rise in the electro-motive force of the aluminum, so that thereby the decrease of current strength is partly prevented.

571

From a note presented to the French Academy it appears that Prof. Crova, of Montpel-

lier, has succeeded in measuring very high temperatures by observation of the changes undergone by spectral lines. He takes for term of comparison the heat developed in the wick of a moderator lamp fed with colza oil. This is reckoned equal to 1,000° in the optical scale (necessarily arbitrary) of temperatures. It is found that platinum, heated red in a gas lamp, gives 524. The white produced by an oxyhydrogen blow-pipe in the same metal corresponds to 810. The flame of a stearic candle is at 1,162, and that of an Argand burner, with ordinary coal gas, 1,373. The mixture of oxygen and coal gas projected on lime gives 1,806; the electric light developed by 60 Bunsen elements 3,060; and solar light 4,019. Prof. Crova is hopeful of the application of his method to measurement of stellar temperatures on the one hand, and on the other to the surveillance (in a more practical way) of numerous metallurgical and industrial operations. He promises an extended memoir on the subject.

May 79

ACTION OF MAGNETISM ON CIRCULARLY POLARISED LIGHT.

It is known to have been demonstrated by Fresnel, that a rectilinearly polarised beam of light passing through a quartz plate at right angles to the axis, may be decomposed into two rays circularly polarised in different directions, propagated in this crystal with unequal velocities. This phenomenon corresponds to a rotation of the plane of polarisation of the incident ray. M. Henry Becquerel has recently inquired whether the same holds for the magnetic rotation of the plane of polarisation discovered by Faraday; whether, accordingly, a circularly-polarised light ray, passing through a piece of heavy flint glass, subjected to the action of magnetism, may undergo an acceleration or retarded action while the magnetism acts.

The mode of experiment was as follows: Rays from a lime-light were circularly polarised by a Nicol and a doubly refracting crystal plate; then, made parallel by a lens, they passed through two slits situated very near each other, so that they were divided into two portions, each of which passed through a parallelopipedon of heavy flint-glass, and were then so united that they formed interference-fringes, which were observed with a lens. Of the two parallelopipeda, one was placed between the armatures of a strong horse-shoe electro-magnet, the other beyond the armatures in the prolongation of the line of poles. The magnetism then acts on the two glasses oppositely, and on the second more weakly than on the first. If the light rays experience a difference of passage by reason of the action of magnetism, the interference-fringes must be displaced.

When M. Becquerel accordingly sent a current through the electro-magnet, he observed a slight displacement of the fringes, and this displacement was now right, now left, according to the direction of the current. When he turned the doubly-refracting plate round through 90°, the direction of the circular motion was reversed, and it was observed that, for one and the same direction of the magnetisation, the direction of displacement of the fringes was reversed.

Certain errors through displacement of the entire system M. Becquerel excluded by direct experiment. He could now measure the amount of rotation of the plane of polarisation by magnetism, and found it, for the one parallelopipedon between the poles, 20° 15′ of the micrometer, and for the other 4° 11′ in the opposite direction; hence altogether a rotation of 24° 26′. From this, according to Fresnel, the displacement of the fringes will be = 0·067; and observation gave an actual displacement of about 0·07 fringes.

"The foregoing results," says M. Becquerel, "show that the phenomenon of magnetic rotation of the plane of polarisation is accompanied by a change of the velocity of propagation of the two light-rays circularly polarised in opposite directions; and it is not without interest to see how the direction of the circular light vibration is of influence in the same degree as the direction of the electric current which produces the magnetism; a phenomenon, which was theoretically foreseen, and of which the experiment described gives experimental confirmation.

51

ELECTRICAL INDICATOR FOR SHOWING THE ROTATION OF THE EARTH.

BY GEORGE M. HOPKINS.

Although the apparent displacement of the plane of vibration of the pendulum had long been noticed, it was not until the year 1852 that the fact was coupled with the diurnal rotation of the earth. In September of that year M. Foucault, a distinguished French physicist, suspended a ball, by means of a fine wire, from the dome of the Pantheon at Paris, and for the first time in the history of the world made visible the rotation of the earth. The pendulum thus formed, after receiving an impulse, vibrated for many hours, and preserved its plane of vibration while the earth slowly turned under it. This splendid experiment was subsequently repeated at the Capitol at Washington, and at other places, and is now about to be again performed in Paris.

Soon after the pendulum experiment, Foucault, to illustrate the same thing, constructed a gyroscope which was a modification of Bohnenberger's machine. This gyroscope received a rotating impulse from the hand of the operator, and the momentum of the disk was depended on to continue the rotation for a sufficient length of time to exhibit the movement of the earth.

The duration of the rotary movement thus produced must have been short, and the result unsatisfactory.

Recognizing the desirability of a more practicable means of making visible the diurnal movement of the earth, I have made the action of the gyroscope continuous by applying electricity as a propelling power.

In the first engraving (which represents the machine arranged for the purpose named) the rectangular frame which contains the wheel is supported by a fine and very hard steel point, which rests upon an agate step in the bottom of a small iron cup at the end of the arm that is supported by the standard.

The wheel spindle turns on carefully made steel points, and upon it are placed two cams—one at each end—which operate the current-breaking springs.

The horizontal sides of the frame are of brass, and the vertical sides are iron. To the vertical sides are attached the cores of the electro-magnets. There are two helices and two cores on each side of the wheel, and the wheel has attached to it two armatures—one on each side—which are arranged at right angles to each other. The two magnets are oppositely arranged in respect to polarity, to render the instrument astatic.

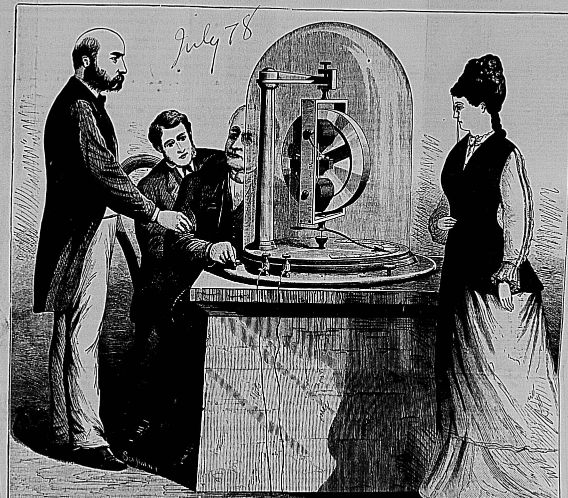
An insulated stud projects from the middle of the lower end of the frame to receive an index that extends nearly to the periphery of the circular base piece and moves over a graduated semi-circular scale. An iron point projects from the insulated stud into a mercury cup in the center of the base piece, and is in electrical communication with the platinum pointed screws of the current breakers. The current-breaking springs are connected with the terminals of the magnet wires, and the magnets are in electrical communication with the wheel supporting frame.

One of the binding posts is connected by a wire with the mercury in the cup, and the other is connected with the standard. A drop of mercury is placed in the cup that contains the agate step to form an electrical connection between the iron cup and the pointed screw. The instrument is covered with a glass shade to exclude air currents, and the base piece is provided with leveling screws.

The current breaker is contrived to make and break the current at the proper instant, so that the full effect of the magnets is realized, and when the binding posts are connected with four or six Bunsen cells the wheel rotates at a high velocity.

The wheel will maintain its plane of rotation, and when it is brought into the plane of the meridian the index will appear to move slowly over the scale in a direction contrary to the earth's rotation, but in reality the earth and the scale with it move from west to east, while the index remains stationary, or nearly so.

[Continued on page 4.]



ELECTRICAL INDICATOR FOR SHOWING THE ROTATION OF THE EARTH.

ELECTRICAL INDICATOR FOR SHOWING THE ROTATION OF THE EARTH.

[*Continued from first page.*]

If the index were absolutely motionless the scale would move under it at the rate of 15° an hour, but owing to friction the motion of the scale or apparent motion of the index is less.

It makes no difference whether the index points northward or southward, its apparent motion is always westward, thus affording visible evidence that the earth rotates.

The instrument I have thus described may be easily modified, so as to illustrate other interesting phenomena of rotary motion.

By removing the index and point from the insulated stud at the lower part of the frame and unscrewing the supporting piece from the top of the frame, the frame may be suspended in a horizontal position upon pointed screws in a fork which is supported upon a vertical pivot, as shown in the second engraving.

Fig 2

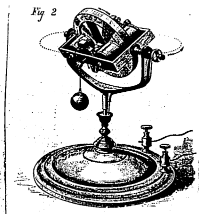


Fig. 2.—ELECTRICAL INDICATOR.

The pointed screw that enters the insulated stud is insulated, and communicates, by an insulated wire, with mercury contained in an annular vulcanite cup on the fork supporting pivot. One of the binding posts is connected with the pivot of the fork and the other communicates with the mercury in the vulcanite cup.

When the instrument is connected with a battery the wheel revolves rapidly, and if undisturbed will remain in the position in which it was started. If a small weight, such as a key, be hung upon one of the pivot screws of the wheel spindle, the frame containing the wheel does not turn quickly on its pivots as might be expected, or as it would if the wheel were not revolving, but the entire apparatus immediately begins to revolve slowly on the vertical pivot, while the weighted side of the frame descends almost imperceptibly. Transfer the weight to the opposite pivot, and while the wheel still revolves in the same direction the apparatus will revolve on the vertical pivot in the opposite direction. The rotary movement on the vertical pivot is in opposition to the friction of the wheel; that is, the apparatus if rotated on the vertical pivot by the friction of the wheel on its pivots would be in the opposite direction.

By removing the weight from the pivot screw and turning the apparatus on the vertical pivot the converse of what has just been described will result; that is, the wheel besides revolving on its own axis will turn in a plane parallel with its axis.

If the apparatus be turned on the vertical pivot in the opposite direction the rotation of the wheel on its new axis will be reversed, and by oscillating the apparatus on the vertical pivot the wheel and frame will revolve rapidly on the pointed screws that support the frame.

The law controlling these movements is as follows: "Where a body is acted upon by two systems of forces, tending to produce rotations about two separate axes lying in the same plane, the resultant motion will be rotation about a new axis situated in the same plane between the directions of the other two."

By means of this continuously operating gyroscope Dr. Magnus' experiments showing some of the causes of deviation of projectiles may be nicely exhibited.

OXIDATION OF GOLD BY GALVANIC ACTION.—Grotthus, says Mr. Berthelot, observed that a gold wire is dissolved when employed as the positive terminal of a circuit in sulphuric acid. The author confirms these results, and shows that under similar circumstances nitric acid also dissolves gold. This is due neither to ozone nor, as suggested by Chevreul, to persulphuric acid, for neither of them has any action on gold.

When two charges are shared in this way there is a loss of energy. For the total energy at first is

$$\tfrac{1}{2} S_1 V_1^2 + \tfrac{1}{2} S_2 V_2^2,$$

out after sharing, it is $\tfrac{1}{2}(S_1 + S_2)V^2 = \tfrac{1}{2}\frac{(S_1 V_1 + S_2 V_2)^2}{S_1 + S_2}$

So, if w is the loss of energy,

$$2w(S_1 + S_2) = (S_1 V_1^2 + S_2 V_2^2)(S_1 + S_2)$$
$$-(S_1^2 V_1^2 + 2 S_1 S_2 V_1 V_2 + S_2 V_2^2) = S_1 S_2 (V_1^2 + V_2^2 - 2 V_1 V_2).$$

Hence
$$w = \tfrac{1}{2}\frac{S_1 S_2}{S_2 + S_1}(V^1 - V_2)^2.$$

A necessarily positive quantity. This is the energy of the sharing spark.

ANSWERS TO QUERIES.

7. "J. Davies" asks in what does potential, as applied to electricity, differ from potential as applied to energy? He should consult some handbook of telegraphy—say Preece and Sievewright's; but, meanwhile, he may be helped by the following rough explanation. The term has the same signification applied to both, namely, the efficient power capable of being but not yet exerted. As applied to energy, it takes into account mainly the resistance to be overcome. Electrical potential often involves more complex conditions. The measure of electro-motive force is represented by the difference of electrical potentials at two points, and, when earth is used, both are referred to the electrical potential of the earth. Strictly speaking, the potential value of a current will be determined by the difference between the differences of potentials at the two points. J. L.

8. If "J. W." is under eighteen years of age, and is in other respects eligible, he can obtain a nomination for the Postal Telegraph service by applying to the Secretary, General Post Office, London. J. L.

QUERIES.

17. Will you explain to a puzzled party how the two opposite poles of an electro-magnet attracts the plate on the hammer of an electric bell, which is *charged* with *one* of the same kind of electricities of one of the poles of the said electro-magnet? We imagine that the two opposite poles should neutralise each other in respect to a body *charged* with an electricity of the kind of one of the poles. A SUBSCRIBER.

THE PHYSICAL SOCIETY—JUNE 8TH.

[CONTINUED.]

THE ELECTRICAL PROPERTIES OF BEES' WAX AND LEAD CHLORIDE.

Professor REINOLD at the last meeting of the Physical Society read a paper by Professor W. E. Ayrton, of the Imperial College of Engineering, Tokio, Japan, on "The Electrical Properties of Bees' Wax and Lead Chloride." The author stated that, in the two papers by Professor Perry and himself on Ice as an Electrolyte 'Result, read before the Physical Society, they showed that both the nductivity and specific inductive capacity of $\left\{ \begin{matrix} \text{ice} \\ \text{water} \end{matrix} \right\}$ increased regu-y without discontinuity in passing from several degrees below the ezing point to several degrees above it. They drew attention to the fact at, in consequence of the absorbed charge in water being immeasurably greater than the surface charge, they could not hope by any method of experimenting to properly compare the true specific inductive capacity with the index of refraction for light of infinitely long waves, so that, in fact, the only support that Professor C. Maxwell's electro-magnetic theory of light could hope to derive from these experiments must be based simply on the fact that in $\left\{ \begin{matrix} \text{ice} \\ \text{water} \end{matrix} \right\}$ both the specific inductive capacity and the index of refraction increase as the temperature rises. At the meeting of the Society in November, at which the second of their two papers was read, Professor G. Foster mentioned that he was gathering together all the results obtainable, connecting specific inductive capacity with index of refraction. He (Professor Ayrton) therefore begged to forward, as a contribution to this collection, the following results of some further experiments which he had been making on this subject. For the last two years his attention had een turned to wax as a good material for electrically testing, especially in regard to the connection which, in their paper on the "Viscosity of Dielectrics," communicated to the Royal Society, they pointed out existed between high specific inductive capacity and low specific resistance. He therefore had constructed a large condenser, consisting of many sheets of letter paper soaked in melted bees' wax, with alternate sheets of tin-foil. After the condenser was built up in the usual way, melted bees' wax was poured in, the plates squeezed together, and the whole shut up in a fairly good water-tight wooden box. The condenser was buried several feet under ground to insure uniformity of temperature, connexion being made with the insulated coating by a piece of Atlantic cable core and with the other coating by a piece of bare copper wire. After this condenser had been buried for a short time it showed the apparently abnormal condition of diminution of resistance by electrification. This phenomenon then formed the subject for special investigation with this condenser. As beeswax is one of the few substances in which the index of refraction for light increases in passing from the liquid to the solid state, it seemed important in connection with the electro-magnetic theory of light to carefully measure the specific conductive capacity of a wax condenser as it was gradually cooled through the solidifying point. A small shallow clean copper box, 19 centimetres long by 17 centimetres wide, was therefore lined with a sheet of letter-paper 0·036 centimetres thick, previously well soaked in melted beeswax. A clean copper disc 12·8 centimetres in diameter was placed on the top, weighted down, and the dish filled up with melted wax. This condenser, A B was heated in an oil bath, *C D*; E and F are holes for the insertion of thermometers, of which the bulbs were just above the wax condenser; G is an opening through which the insulated electrode, H, of the condenser may protrude without touching the oil bath. A wooden stand, W W, supported the condenser in the middle of the bath, and a glass vessel, V, holds strong sulphuric acid to keep the inside space artificially dry. The bath is closed by a double door, which is made to fit well by a strip of leather inserted between it and the bath. The condenser having been inserted, the bath was heated to about 99° C, and kept at that temperature for some time; the lamps were then removed, when the temperature fell very slowly. The capacity was then measured (several observations being made at each temperature) by charging the condenser with 75 Daniells cells joined in series and discharging it through an exceedingly delicate Thomson's reflecting galvanometer. The curves obtained (on three different days) did not give the same capacity for the same temperature, but, considering, first, the very small capacities that had to be measured, and, secondly, the difficulty of accurately determining the temperature of a non heat-conductor like wax, even when enclosed in the oil bath, the discrepancies in the curves were not to be wondered at. One fact, however, was very striking in all three curves, and that was the *rise* in capacity as the temperature very slowly fell from about 80°. to 60°. and the subsequent diminution in the capacity on a still further diminution of the temperature. Probably, had experiments on capacity been made when cooling from a much higher temperature, there would have been observed, first, a gradual diminution in capacity due to cooling, down to about 80° C.; then they had the rise of capacity in the wax solidified at about 60° C.; and, lastly, they saw the subsequent rapid decrease on further cooling. Now, this was precisely in agreement with the changes known to occur in the index of refraction for light, and hence the interest of these experiments. As there was always a small electromotive force in the wax condenser, and, as the vibrations of the galvanometer needle were, as usual, damped by the air vane, he used for calculating the capacity the formula developed by Professor Perry and himself for employment in such cases ("A test for Determining the Position of a Partial Discontinuity without Earth-fault," by Professors W. E. Ayrton and John Perry, page 12). It might, of course, be at once objected that the rise in capacity, as the work cooled from about 80° C., to 60° C. was perhaps due not to any change in the specific inductive capacity, but merely indicated that the distance between the copper plates of the condenser was slightly diminished by the wax shrinking on solidifying. This solution, however, was impossible, since, although a sudden expansion of the wax on solidifying, if such an expansion existed, might have separated the plates, it was unlikely that the contraction which really occurred could have brought them nearer together than the thickness of the paper by which they were separated when the wax was liquid. Nevertheless, partly to obtain additional evidence on this point, and partly to measure specific resistance, or resistance per cubic centimetre, of beeswax at different temperatures, he made ten distinct sets of experiments, occupying many days, on the conductivity of wax. In these experiments the wax condenser was heated up to about 130° C., and a current sent through it with the seventy-five Daniells cells in series. The temperature was kept constant at about 130° C., until the galvanometer deflection had reached its maximum, when it was considered that the wax had acquired the temperature indicated by the thermometer. The temperature was then allowed to fall very slowly, and frequent readings of the galvanometer and thermometer were taken. The results were shown by a diagram. In no curve was there *the slightest appearance* of a rise of conductivity at the melting point, which would probably have been obtained had the copper-plates approached one another in appreciable distance on the wax solidifying. They might, therefore, conclude that in the previous experiments the rise in the capacity at melting indicated a true increase in the specific inductive capacity coincident with an increase in the index of refraction for light. As regards apparent increase of resistance by electrification, which, as mentioned, he observed during repeated experiments, extending over some months, with the wax condenser buried under ground, the general conclusions arrived at were that, not only did the conductivity usually increase by electrification, but that it steadily increased day by day—a result indicating that the wax was deteriorating, probably from damp penetrating through the joints of the wooden box, in spite of leather having been inserted between the different parts of the wood before they were screwed together. This conclusion appeared to be correct, since on digging up the condenser and keeping it near a fire for many days, it regained its original high resistance. The damp must, therefore, not only have entered through the joints in the wood, but through some small cracks that were observed in the mass of wax when the condenser was opened, and it was probably due to this damp that the peculiar effects of polarization were observed similar to those noticed by the Comte du Moncel when testing stones, and by Mr. T. Warren in certain insulating oils. He now made a number of experiments with lead chloride as a dielectric—a substance to which his attention was particularly drawn by some remarks of M. Buff Ann. Chem. Pharm. cx., s. 258, 1859, in which he said that this substance conducts electricity like a metal that is without decomposition, a conclusion, however, which at first sight would appear to be negatived by certain experiments of Herr Wiedemann, published in Pogg. Ann. c. liv., 318—320, from which he found that the resistance of lead chloride diminished by increase of temperature. He (Professor Ayrton) first had made a small carbon box containing a carbon plate, but prevented from touching it by three small pieces of clean glass. The carbon plate had a carbon electrode attached to it, the whole being cut out of a solid piece of carbon, so as to have the shape of an inverted "T." Into the box lead chloride was poured in a fused state until it covered up the plate, but leaving the carbon electrode of the plate protruding for connection with the battery. The whole was then allowed to cool very slowly. The outer part of the carbon box and the end of the carbon electrode were now electrotyped, and copper wires soldered on, the junction of the carbon and copper being quite clear of the lead chloride. [The results observed with this condenser were given in a table showing twelve experiments on different dates.] In addition to the resistance of the condenser being measured while the battery was con-

nected, time readings were also taken with the galvanometer and the discharge from the condenser after the removal of the battery, as well as time-readings with an electrometer of the electromotive force in the condenser producing the discharge. As, however, diminution in the discharge and deflection was in each case quite regular, and curves were not given, it was interesting to observe, in the preceding table, that in every case there was a diminution of resistance by electrification, although in some cases there was an increase during the first minute. Looking at the first group of tests taken between November 13 and 15, they saw a gradual increase in the resistance day by day. Looking, also, at the second group of tests made between November 21 and December 1, they likewise saw a steady daily increase in the resistance, but, in the interval between November 15 and 21, when no tests were made, there appeared to be a decided diminution in resistance. Considering, however, that the tests taken on Nov. 13, and at the beginning, and on December 1, at the end of the investigation, gave almost identical results, it could not be concluded with certainty that there was any decided deterioration taking place in the lead chloride. But, on breaking up the condenser, the lead chloride was found to contain many small holes, so that it was possible that damp might have collected in these. This solution, however, would, at first sight, appear to be rather improbable, since the condenser, both when being tested, and when not tested, was kept in an atmosphere kept partially dry with sulphuric acid. Some fresh lead chloride was prepared in the same way as before—that is, by precipitating from a solution of lead acetate with a solution of common salt, and carefully washing the precipitate several times with distilled water. But, the new condenser, made with the carbon box and plate, was found to have a resistance of only two megohms at 16° C., and, unlike what was experienced in the former case, the resistance in all the experiments was now found to increase by electrification. This, however, was probably explained by the fact that whereas in the previous case 33 volts electromotive force was used now, only one volt was employed, so that decomposition—whether of the lead chloride itself, or of the damp, which, after decomposition, might act on the chloride—was probably not produced. Some preliminary temperature tests were now made, and, in accordance with Herr Wiedemann's results, he found that the resistance diminished with elevation of temperature. The condenser was now left in an atmosphere dried with sulphuric acid from December 21 to January 7, when it was found that the resistance had increased to about 15·6 megohms at 70° C. A large number of measurements of the conductivity at different temperatures, using the same oil bath for raising the temperature, were now made. The different experiments gave results nearly agreeing. The representative curve was approximately logarithmic, that is, the ratio of the difference of the logarithms of the conductivities to the difference of temperatures was approximately constant. Thinking that possibly the method previously employed for making the lead chloride by precipitating it from a solution of lead acetate with a solution of common salt might have introduced traces of some salt of lead other than the chloride, the following method was now employed for making another supply of the chloride. From a clear solution of lead nitrate a precipitate was formed with colourless hydrochloric acid, and the precipitate well washed with distilled water. A third condenser was now constructed, three small pieces of glass 0·225 centimetres thick being used to separate the carbon plate from the box. The connections with the box and plate were made as before by first electrotyping the carbon with copper, and then soldering on copper wires, the junctions of the carbon and copper not being in contact with the lead chloride. A condenser was also made with a copper box and a copper plate, the two being well coated with graphite to protect them from the action of lead chloride, and separated from one another by three small pieces of glass 0·135 centimetres in thickness. Tests of conductivity were now made at different temperatures with both condensers, 0·075 volts being employed with the carbon, and 7·5 volts with the copper condenser, or sometimes 2·2 volts with the latter. With the carbon condenser and with the smaller electro-motive force the resistance was found to increase with electrification, whereas, with the copper condenser and with the electro-motive force 2·2 volts, the resistance diminished with electrification, and with 7·5 volts this diminution became much more rapid, these results being observed at both high and low temperatures. In the earlier experiments with this copper condenser the diminution was regular, whereas later on it proceeded irregularly; but, on the whole, it might be said that, when an electro-motive force not exceeding one and three-quarters volts was employed, there was an increase in resistance with electrification such as is usually experienced with gutta percha and with ordinary dielectrics, while when the electro-motive force exceeded this limit there was either a regular or an irregular diminution of resistance by electrification, the results apparently not depending much on whether carbon or copper coated with graphite was used for the plates of the condenser. As this limiting electro-motive force appeared to be about the same as that necessary to decompose water, he thought they might fairly conclude that the diminution in resistance was due to a decomposition of the damp (which appeared to be contained in the lead chloride even when careful means were taken to dry it), and to the products of the decomposition acting on the chloride.

TELEGRAPH SHARE LIST.

Amount of Issue.	Amount of Share.	Paid on Share.	Company.	Reserve as per last Report.	Dividends 1875. %	1875. %	1876. %	1876. %	1877. %	1877. %	When Payable.	Prices 1875. Highest.	1875. Lowest.	1876. Highest.	1876. Lowest.	1877. Highest.	1877. Lowest.
£3,251,780	Stock	100	Anglo-American	Deferred receiving no dividend until 6 per cent. has been paid to Preferred.		year.	6	4†	3	5	† Div. 5 % per ann. for quarter ending Dec. 31, 1876, 2 % for quarter ending Mar. 31, 4 % for quarters ending June 30 and Sept. 30, 6 % for quarter ending Dec. 31, 1877, and 4 % for quarter ending March 31, 1878.	75½	51½	68½	53	62½	53
1,872,710	Stock	100	Do. Preferred B		—	—	10	2	6	6		Crtd	1876	93	75	88½	79
1,872,710	Stock	100	Do. Deferred A		—	—	Nil.	6	Nil.	4		Crtd	1876	44	29	33	25½
1,300,000	10	All	Brazilian Submarine	120,000	5	5	5	5	5	5	Quarterly.	7½	6	7½	5½	6½	5½
160,000	10	All	Cuba (Limited)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60,000	10	All	Do. 10 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
116,373	10	9	Direct Spanish (Limited)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
58,430	10	All	Do. 10 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
65,000	20	All	Direct United States	Nil.	—	Nil.	Nil.	Nil.	Nil.	5	Quarterly.	13	7	11½	6½	13½	5½
329,700	10	All	Eastern (Limited)	110,000	5	year.	5	5	5		aJany., April, July, Oct.	8	6½	7½	5	8½	6½
232,000	100	All	Eastern 6 per cent. Debentures	—	—	—	—	—	—	—	—	—	—	—	—	—	—
200,000	100	All	Do. 5 per cent. Debentures	—	—	—	—	—	—	—	—	—	—	—	—	—	—
700,000	10	All	Do. 6 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,997,500	10	All	Eastn. Exten. Australasia & China	125,404	5½	year.	5	year.	5	year.	aJany., April, July, Oct.	8½	7	7½	5½	8	6½
320,000	100	All	Eastn. Exten. 6 p.c. Deben. (1875)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
192,080	10	All	German Un. Tl. and Tst.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1,500,000	10	All	Globe Telegraph and Trust	Nil.	5	7 4-5	4½	7 5-6	3½	7 6-7	bJany., April, July, Oct.	6½	5½	6½	4½	5½	4½
1,500,000	10	All	Do. 6 per cent. Preference		6	6	6	6	6	6	Jany., April, July, Oct.	10½	9½	10½	9½	10½	9½
150,000	10	All	Great Northern	85,543	5½	year.	6½	year.	6½	year.	5 % Intrm. Jan. 1, July 1. Final Dividend April.	11½	7½	9½	7	8	7
			Shares to Bearer, or can be Regstrd.														
—	25	All	Indo-European	—	—	—	—	—	—	—	—	—	—	—	—	—	—
120,000	10	All	Mediterranean Extension (Lmtd.)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
32,000	10	All	Do. 8 per cent. Preference	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	18	All	Reuter's (Limited)	—	—	—	—	—	—	—	—	—	—	—	—	—	—
65,000	10	All	West India and Panama	16,000	Nil.	Nil.	Nil.	Nil.	1	1	‡ Converted from a 10 % into a 6 % 1st Preference.	4½	1½	2½	½	3½	1½
34,563	10	All	Do. 6 per cent. Preference		7/6ac	year.	10 ac	year.	6½	6		12	9	11	7	11	7½
67,500	20	All	Western and Brazilian	7,793	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Half-yearly.	18½	9½	10½	4½	5½	4½
$1,500,000	$1000	All	Western Union Telegraph 7 per cent. First Mortgage Bonds	—	7	7	7	7	7	7	May, November.	108	102½	109½	105	113	106
£1,030,000	200	All	Do. 6 per cent. Sterling Bonds	Redeemable by annual drawings at par.	6	6	6	6	6	6	March 1, September 1.	93	86	98	89	101	94

a Year ends March 31st. Interim Dividend of 5 per cent. Final dividend in July. b Year ends July 18th. Final dividend in July.

Companies.	Business Done. Th., 13.	F., 14.	Sat., 15.	Mon., 17.	Tu., 18.	Wed., 19.
Anglo-American (Lim.).	62½	62½	62½	63½, ½	63½, ¾	64, 3½
Do. Preferred	92½, ¾	—	92½, ¾	93	93½	93½
Do. Deferred	—	—	35½	35½, ½	35½, 36	—
Brazilian Submarine	6 15-16	7½, 1-16	7	7 1-16, ½	—	—
Cuba (Limited)	acc 9½	—	—	—	—	9½, ½
Do. 10 p. c. Prefrnce.	—	—	—	16	—	—
Dret. Span. 10 p. c. Pref.	—	9 13-16, ¾	—	—	9½, ½, ¾	—
Dret. U. S. Cable (Lim).	acc 13½, ½	14½, ½, ¾	14½, ½	14½, ½	14½, ½	—
Eastern (Limited)	7½, acc 7½	7 11-16	7½, 9-16	7½, 9-16	7 11-16, 9-16	7½
Do. 6 pr. cnt. Deben.	—	—	—	103½	—	—
Do. 5 pr. cnt. Deben.	acc 103½	—	—	—	—	—
Do. 6 p. c. Prefrnce.	11½, ac 11½	11½	11½	12	—	—

Companies.	Business Done. Th., 13.	F., 14.	Sat., 15.	Mon., 17.	Tu., 18.	Wed., 19.
Eastern Extension, Austral., & China (Lim.).	ac 7 13-16, ½, ½	7½, ½	—	7½	7 13-16, 15-16	7½
Globe Tl. & Trst. (Lim.).	acc 5 5-16	5½	5 7-16, ½	—	5½, ½	5½, ½
Do. 6. p. c. Prefrnce.	acc 10½, 11	11	11½, 11	11	11, 10½, 11	11, ½
Great Northern	8½, ac 8 15-16	9	8½	—	9½	9, ½
Indo-European	—	—	—	—	20½, ½	—
Reuter's (Limited)	—	—	—	10½, ½	—	—
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Do. 6 p. c. 1st Prefnc.	acc 8½	8½	8 13-16	8½	8½, 9, 8½	—
Do. 2nd Preference.	—	—	—	8½	—	—
*Western and Brazilian (Limited)	acc 5 5-16	5½	5½, ½	5½	5	—

53

EFFECTS OF ELECTRIC CURRENTS ON THE SURFACES OF MUTUAL CONTACT OF AQUEOUS SOLUTIONS.*

BY G. GORE, LL.D., F.R.S.

In the year 1859 I made the following experiments, for the purpose of ascertaining whether visible movements, similar to those obtained by passing an electric current through mercury and an aqueous solution, could be obtained by passing a current through the surface of mutual contact of two aqueous liquids alone:—

"1st. A definite layer of oil of vitriol was placed beneath a layer of distilled water weakly acidulated with sulphuric acid, and the terminal wires of a voltaic battery immersed in the upper liquid; no visible movements occurred at the boundary line of the two liquids.

"A dense solution of cyanide of potassium was placed in a small glass beaker, a few particles of charcoal sifted upon its surface, and a layer of aqueous ammonia, half an inch deep, carefully poured upon it. A vertical diaphragm of thin sheet gutta percha was then fixed so as completely to divide the upper liquid into two equal parts; the vessel was placed in a strong light, and two horizontal platinum wire electrodes, from sixty-six freshly charged Smee's cells, were immersed one-eighth of an inch deep in the liquid ammonia on each side of the diaphragm. A copious current of electricity circulated, but no movement of the liquids at their mutual boundary line could be detected." (See *Proc. Roy. Soc.*, vol. x, 1860, p. 235, par. 9).

Recently, also, I have made similar experiments, but in a much more searching manner, in order to ascertain whether an electric current, passing between two aqueous liquids, affects their diffusion into each other. The essential difference in the form of these experiments from that of the above-mentioned ones was to concentrate the action of the current upon a very much smaller surface of contact of the liquids, and thus render any visible effect upon their diffusion more manifest.

After making several forms of apparatus, in order to obviate certain difficulties of manipulation which arose and were fatal to success, I found that, when an electric current was passed between the surfaces of mutual contact of certain aqueous solutions of different specific gravities, the boundary line of contact of the two liquids became indefinite at the surface where the current passed from the lighter into the heavier solution, and became sharply defined where the current left the heavier liquid and re-entered the lighter one; and that on reversing the direction of the current several times in succession after suitable intervals of time, these effects were reversed with each such change. Also, in various cases in which the contiguous boundary layers of the two liquids had become mixed, the line of separation of the two solutions became, by the influence of the electric current, as perfect as that between strata of oil and water lying upon each other. In rarer cases two such distinct lines of stratification appeared. Other new phenomena were also observed.

As I have sought, without success, for any record of previous discovery of essentially similar effects, and as it is evident that those I have observed belong to a large class of similar phenomena, I beg leave to take the earliest opportunity of submitting this brief statement to the Royal Society.

* Abstract of a Paper presented to the Royal Society,

Electrician May 1, 1880

ANALOGY BETWEEN FLUIDITY AND GALVANIC CONDUCTIVITY.

Scientific American Supplement Apr 17 1880

O. Grothian finds an interesting relation between the reciprocal of the constant of friction in fluids and the galvanic conductivity of a number of salt and acid solutions. Let t designate the temperature of the fluid, f the temperature coefficient of fluidity, and k the conductivity. Then the value of the coefficient, $\frac{df}{dt}\frac{1}{f}$, in a change of concentration, always alters in the same direction as the corresponding coefficient of conductivity, $\frac{dk}{dt}\frac{1}{k}$.—*Wied. Ann.*

THE ELECTRICAL INDICATOR FOR SHOWING THE ROTATION OF THE EARTH.—A NOTE FROM PROF. MAYER.

To the Editor of the Scientific American:

The reading of the article by Mr. George M. Hopkins on the "Electrical Indicator for Showing the Rotation of the Earth" has suggested an addition to the apparatus which will render the experiments with it more delicate, and make manifest the rotation of the earth after the gyroscope has run for only a minute. If he will attach a plain or concave mirror to the frame of the gyroscope and reflect a beam of light from the mirror to a screen he will have an index which may be of considerable length, of no weight, and have no momentum. If the distance of the screen from the mirror is, say, ten feet, then the spaces over which the light passes on the screen will be the same as those which would be passed over by a rod 20 feet long attached to the gyroscope as an index. This is because the angle of deflection of the reflected beam is always double of that of the angular deflection of the mirror.

The apparent angular motion per hour of Foucault's pendulum and of his gyroscope for showing the earth's rotation is equal to 15° multiplied by the sine of the latitude of the place where the pendulum or gyroscope is mounted. Calling the latitude of New York 40° 43', we have 9°·47' as the amount of hourly motion in azimuth. But as the reflected beam moves through double the angle of the mirror attached to the gyroscope, we have 19° 34' as the hourly angular motion of the reflected beam of light. In one minute of time the beam will move through $\frac{1}{60}$ of 19° 34', or through 19½ minutes of arc. This angular displacement of the beam will equal ·678 of an inch on a screen ten feet distant from the mirror. In ten minutes of time we will consequently see the spot of light on the screen move through $6\frac{78}{100}$ inches. This quantity, however, gives the motion during the first ten minutes, if we suppose the beam to have started for a direction at right angles to the screen. The distance through which the spot of light travels will be greater during succeeding 10 minutes of time, for the distances will be the tangents of the angular deflections. If, however, the screen have a cylindrical surface with a radius equal to the distance of the axis of rotation of the gyroscope to the screen, then the spot of light will travel over equal distances in equal successive portions of time.

For accurate measurements of the motion of the gyroscope it will be better to place a horizontal scale of equal parts facing the mirror at the distance of, say, five to ten feet, and view the reflection of this scale from the mirror by sighting through a telescope with cross threads in its focus. With such an arrangement (see Article XI. of the "Minute Measurements of Modern Science," in the SCIENTIFIC AMERICAN SUPPLEMENT, by the writer) two or three minutes' observation on the motion of the scale over the cross threads of the telescope will suffice to give the amount of angular motion, which may be compared with that which theory requires, and which is computed by any one who has a table of natural sines. He will find the sine corresponding to the angle of the latitude of the place, and multiply this by 15° (the hourly angular motion at the poles of the earth); he will then take $\frac{1}{60}$ of the product for the angular motion in one minute, and double this result to allow for the doubling of the angle of reflection.

Foucault suspended his gyroscope by a strand of untwisted silk fibers, and if Mr. Hopkins will adopt this mode of suspension in place of the steel point, he will get rid of the friction, which should be avoided. There is a good description of Foucault's gyroscope, with four engravings, in Arago's "Astronomie Populaire," volume 3, page 50, *et seq.*

I have during the past winter repeated the Foucault experiment with the pendulum, and the apparent hourly angular motion of the instrument corresponded quite well with the theoretic value. The bob of my pendulum was a thirty pound cannon ball, which I floated in a hemispherical bowl containing mercury, and thus found out the position the ball has when its center of gravity is in a vertical line with its center of figure. The ball was suspended in the same position it had when it floated in the mercury.

ALFRED M. MAYER.

South Orange, N. J., July 1, 1878.

Electrical Indicator for Showing the Rotation of the Earth.

To the Editor of the Scientific American:

In my article on an "Electrical Indicator for Showing the Rotation of the Earth," in your issue of July 6, I mention that the apparent motion of the index is 15° per hour. With this instrument this would be true only at the poles, at the equator it would be 0°, and in this latitude it would be about 9°.

I intend soon to furnish you with sketches of another form of instrument, which will indicate the full diurnal motion when placed at any point on the earth's surface.

GEO. M. HOPKINS.

ON THE MAGNETIC ROTATION OF THE PLANE OF POLARIZATION OF LIGHT UNDER THE INFLUENCE OF THE EARTH. BY HENRI BECQUEREL.—In the course of my investigations on magnetic rotatory polarization I have been led to the direct estimation of the action of terrestrial magnetism upon various substances. This action can be very neatly made evident by an experiment which seemed to me sufficiently interesting to be communicated to the Academy. Between a Jellet polarizer and an analyzer furnished with a telescope and mounted on a divided circle is placed a tube of half a metre length, terminated by parallel glass plates and containing bisulphide of carbon. At the two ends of the tube plane mirrors, arranged as Faraday arranged them, gave several successive reflections of the luminous ray, and thus augmented the observed rotation. In the present experiment the second reflection could be viewed; the ray had therefore traversed the tube five times, corresponding to a thickness of 2·5 metres of bisulphide of carbon. The source of light was a pipe with oxyhydrogen gas. A great amount of light was lost by absorption and by the successive reflections, and the rays transmitted to the eye were chiefly the yellow rays. The entire system was firmly fixed to a horizontal copper rule, and could turn about a vertical axis so as to orient the luminous beam in various directions. With this arrangement it is ascertained that, if the system be made to coincide in direction with the plane of the magnetic meridian, the same position of the polarization-plane is not obtained whether we look towards the south or towards the north; a great number of closely concordant measures gave an angular difference of about 6'·5 between the two positions. On the contrary, if we place ourselves in a position perpendicular to the magnetic meridian, we get the same direction of the plane of polarization whether we look towards the east or towards the west, and this position is the bisectrix of that which we have in viewing towards magnetic north and south. It may hence be concluded that the angular difference observed is a rotation of the plane of polarization of the light, due to the action of the earth; the number 6'·5 measures the double of the rotation for yellow light and in the special conditions of the experiment. The direction of this rotation is the same as that of the rotation of the earth; it is the direction of an electric current which, on the hypothesis of Ampère, would give rise to the phenomena of terrestrial magnetism. It must be remarked that the number we have given only refers to observations made in the laboratory of the Muséum d'Histoire Naturelle, in proximity to more or less considerable masses of iron. To ascertain with more precision the action of the globe, and to utilize this method for estimating the intensity of the earth's magnetism, it would be necessary to use the same precautions as for ordinary observations of terrestrial magnetism, and to amplify the phenomenon by taking a longer tube. This is what I am at present engaged in. The system arranged as above indicated exhibits remarkable sensitiveness to the action of magnetism; an ordinary bar magnet held in the hand, and brought parallel near to the tube, first in one direction then in the other, is sufficient to make manifest a rotation of the plane of polarization that may attain to upwards of 1°. It is interesting to compare this direct measurement with an estimation made by Mr. Gordon* of the magnetic rotation produced by 1 centm. of bisulphide of carbon under a magnetic action equal to unity. The result found by calculating from this number the action of the terrestrial horizontal component is that 2·5 metres of bisulphide of carbon should give, with yellow light, a single rotation of 3'·8 instead of 3'·25, which results from our direct observation. The difference may be due to exterior perturbations. If we adopt the latter number we see that, under the conditions in which we have placed ourselves, the double rotation of 1 metre of bisulphide of carbon would be 2'·6, and that of 1 metre of water 0'·8.—*Comptes Rendus de l'Académie des Sciences*, April 29, 1878.

* 'Philosophical Transactions, 1877.' Part I.

ON GALVANIC CURRENTS BETWEEN SOLUTIONS OF DIFFERENT DEGREES OF CONCENTRATION OF THE SAME SUBSTANCE, AND THEIR SERIES OF TENSIONS. BY DR. JAMES MOSER.—The electromotive force of liquid galvanic series is influenced by the concentration of the liquids. In order to determine the nature of this influence, I have investigated, in the laboratory of Professor Helmholtz, liquids with which it is possible to isolate this influence of the concentration. All chemical processes were to be excluded; therefore, only differences of concentration might exist, or changes in it occur during the passage of the current. Likewise, for the elimination of all chemical actions, it was necessary that the electrodes should consist of that metal which was contained in the solution. Two glasses with differently concentrated solutions of the same salt were connected by a siphon; and the circuit was closed by a metallic conduction with the electrodes just mentioned. I then observed, in all the cases investigated, *that a current arises which proceeds from the more dilute to the more concentrated solution.* It may be represented thus:—

Zn, dilute Zn SO_4, concentrated $ZnSO_4$, Zn.

This current appeared regularly in a series of solutions of sulphate, nitrate, chloride, and acetate of zinc, sulphate and nitrate of copper, chloride of iron, acetate, and nitrate of silver, &c. I observed the electromotive forces of these series by Poggendorff's method of compensation, modified by Du Bois-Reymond, from a few thousandths up to one-fifth of a Daniell, the latter force between very dilute and highly concentrated solutions of zinc chloride. I give, in the following table, the ten electromotive forces, between the combinations of two, of five solutions of sulphate of zinc, the unit being nearly 0·001 of a Daniell:—

100 parts of solution contain of $ZnSO_4+7H_2O$	15 per cent.	30 per cent.	45 per cent.	60 per cent.
1 per cent.	18	22	28	36
15 "	...	5	13	21
30 "	...	...	7	17
45 "	...	...	...	9

These numbers indicate a series of tensions; for, *e.g.*, the electromotive force between 15- and 30-per-cent. solution is 5, 30- and 60-per-cent. solution 17, 15- and 60-per-cent. solution 21. I then confirmed the existence of a series of tensions, by connecting with each other, by four siphons, five glasses, of which the 1st, 3rd, and 5th contained solutions of equal strength (45 per cent.), the second contained stronger solution (60 per cent.), the 4th weaker (15 per cent.). I immersed the one electrode in glass 1, the other successively in 2, 3, 4, 5. When the second electrode dipped in 3 and 5 I obtained no current, because the concentrations of the terminal solutions were equal; but, on the immersion of this electrode in glass 2, and in 4, there was always a deflection produced—in the one case by the electromotive force 9, between solutions of 45 and 60 per cent., in the other by the force 13, in the opposite direction, between 45- and 15-per-cent. solutions. I made the same experiments on a series of other salts, and thus determined the 15 electromotive forces between the couples formed by six solutions of cupric sulphate:—

	B	C	D	E	F
A	10	16	21	25	27
B	...	6	11	15	17
C	...	...	5	9	11
D	...	...	...	4	6
E	...	...	...	...	2

F was a solution containing, in 100 parts, 30 of crystallized salt ($CuSO_4+5H_2O$). One hundred parts by volume of this solution were mixed in E with 33⅓, in D with 100, in C with 300, in B with 700, in A with 2,900 parts of water. By these currents, going from the diluted to the concentrated solution, metal is dissolved in the diluted, and separated from the concentrated solution. Only when the concentration is the same in both solutions does the current cease. For the work accomplished by the current we should have to seek the corresponding equivalent in the work of the force of attraction between the salt and the water, which makes itself perceptible in the thermal actions which can be observed on mixing different solutions of the same salt. Accordingly, the current observed by me must be conceived as a reaction-current against the migration of the ions, as the polarisation-current is one of reaction against the decomposition-current; for, whenever any salt is electrolysed, the solution becomes more concentrated at the anode, more dilute at the cathode. My experiments show that then arises an electromotive force which acts in opposition to that of the electrolysing battery.—*Monatsbericht der kön. preuss. Akad. d. Wissensch. z. Berlin.*

Motion of Electricity in Insulated Telegraph Wires. By G. Kirchhoff.—Assuming that the induction effects produced by alterations of the current intensity may be neglected against the influence of the charges of an underground telegraph wire, Sir W. Thomson has referred the propogation of the electricity therein to the same laws as the conduction of heat. G. Kirchhoff developes this relation in connection with the equations developed by Helmholtz respecting the components of the current density ($u = -\lambda \frac{\partial \phi}{\partial x}$, &c., where λ denotes the conductivity) and of the electrostatic moment dependent on the dielectric polarisability ($a = -k \frac{\partial \phi}{\partial x}$, &c.), if ϕ denotes the electrostatic potential, which is a function of x, y, z and consists of three parts, arising—first, from the free electricity in and upon the conductor; secondly, from dielectric polarization; and, finally, from the double electric layer at the boundary surfaces of heterogeneous conductors. From the calculations, which cannot be given in abstract, it follows that $\Phi = e^{\beta z}\left(C \cos. (n t + a z) + C' \sin. (n t + a z)\right) + e^{-\beta z}\left(D \cos. (n t - a z) + D' \sin. (n t - a z)\right)$, which equation represents two passages of waves in opposite directions along the z axis of the wire, in which the height of each wave as it moves forward diminishes correspondently to the value β. The period for ϕ, according to the time, is $\frac{2\pi}{n}$; β and a are given by the equations

$$\beta^2 - a^2 = \frac{2\lambda}{\lambda_1 \rho_1^2 \log \frac{\rho_2}{\rho_1}}, \qquad \beta a = \frac{n \mu}{\lambda_1 \rho_1^2 \log \frac{\rho_2}{\rho_1}},$$

where ρ_1 and ρ_2 are the internal and external radius of the gutta-percha sheath, λ and λ_1 the conductivities of it and the wire, $4\pi\mu = 1 + 4\pi k$ the constant of dielectricity of the gutta-percha. Therefore the velocity of propagation of the waves increases with the conductivity of the gutta-percha, simultaneously with which their height diminishes as they travel onwards. If the conductivity of the gutta-percha $\lambda = 0$, then becomes

Aug 78

$$a = \beta = \sqrt{\frac{n \mu}{\lambda_1 \rho_1^2 \log \frac{\rho_2}{\rho_1}}}.$$

If the wire is infinitely long, then (if, for $z = 0$, $\phi = \cos. n t$) is $\phi = e^{-\beta z} \cos. (n t - a z)$. Further, the following case is discussed: That the wire possesses the length l, but has its termination connected with one of the coatings of a condenser, the other side of which is led away to earth. For the calculation in question, as well as the rest of the working, which cannot well be given in abstract, we must refer the reader to the original memoir.—*Beiblätter zu den Annalen der Physik und Chemie.*

Earth Currents and Electrical Meteorology.—Mr. Richard Owen, writing from Indiana State University, Bloomington, Ind., gives an account of some tests with regard to the strength and direction of electrical currents in the earth's crust. He states that when a storm is approaching, the needle of his galvanometer is affected as long as twenty-four or even forty-eight hours before the storm arrives, and suggests that this should be taken advantage of in signal offices. He finds also that, when one wire is attached to earth and the other to a high lightning conductor, the current is from the air to earth, but, with a low conductor, the contrary is the result. Sept 78

The Variations in the Intensity of Currents Transmitted through Imperfect Contacts according to the Pressure Exerted between them.*—One of the most interesting modes of demonstrating the variations in the intensity of currents transmitted through imperfect contacts, according to the pressure exerted upon the latter, is to wind upon a glass tube a helix of copper wire (say No. 16), without any insulating covering, and then to fix to the ends of the tube an appliance for compressing the spirals. When this means is employed we observe that when the compression of the turns of wire, one against another, is very small, the resistance of the wire of the helix *is but little less than what it would be if the wire were completely covered with silk, and that this resistance constantly diminishes with the compression until the latter arrives at its maximum.* When the wire is bright the effect is less marked than when it is slightly oxidised; nevertheless, it is even then very appreciable; and since an inverse effect is produced when the compression is slackened, we cannot attribute this effect to a simple action of the layer of oxide which may have formed upon the wire. I had made the experiment in 1864, at the time when I laid before the Academie des Science the electro-magnets, with uncovered wire of M. Carlier instruments, which at that period attracted much attention in the scientific world, and which are, even in our days, advantageously employed in certain circumstances—for example, to avoid the sparks of the extra current. In 1865 I published a long memoir in the *Annales Télégraphique* on the effects produced with this interesting apparatus, and I even quoted the experiment above mentioned (see vol. viii., p. 211). I think we have not hitherto sufficiently considered the physical effects produced at the points of contact of conducting bodies traversed by a

Aug 78

* *La Correspondance Scientifique.*

current. There is positively a resistance to the passage, which varies with the pressure exerted upon the contact pieces. Is this effect to be accounted for on the hypothesis that the surface of contact may become better developed in consequence of this pressure, the action being equivalent to an augmentation of section in the conductors?—or should we attribute it to repulsions occurring between the contiguous elements of the same current, which, being effected with greater facility with slight contacts than with better contacts, would tend to be destroyed by the latter?—or, again, should they be ascribed to the molecular variations which produce sounds in microphones employed as receivers? Such are the ideas which occur to one whilst observing the phenomena, but these ideas require investigation, and to this point I would direct the attention of experimentalists.—Th. du Moncel.

58

ON THE RELATION BETWEEN THE ELECTROMOTIVE FORCE ACTING IN A VOLTAIC CIRCUIT, AND THE WEIGHT OF ZINC CONSUMED IN THE BATTERY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The question propounded by your correspondent "C. E. B." is somewhat indefinite, but merits, I think, a more accurate answer than it has hitherto received, since it involves points of very considerable theoretical and practical importance.

This question is stated as follows:—"Is not the increase of electromotive force of one battery over another obtained chiefly, if not entirely, by a more rapid consumption of zinc? Take, for example, a Grove and a Daniell; the former is said to have twice the power of the latter. Does it not consume twice as much zinc as the Daniell in each unit of time?"

To answer the particular question it is necessary to assume certain conditions which are not specified, as, for instance:—

1. The current is maintained constant;

Or, 2, the resistance of the circuit is constant.

Moreover, to answer the general question, we require to take one of the two following cases:—

(*a*). The total E.M.F. is increased by augmenting the E.M.F. of each couple in a battery of a given number of cells,

Or (*b*) the E.M.F. is increased by augmenting the number of cells in series.

Thus the one question resolves itself into four questions, the answers to which are as follow:—

I (*a*). The consumption of zinc is not increased by any augmentation of the E.M.F., although the current traverses a resistance necessarily increased in the same ratio as the E.M.F.

I (*b*). The consumption of zinc is increased proportionately to the E.M.F.

II (*a*). The consumption of zinc is increased proportionately to the increased E.M.F., or proportionately to the current.

II (*b*). The consumption of zinc is proportionate to the square of the ratio between the increased and the original E.M. Forces.

Mr. L. A. Davies—in the first sentence of whose communication the words, "If we wish to double the E.M.F." have evidently, by a *lapsus pennæ*, been written for "If we wish to double the current"—has taken the last case; and his answer, under the conditions specified, is correct.

In regard to Mr. A. C. M. Weaver's letter, I may state that I am answerable for the formula $Z = \frac{E^2 \times 16}{R}$ grains per hour, given by him, but not for its application to any battery other than Daniell's. The case taken by him is that indicated by 2 (*a*), and his answer is therefore incorrect.

My general formula for the consumption of zinc in a battery is the following:—

$$Z = \frac{E^2}{R\,e} \times 17{\cdot}3 = \frac{E}{R}\,n \times 17{\cdot}3 = \frac{I\,E}{e} \times 17{\cdot}3 = I\,n \times 17{\cdot}3,$$

Where Z = weight of zinc consumed, in grains per hour,
E = the total E.M.F in volts,
R = the resistance in ohms,
I = the current in Vebers per second,
e = the E.M.F. of each cell of the battery,
and n = the number of cells in the battery.

The economy—so far as regards the consumption of zinc—of employing cells of high E.M.F. is, perhaps, best seen in the case of a constant current through a constant resistance—*e. g.*, when a given current is obtained through a telegraph circuit with cells of lower and of higher E.M.F. In this case the consumption of zinc is inversely as the E.M.F. of each of the couples of which the requisite battery is made up; or, in other words, the economy of zinc is directly as the E.M.F. of the cell employed.

It may be useful to give an example of the application of the formula $Z = \frac{E}{R}\,n \times 17{\cdot}3$ *grains per hour* to the four cases specified above. According to the suggestion of "C. E. B.," I will take the Daniell and the Grove cells, and *suppose* that their electromotive forces are respectively 1 and 2 volts. Let our initial current be that of a battery of five Daniells in series acting through a total resistance of 100 ohms.

Here we have $E = 5$, $R = 100$, and $n = 5$.

The current is $\frac{E}{R} = \frac{5}{100} = {\cdot}05$,

Aug 74

and the weight of zinc consumed per hour will be:—

$$Z = {\cdot}05 \times 5 \times 17{\cdot}3 = 4{\cdot}32 \text{ grains.}$$

I. (*a*). Instead of the five Daniells, let us now use five Groves. We shall now have $E = 10$, $n = 5$, and, since $\frac{E}{R}$ must be ${\cdot}05$, $R = 200$.

$$\text{Thus } Z = \frac{10}{200} \times 5 \times 17{\cdot}3 = 4{\cdot}32 \text{ grains per hour.}$$

I. (*b*). Let us now double the initial E.M.F. by doubling the number of Daniells' cells in series. We shall have

$$E = 10,\ R = 200,\ n = 10,\ \frac{E}{R} = {\cdot}05, \text{ and}$$

$$Z = \frac{10}{200} \times 10 \times 17{\cdot}3 = 8{\cdot}65 \text{ grains per hour.}$$

II. (*a*). Using five Groves through the initial resistance of 100 ohms, we have

$$E = 10,\ R = 100,\ n = 5,\ \frac{E}{R} = {\cdot}1, \text{ and}$$

$$Z = \frac{10}{100} \times 5 \times 17{\cdot}3 = 8{\cdot}65 \text{ grains per hour.}$$

II. (*b*). Lastly, with ten Daniells acting through the initial resistance of 100 ohms, we have

$$E = 10,\ R = 100,\ n = 10,\ \frac{E}{R} = {\cdot}1, \text{ and}$$

$$Z = {\cdot}1 \times 10 \times 17{\cdot}3 = 17{\cdot}3 \text{ grains per hour.}$$

The last value equals $4{\cdot}32 \times 4$—*i. e.*, the original consumption of zinc multiplied into the square of the ratio $\frac{10}{5} = 2$ of the increased to the initial E.M.F.

DESMOND G. FITZGERALD.

IS ELECTRICITY LIGHT?—This rather startling statement was the heading of a letter recently appearing in a contemporary, but still we doubt if the fact is proved. Scepticism is natural, even when the experiments of Professors Ayrton and Perry give equivalent velocities to Light and Electricity. We may be on the high road to discover what electricity is, and give such proofs as will generally be accepted by scientific men, but as yet eminent men are undecided as to the answer of the question, What is Electricity? M. Rotti and others have attempted to attribute it to ether currents, and, if we are not mistaken, Mr. Preston not only imagines one great ether system, but he would have two, or, if required by the exigencies of his theories, three or thirty. M. Edlund differs, to a certain extent, from MM. Rotti and Herwig, but he theorises that electricity is identical with the luminiferous ether.

Electrician Sept. 78

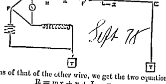
TERRESTRIAL INFLUENCE ON POLARISATION OF LIGHT.—In the course of his researches on rotary magnetic polarisation, Henri Becquerel has been led to the direct estimate of the action of terrestrial magnetism upon different bodies. In the course of these experiments he has found that if a tube, containing bisulphide of carbon, is placed between a polariser and an analyser, in the plane of the magnetic meridian, there is an angular difference of 6·5′ between the two positions of the plane of polarisation when looking towards the south or towards the north. This difference he attributes to terrestrial action.—*Comptes Rendus.* Sept 78

59

DETERMINATION OF A POINT OF CONTACT BETWEEN TWO WIRES.

The formula for the localisation of a contact between telegraphic wires previously given in this journal (see *Electrician* July 20th), in addition to the simplicity of its application, has the merit of being independent of the diameter of the wires.

Expressing the resistance of the portion of wire B C (Fig. 1)*



in terms of that of the other wire, we get the two equations:

$$R = m\,x + y + L - x,$$

$$r = \frac{(m\,x + y)\,x}{m\,x + y + x} + L - x.$$

If in this latter we substitute the value of y obtained from the first equation, the quantity $m\,x$ is eliminated, and we have

$$r = \frac{R\,x - L\,x + x^2}{R - L + 2x} + L - x,$$

which, simplified as before, becomes

$$x = L - r + \sqrt{(L - r)\,(R - r)},$$

where x is the resistance of the length of wire between the station whence the experiment is made, and the fault, referred, therefore, always to the wire which has its further extremity put to earth.

It can also be demonstrated that the above formula is independent of the diameter of the wires in contact if we take the two resistances B C and y as a single one. Working out the calculations, we arrive at the same result. Yet another method might be adopted with advantage, which is expressed in a formula even more simple than the first, but it has the drawback of necessitating the alteration of one of the communications at the distant stations. The following explains this second method:—

The resistance B C F E is measured as before, and results in $R = L + y$. The further extremity of the wire H E is then also insulated, and the communications being disposed as shown in the cut, the resistance of the complete circuit B C F H is taken. This will be expressed by $r = 2\,x + y$. Subtracting from this last the former resistance, we obtain $r - R = 2x - L$; and thence $x = \frac{L + r - R}{2}$.

From this formula we at once perceive that, if $r = R - D$, $x = \frac{L}{2}$, or, in other words, that the fault is half way down the line. If $r >$ or $< R$, the point of contact is respectively beyond or before the middle of the line.

The general formula of Schwendler for determining the distance of a contact between two wires of different diameters is as follows:—

$$x = \frac{r - \sqrt{(L\,m + L'\,m' - r)\,(R - r)}}{m + m'}$$

where L is the length in miles of one of the wires, m its resistance per mile, L' the length of the other wire, m' its resistance per mile, r the resistance of the complete circuit when the two wires are insulated at the further extremities, and R the resistance of this circuit when the two further extremities are united. This method of Schwendler has the advantage of not comprising the earth within the circuit, but it cannot be expressed in a simple form.—F. CARDARELLI, in the *Elettricista.*

* In this diagram, for Fig. 1 A H should be joined by a dotted line; for Fig. 2 the earth-plates T should be removed.

advantageous for correspondence from Lisbon to St. Petersburg, or from Dublin to Constantinople, still would not increase these messages much where the telegraphing community is not numerous. It would, however, sensibly diminish the traffic between adjoining or near states to the detriment of the numerous relations between these countries. This grave inconvenience would involve without doubt the maintenance of the reduced taxes already applied between them, and then the system, while ceasing to be uniform, would become ruinous for great distances without compensation in the nearer relations. One understands, then, why this proposition was discarded for a long time to come.

A higher tax is justified beyond a certain distance by the single fact that the telegram has a much higher value for correspondents. It is equally justified when greater promptitude (priority of transmission) or other special advantages are obtained.

These higher charges constitute the only means of preserving a reduced tariff for short distances, and for ordinary correspondence.

[TO BE CONTINUED.]

NOTE ON THE THEORY OF ELECTRIC ABSORPTION.

BY H. A. ROWLAND, C.E.

In experimenting with Leyden jars, telegraph cables, and condensers of other forms in which there is a solid dielectric, we observe that, after complete discharge, a portion of the charge reappears, and forms what is known as the residual charge. This has generally been explained by supposing that a portion of the charge was conducted below the surface of the dielectric, and that this was afterwards conducted back again to its former position. But, from the ordinary mathematical theory of the subject, no such consequence can be deduced, and we must conclude that this explanation is false. Maxwell, in his "Treatise on Electricy and Magnetism," Vol. 2, Chap. X., has shown that a substance composed of layers of different substances can have this property. But the theory of the whole subject does not yet seem to have been given.

Indeed, the general theory would involve us in very complicated mathematics, and our equations would have to apply to non-homogeneous crystalline bodies, in which Ohm's law was departed from, and the specific inductive capacity was not constant. We should, moreover, have to take account of thermo-electric currents, electrolysis, and electro-magnetic induction. Hence, in this paper I do not propose to do more than to slightly extend the subject beyond its present state, and to give the general method of still further extending it.

Let us at first, then, take the case of an isotropic body in general, in which thermo-electric currents and electrolysis do not exist, and in which the changes of currents are so slow that we can omit electro-magnetic induction. The equations then become*

$$\frac{d}{dx}\left(\kappa\frac{dV}{dx}\right)+\frac{d}{dy}\left(\kappa\frac{dV}{dy}\right)+\frac{d}{dz}\left(\kappa\frac{dV}{dz}\right)+4\pi\rho=0,$$

$$\frac{d}{dx}\left(k\frac{dV}{dx}\right)+\frac{d}{dy}\left(k\frac{dV}{dy}\right)+\frac{d}{dz}\left(k\frac{dV}{dz}\right)-\frac{d\rho}{dt}=0,$$

in which κ is the specific inductive capacity of the substance, K the electric conductivity, V the potential, ρ the volume density of the electricity, and t the time. The subtraction of one equation from the other gives

$$(1)\quad \frac{dV}{dx}\frac{d}{dx}\left(\log\frac{k}{\kappa}\right)+\frac{dV}{dy}\frac{d}{dy}\left(\log\frac{k}{\kappa}\right)+\frac{dV}{dz}\frac{d}{dz}\left(\log\frac{k}{\kappa}\right)-\frac{1}{k}\frac{d\rho}{dt}-\frac{4\pi\rho}{\kappa}=0.$$

To introduce the condition that there shall be no electric absorption, we must observe that, when that phenomenon exists, a charge of electricity appears at a point where there was no charge before; in other words, the relative distribution has been changed. Hence, if the relative distribution remains the same, no electric absorption can take place. Our condition is then $\frac{\rho}{\rho'}=c$, where c is independent of t, and ρ and ρ' are the densities at the points x, y, z, and x', y', z'. This gives $\frac{d}{dt}\left(\log\frac{\rho}{\rho^0}\right)=0$,

$$(2)\quad . \; . \; . \quad \text{or}\ \frac{1}{\rho}\frac{d\rho}{dt}=\frac{d}{dt}\left(\log\frac{\rho}{\rho^0}\right)=-c,$$

where c is a function of t only, and not of x, y, z, and ρ^0 is the equal of ρ at the time $t=0$. As we have

$$\frac{1}{m}\frac{dV}{dn}\frac{dm}{dn}=\frac{dV}{dx}\frac{d}{dx}\left(\log\frac{k}{\kappa}\right)+\frac{dV}{dy}\frac{d}{dy}\left(\log\frac{k}{\kappa}\right)+\frac{dV}{dz}\frac{d}{dz}\left(\log\frac{k}{\kappa}\right),$$

where $m=\frac{k}{\kappa}$ and n is a line in direction of the current at the given point, equation (1) becomes

$$\frac{1}{m}\frac{dV}{dn}\frac{dm}{dn}-\frac{1}{k}\frac{d\rho}{dt}-\frac{4\pi\rho}{\kappa}=0.$$

From equation (2) $\rho=\rho^0\epsilon^{-\int_0^t c\,dt}$, and hence

$$\frac{1}{m}\frac{dV}{dn}\frac{dm}{dn}+\rho^0\epsilon^{\int_t^0 c\,dt}\left(\frac{c}{k}-\frac{4\pi}{\kappa}\right)=0.$$

If we denote the strength of current at the point S, we have $S=-k\frac{dV}{dn}$, and

$$(3)\quad . \; . \; . \quad \frac{1}{cm-4\pi m^2}\frac{dm}{dn}=+\frac{\rho^0}{S}\epsilon^{\int_t^0 c\,dt};$$

this equation (3) gives the value of $\frac{k}{\kappa}=m$ at all points of the body and at all times, so that the phenomenon of electric absorption shall not take place. As this equation makes m a function of x, y, z, s, and t, the relation in general is entirely too complicated to ever apply to physical phenomena without some limitation. Firstly, then, as c is only an arbitrary function of t, we shall assume that it is constant:—

$$\therefore\quad \frac{1}{cm-4\pi m^2}\frac{dm}{dn}=+\frac{\rho^0\epsilon^{-ct}}{S}.$$

The most important case is where m is a constant; then $\frac{dm}{dn}=0$ and $c=4m$, $S=S_0\epsilon^{-ct}$, $\rho=\rho^0\epsilon^{-ct}$. In this case, therefore, we see that both the electrification and the currents die away at the rate c. The case where Ohm's law is true and the specific inductive capacity is constant is included in this case, seeing that, when k and κ are both constant, their ratio m is constant. But it also includes the cases where k and κ are both the same functions of V, S, or x, y, z, seeing that their ratio m would be constant in this case also.

When m is not constant, the chances are very small against its satisfying equation (4).

Hence, we may in general conclude that electric absorption will almost certainly take place unless the ratio of conductivity to the specific inductive capacity is constant throughout the body.

This ratio m may become a variable in several manners, as follow:—

1st manner.—The body may not be homogeneous. This includes the case which Maxwell has given, where the dielectric was composed of layers of different substances.

2nd manner.—The body may not obey Ohm's law; in this case k would be variable.

3rd manner.—The specific inductive capacity κ may vary with the electric force.

It is to be noted that the cases of electric absorption which we observe are mostly those of condensers formed of two planes, or of one cylinder inside another, as in a telegraph cable. Our theory shows that different explanations can be given of these two cases.

The case of parallel plates does not admit of being explained, except on the supposition that m varies in the first manner above given, or in this manner in combination with the others, for we can only conceive of the conductivity and the specific inductive capacity as being functions of the ordinate or of the electric force. As the latter is constant for all points between the plates, m would still be constant, although it were a function of the electric force, and thus electric absorption would not take place.

We may, then, conclude that, in the case of parallel plates, omitting explanations based on electrolysis or thermo-electric currents, the only explanation that we can give at present is that which depends on the non-homogeneity of the body, that is the case which Maxwell has given in the form of two different materials. Our equations show that the form of layers is not necessary, but that any departure from homogeneity is sufficient. It is to be noted that the homogeneity which we speak of is electrical homogeneity, and that a mass of crystals with their axes in different directions would evidently not be electrically homogeneous, and would thus possess the property in question. In the case of glass it is very possible that this may be the case

* "Maxwell's Treatise," Art. 325.

ELECTRIC DISCHARGE IN GASES

I.

IN a paper read some time since at the Royal Society,[1] Drs. Warren De La Rue and Hugo W. Müller gave the first part of an account of their researches on the electric discharge in gases. This part, of which we shall at present give some account, consists mainly of a discription of the apparatus employed in this research, and of the results of their experiments with gases at atmospheric pressure and pressures down to 141 millimetres. They have since communicated to the Royal Society a second part, which treats of the discharge in highly rarefied gases (vacuum tubes).

The source of electrification used by Messrs. De La Rue and Müller was a battery of chloride of silver elements; commencing with 1,000, the authors have from time to time increased the number of cells to 11,000 joined in series (11,330 volts). In spite of its containing a somewhat costly material, this element, when compared with the many other forms of voltaic cell at present in use, possesses points of advantage such as render its general adoption extremely probable; we therefore transcribe in considerable detail the authors' description of it in its present improved form.

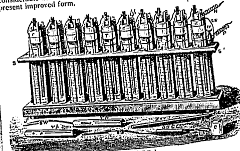


FIG. 1.—Nest of Cells.

Fig. 1 shows a nest of twenty cells of the most recent construction; the several components of the cells are given separately at the base of the stand. The glass tube T is $5\frac{1}{2}$ inches high, and $1\frac{1}{8}$ inch in diameter: it has a flat bottom. The stopper *c* is of paraffin, and is perforated with two holes, one for the zinc rod (*z*) to pass through, the other for letting in the liquid; the latter is ultimately closed with a paraffin plug (*pp*). Cork and india-rubber stoppers were tried and abandoned. The zinc is obtained of the Belgian Vieille Montagne Company. When it is intended to keep a battery more than a year in action the zincs should not be amalgamated, as the silver wires in contact with them would gradually be rotted through. Platinum, which would not become amalgamated, might have been substituted for the silver wires; but it would have cost 55*l.* extra per 1,000 cells. The zinc rods are 15 cm. long, 0·56 cm. in diameter, and perforated at the top with a hole 0·25 cm. in diameter. The chloride of silver (AgCl) is cast in the form of a rod on a flattened silver wire S W; the rods are 5·4 cm. long, 0·762 cm. in diameter, and weigh 12·97 grms. The silver wires are 20 cm. long, 0·127 cm. wide, and 0·0229 cm. thick, weighing 0·88 gms. each; they protrude slightly beyond the bottom of the rod of chloride, as will be seen from the figure. The wires and rods were obtained from Messrs. Johnson and Matthey, of Hatton Garden; the cost, including labour of casting, amounted to 2*s.* per cell. *v p* is a cylinder of three folds of vegetable parchment; at its lower end the folds are stitched together with thread, and at the upper part they are interlaced with the silver wire, and thus prevented from unfurling. The object of the parchment cylinder is to prevent the reduction of the chloride of silver rod, which would result from its accidental contact with the zinc. By giving proper bends to the silver wire before making up the cell it is easy to cause the chloride rod to lie vertically and press gently against the glass wall.

The liquid used for the cells is a solution of chloride of ammonium, 23 gms. to 1 litre of distilled water; by making use of a glass siphon with a long arm of india-rubber tubing, provided with a pinch cock, and terminating in a glass tube drawn down to enter freely into the hole in the paraffin stopper, it was found that 2,400 cells could be charged by one person in ten hours.

In making up a battery the glass cells are first arranged in their nests; next the paraffin stoppers are fitted with zincs; then the chloride rods are inserted and the cell closed with the stopper, the thin silver wire passing between the glass and the paraffin. When these operations have been performed for all, the cells are joined up by passing the silver wire of each cell through the hole in the zinc rod of its neighbour, and securing it there by pressing in a taper brass plug *p* with a pair of pliers. Ultimately, the cells having been charged with fluid, as already described, and closed by the insertion of *p p*, a hot iron is run round the outside of the stopper and round the zinc rod to secure the latter in its place, and make tight the joints by the melting and re-setting of a little paraffin.

Thus set up, the battery has an electromotive force of about 1·03 volt and internal resistance of not more than 5 ohms per cell: the former remains remarkably constant, but the latter increases, especially in cells that are left long idle. This rise in internal resistance is caused by a skin of oxychloride of zinc, which gradually forms on the zincs in all batteries where the zincs are immersed in a neutral chlorine compound. The battery may be restored to its original resistance by removing and scraping the zinc rods, but a more expeditious mode is to withdraw the small paraffin plug used to close the hole in the stopper through which the cells are charged, and to introduce into each cell, containing 50 c.c., 1 c.c. of pure hydrochloric acid, sp. gr. 1·16, containing 31·8 per cent. HCl gas, equivalent to 0·3689 gm. acid. Before introducing it into the cells, as is conveniently done by means of a graduated pipette furnished with a stop-cock, it is better to dilute the acid with an equal volume of distilled water. An effervescence takes place, and it is therefore necessary to allow the tubes to remain open twenty-four hours before the small paraffin plug is replaced, in order to permit the hydrogen, which is generated, to escape. It required two days for one person to perform this operation on a battery of 1,200 cells. The acid dissolves 0·3295 gm. of zinc or its equivalent of oxide.

After having been in almost daily use on circuits comparable with those occurring in overland telegraphy, it was found that in two batteries the amount of AgCl reduced in sixteen months averaged 4·57 gms. per cell, while in two other batteries which had been worked for ten months the reduction amounted to 3·57 gms. per cell.

An accident enabled the authors to give precise information as to the loss in working up the reduced silver; 600 cells having been accidentally allowed to run

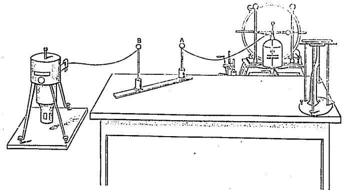
[1] *Phil. Trans.*, clxix. pp. 55-122.

THE DISRUPTIVE DISCHARGE OF ELECTRICITY[1]

BY means of the following method we have been able to investigate the laws of the disruptive discharge of electricity of high potential—a subject of investigation which is the complement of that in which Drs. Warren de la Rue and Müller have been simultaneously engaged. In making these experiments I have had the able co-operation in succession of Messrs. Salvesen, Connor, Stewart, Simpson, and Playfair.

The method essentially consists in connecting the prime conductor of the Holtz machine, not with the electrometer directly, but with an insulated spherical ball placed at some distance from an equal spherical ball, the latter being connected with the electrometer. The woodcut represents, *in situ*, the apparatus which was used in the case of the gases. The receiver of the air-pump, which has a rod capable of moving air-tight, was attached to one of the conductors of the Holtz machine in such a manner that the conductor and the rod formed one conducting system. Projecting from the plate of the air-pump was a short metal rod, which formed one conductor with the metallic parts of the air-pump, and, by means of a wire, with the uninsulated conductor of the Holtz machine. Electrodes of various forms were made to screw on to the ends of the rods. Of the two insulated brass balls one, A, was fixed; the other, B, could be moved along the connecting board. The wire joining A to the collar of the receiver is insulated with gutta-percha. The electrometer in connection with B is one of Sir W. Thomson's divided ring reflecting electrometers.

When the potential of A is raised by driving the machine, the potential of B is also raised, and this goes on until a discharge takes place between the electrodes inside the receiver. Hence the maximum deflection of the spot of light from zero is an indication of the difference of potential of the two surfaces between which the spark passed immediately before the discharge. By breaking the contact between the conductors of the Holtz machine before beginning to turn the wheel, and, by turning slowly and uniformly, we were able to make the image of the



wire move up continuously, and to be at rest at the instant of discharge. After the discharge took place the image fell back to zero, or a point near zero. We always noted the position taken up by the image when the conductor of the machine was completely discharged.

The force resisting the deflection of the mirror is the action of two external magnets upon several small magnets fixed to the back of the mirror.[2]

One great merit of our method is the rapidity with which observations can be made. Three readings were in general taken for each entry. The mean of these is very probably free from any error due to accidental variations in the passage of the spark. An extensive series of observations have been printed in full in the *Transactions* of the Royal Society of Edinburgh. The following are the more important results:—

A spark was taken through air between plates at a constant distance, and the distance between the balls A and B varied. Let V denote the induced potential, and r the distance between the centres of A and B; then the experimental curve obtained satisfies the equation—

$$V = 6081r^{-1} - 42{\cdot}26$$

for values of r greater than 24 centimetres; but for less values of r the function requires to be corrected by being multiplied by—

$$\cdot 524 + \cdot 02r.$$

Sparks were taken through air at the atmospheric pressure between parallel metal disks of 4 inches diameter for distances up to 1·2 centimetres. The function for V, the difference of potential in terms of s, the length of the spark is—

$$V = 66{\cdot}94\sqrt{\{s^2 + \cdot 205s\}},$$

[1] Abstract by the author of thesis for D.Sc. and other papers printed in the recently issued part of the *Transactions* of the Royal Society of Edinburgh. By Alexander Macfarlane, M.A., D.Sc.

[2] Our results were reduced to absolute measure by means of the absolute electrometer represented on the table.

the equation of a hyperbola whose semi-transverse axis is ·1025 centimetres, and semi-conjugate axis 6·8623 C.G.S. units. From the above equation we infer that—

$$R = 66{\cdot}94\sqrt{\left\{1 + \cdot 205\frac{1}{s}\right\}}$$

where R denotes the electrostatic force; from which it is evident that as s becomes smaller R becomes greater. A similar curve was obtained when hydrogen was substituted for air.

When the disks were heated before taking the sparks, the curve obtained satisfies the equation—

$$V = 87{\cdot}04s - 19{\cdot}56s^2,$$

a parabola, from which we deduce—

$$R = 87{\cdot}04 - 19{\cdot}56s.$$

It was found that when the capacity of the charged conductor was changed, the difference of potential required to produce a spark remained constant.

When the discharge was continued so as to keep the spot of light at a fixed deflection, the reading was always less than for the corresponding single discharge, but the curves were similar.

Readings were taken of the difference of potential required to produce a ·5 centimetre spark through air at different pressures from the atmospheric to 20 mm. They give—

$$V = \cdot 0458\sqrt{\{p^2 + 203p\}}$$

where p denotes the pressure in millimetres of mercury.

The electric strengths of several gases were determined by comparing the differences of potential required to pass a ·5 centimetre spark through the gas at the atmospheric pressure.

Dielectric.	Electric Strength.		
	Macfarlane.	De la Rue and Müller.	Faraday.
Air...	1	1	1
Carbonic Acid ...	·95	1·06	·91
Oxygen	·93	1	·71
Hydrogen... ...	·63	·54	·53
Coal Gas	·93	—	·71

"Electric strength" is the term used by Prof. Clerk-Maxwell to denote the physical constant in question. I have added, for the sake of comparison, values deduced from the results of De la Rue and Müller and of Faraday, but the ratios given do not strictly give the relative electric strength, but the ratio of the lengths of spark when the difference of potential is kept constant.

The difference of potential required to produce a spark between two spherical balls is approximately proportional to the square root of the length of the spark. This we have verified up to 15 cm.

On proceeding to investigate the discharge through insulating liquids, we first took up oil of turpentine. The liquid was placed in a glass jar of 7 inches diameter and 5 inches height. A screw passing through the bottom of the jar served to fix the lower electrode, and also to afford conducting connection with the earth. We observed four modes of discharge: by means of threads of solid particles, by motion of the liquid, by a disruptive discharge, and by motion of gas bubbles. When a chain was formed the index of the electrometer behaved as if a current were passing. The discharge, when sufficiently great, broke the thread and turned into a spark. The liquid was more easily set in motion when its surface was not much higher than the upper plate. The bubbles of gas appeared to be formed by the passing of the spark. They were always attracted to the negative electrode. When the electrification was neutralised they of course adhered to the under surface of the upper disk; when the disk was electrified negatively they still adhered; when positively they were repelled so as to remain suspended in the liquid or to adhere to the lower electrode, according to the greater or less distance between the electrodes. At a diminished pressure the bubbles produced at the upper surface were observed to effect the discharge by carrying the electricity with them to the negative electrode. The fact that it is possible to cause a shower of electrified bubbles to descend and produce a flash and sound on impinging on the lower surface appears to throw some light upon the nature of lightning balls.

Similar phenomena were observed in paraffin oil, excepting that the gas bubbles produced were generally attracted to the positive surface.

We observed the differences of potential required to pass a spark through paraffin oil and oil of turpentine between plates for distances up to ·5 cm. It was impossible to observe for greater distances, as our insulated wire allowed the charge to escape. For paraffin oil,

$$V = 750s - 15;$$

therefore,

$$R = 750.$$

The above has not been reduced to absolute measure. Thus R is constant in the case of the liquids, but variable in the case of the gases.

Electric Strength of Liquid Dielectrics

Air	1
Paraffin Oil (kind used for burning)	4
Oil of Turpentine	3·7

Sparks were taken between two platinum wires placed at right angles to one another. When one of the wires was heated by a voltaic current the electrometer deflection was diminished by about one-fourth of its amount.

We have also investigated the effect upon the electric spark of heating the air round the disks, the pressure being kept constant. The deflections of the electrometer for a constant spark for temperatures from 20° C. to 280° C. indicate a curve which slopes down gradually as the temperature is increased, while the deflections during cooling give a curve which is somewhat lower at the lower temperatures.

These experiments were made in Prof. Tait's laboratory, to whom we are indebted, not only for the use of apparatus, but also for ever ready advice.

which the greatest part of the Berlin press has assumed with regard to the doctrine of evolution must be attributed to this authority. But much as we must regret the reactionary current in this and other intelligent Berlin circles, yet we must point out that by this evil we are guarded from a far greater one. This greater, indeed the greatest, evil which could befall German science would be a Berlin 'monopoly of knowledge,' the *centralisation of science*. What highly disastrous fruit this centralisation has borne in France, for instance; how the Paris 'monopoly of knowledge' causes a constant degradation of French science, and has led it downwards from the greatest heights for the last half-century, is well known. Probably the wide-spread differentiation and the many-sided individuality of the German national spirit, the often-decried German particularism, will save us from a centralisation of science of this kind, which particularly in our capital, Berlin, would be doubly dangerous. Little as our 'small states' could be politically of any duration or could lead to a useful state-form, they have certainly been most beneficial and fertile for German science. Because this owes its principal advantages over others to the numerous little centres of education, which the capitals of the German small states formed, and to the many little universities which were always in healthy competition with one another. Let us hope that this beneficial decentralisation of science in our politically united Fatherland will continue permanently. Next to the centrifugal striving of our German national spirit, nothing will further this object so much as an energetic resistance to the free progress of science, just as now again it begins to show itself in the capital of the empire. Because at the same rate as this will remain behind in the mighty current of free and unimpeded mental progress, other numerous centres of education in Germany which follow this current enthusiastically, or at least willingly, will outrun it."

"If Emil Dubois Reymond wanted to make his 'Ignorabimus' the watchword of science, and Rudolf Virchow his still further-reaching 'Restringamur,' then from Jena and from a hundred other educational centres they are met with the call—

"*Impavidi progrediamur!*"

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

STUDENTS of Natural Science who would much rather know French and German than Greek will be glad to learn that a very strong memorial against the retention of Greek as a subject for all honour candidates has been presented to Cambridge University. It is signed by ten heads of public schools, including Drs. Hornby (Eton), Butler (Harrow), and Abbott (City of London), Messrs. Matthew Arnold, Carlyle, W. E. Forster, the Bishops of Exeter and Manchester, Dean Cowie, Dean Stanley, and Dr. Vaughan, Prof. Jebb, and Mr. Roby, to say nothing of such bulwarks of science as Mr. Darwin, Prof. Huxley, Sir Joseph Hooker, Mr. Spottiswoode, and Prof. Tyndall.

THE Board of Musical Studies at Cambridge have applied for the appointment of a University Reader in Acoustics.

THE sum in the hands of the Sedgwick Memorial Committee for the erection of a new building for the geological collection is 12,000*l.*, not 1,200*l.* as we stated last week.

King's College (London) *Magazine*, No. 5, vol. ii. of which has been sent us, contains some pleasant reading, but no one would infer from its contents that the College was an important centre of scientific instruction and research.

DR. J. COSSAR EWART has been appointed by the Crown to the Chair of Natural History in the University of Aberdeen.

MR. F. GUTHRIE, formerly of Graaf-Reinet College, has been appointed to the Chair of Mathematics at the South African College, Capetown.

THE *Journal de St. Pétersbourg* gives the following particulars concerning the public provision for education in Russia:—The sum assigned in the Budget of this year for education is 15,971,289 roubles (about 2,395,000*l.*). There are eight Universities (not reckoning that of Helsingfors for Finland), with 5,629 students. Of these 85 are divinity students, 583 belong to the philological faculty, 1,629 to the faculty of law, 30 to that of Eastern languages, 622 to the mathematical faculty, 550 to that of natural science, and 2,130 to the medical faculty. There are 53 ecclesiastical seminaries, with 12,227 pupils; 195 gymnasia and pro-gymnasia, with 50,701 pupils; 56 middle-class schools, with 10,888 scholars. There are 19 military gymnasia, but the number of pupils is not given. For females there are 223 gymnasia and pro-gymnasia, having 34,878 pupils; and this does not include the many institutions which are subject to the control of the Fourth Division of the Imperial Chancellery. There are 68 normal schools and training colleges for teachers, having 4,968 students. There are 10 other such institutions supported by non-public funds. The number of elementary schools in operation this year is 25,491, with 1,074,559 pupils.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, December 5.—"On the Illumination of Lines of Molecular Pressure, and the Trajectory of Molecules," by William Crookes, F.R.S., V.P.C.S.

Induction Spark through Rarefied Gases. Dark Space round the Negative Pole

The author has examined the dark space which appears round the negative pole of an ordinary vacuum tube when the spark from an induction coil is passed through it. He describes many experiments with different kinds of poles, a varying intensity of spark, and different gases, and arrives at the following propositions:—

Illumination of Lines of Molecular Pressure

a. Setting up an intense molecular vibration in a disk of metal by electrical means excites a molecular disturbance which affects the surface of the disk and the surrounding gas. With a dense gas the disturbance extends a short distance only from the metal; but as rarefaction continues, the layer of molecular disturbance increases in thickness. In air at a pressure of ·078 mm. this molecular disturbance extends for at least 8 mm. from the surface of the disk, forming an oblate spheroid around it.

b. The diameter of this dark space varies with the exhaustion; with the kind of gas in which it is produced; with the temperature of the negative pole; and, in a slight degree, with the intensity of the spark. For equal degrees of exhaustion it is greatest in hydrogen and least in carbonic acid, as compared with air.

c. The shape and size of this dark space do not vary with the distance separating the poles; nor, only very slightly, with alteration of battery power; nor with intensity of spark. When the power is great the brilliancy of the unoccupied parts of the tube overpowers the dark space, rendering it difficult of observation; but, on careful scrutiny, it may still be seen unchanged in size, nor does it alter even when, with a very faint spark, it is scarcely visible. On still further reduction of the power, it fades entirely away, but without change of form.

The author describes numerous experiments, devised to ascertain if this visible layer of molecular disturbance is identical with the invisible layer of molecular pressure or stress, the investigation of which has occupied him for some years.

The Electrical Radiometer

One of these experiments is as follows:—An ordinary radiometer is made, with aluminium disks for vanes, each disk coated with a film of mica. The fly is supported by a hard steel cup instead of a glass cup, and the needle point on which it works is connected by means of a wire with a platinum terminal sealed into the glass. At the top of the radiometer bulb a second terminal is sealed in. The radiometer can therefore be connected with an induction coil, the movable fly being made the negative pole.

Passing over the phenomena observed at low exhaustions, the author finds that, when connected with the coil, a halo of a velvety violet light forms on the metallic side of the vanes, the mica side remaining dark throughout these experiments. As the pressure diminishes a dark space is seen to separate the violet halo from the metal. At a pressure of half a millimetre this dark space extends to the glass, and positive rotation commences.

On continuing the exhaustion the dark space further widens out and appears to flatten itself against the glass, and the rotation becomes very rapid.

When aluminium cups are used for the vanes, instead of disks backed with mica, similar appearances are seen. The velvety violet halo forms over each side of the cup. On increasing the exhaustion the dark space widens out, retaining almost exactly the shape of the cup. The bright margin of the dark space becomes concentrated at the concave side of the cup to a luminous focus, and widens out at the convex side. On further exhaustion the dark space on the convex side touches the glass,

THE ELECTRICITY OF THE TORPEDO[1]

II.

4. *CURRENTS induced by a torpedo discharge are all produced at the beginning of each wave. There are currents induced on the completion of a circuit,* i.e., *the inverse of the inducting currents, as is shown by the electrometer.*

Fig. 7 will show the arrangement of the experiment to prove that the torpedo's discharge in the inductive coil

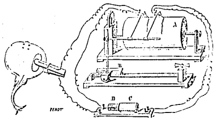


Fig. 7.

(D) produces, in the secondary coil (C) currents of sufficient energy to cause movement in the second signal placed in the circuit of the inducted coil. It must be remarked, however, that the electric apparatus which furnishes the indications of the passage of the discharge is not, as shown in the diagram, that which produces the inducted currents. Currents of sufficient intensity would not have been obtained to act upon the electro-magnetic signal, if we had opposed to the passage of the discharge a resistance so considerable as that of the coils of the electro-magnet. The difficulty has been averted by using the opposing apparatus for signalling; and this we are authorised in doing, since the discharges are absolutely symmetrical to the right and left when the nervous centres are excited by the magnet.

That exception made, let us examine the results of the experiment. The traces were placed one over another; one (as 1 in Fig. 8) indicating the successive waves of the discharge, and the other (as 2 in Fig. 8) the currents inducted by the waves. This figure already shows an important fact: that the number of inducted currents is equal to that of the inducting waves; and that each inducted current is produced at the commencement of each wave, just as in a galvanic current an inducted current is produced at each completion. But here we only find currents inducted by the completion or, more exactly, at the commencement of the waves; none are produced during the decreasing phase of each wave, or at least if they are produced they do not act upon the electro-magnetic signal.

From the preceding it should be inferred that the currents, inducted by the torpedo-waves and produced at the commencement of these waves, must in that be analogous to the inducted currents resulting from the completion of a galvanic circuit.

No instrument could be better than Lippmann's electrometer for giving us information as to the direction of the currents inducted by the torpedo waves. Its instantaneous action enables it to indicate, by a sudden displacement in a determinate direction, the direction of each inducted current.

If a weak current derived from the main discharge is passed through the electrometer, we see the column after moving to one side of the reticule always oscillate to the same side, thus showing that the successive waves are joined one to another, so that there is never an absolute break in the current. In Fig. 9 the arrows show the oscillation of the column towards the right side.

Fig. 8.

If the induced currents are directed through an electrometer by the discharge which causes the column of the instrument to deviate to the right, the direction of oscillation is immediately reversed (Fig. 10).

The comparison of those two diagrams showing that the inducted current has a contrary effect to that of the inducting current, brings together the inducted currents of the torpedo and those obtained by completing a galvanic circuit. To be more exact, since the circuit which comprises the torpedo remains always complete, we shall say that the inducted currents are produced at the beginning of each electric wave of the animal. Thus the torpedo calls forth in each of its electric waves an initial inducted current and does not give a terminal inducted current. This conclusion goes to support what we learned from the wave-writing of the electro-dynamograph, viz., that the initial phase of each wave has a suddenly increasing intensity, whereas the terminal phase presents a gradual decrease.

5. *The discharge of the torpedo is analogous to muscular tetanus; every electric wave in the discharge corresponds to a muscular shock.*

In what precedes we have endeavoured to give an idea of the torpedo discharge from the nature of the successive acts which constitute it, insisting only upon points relating to experimental science and to the direct results of M. Marey's investigations.

We are now enabled to meet the question on higher ground and consider the electric function from a philosophical point of view, by classing it with the muscular function.

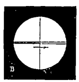


Fig. 9.

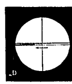


Fig. 10.

Let us first compare the elementary action of electric discharge to the elementary action of muscular contraction, *i.e.*, the electric wave to the muscular shock.

[1] Continued from p. 297.

The simple excitation of the remote end of an electric nerve produces a single wave, as the simple excitation of a motor nerve produces a single shock. In both cases, at the moment of the nerve-excitation produced in the neighbourhood of the electric apparatus or of the muscular apparatus, the amount of delay is sensibly the same, about seven-hundredths of a second. The electric wave, like the muscular shock, has a phase of increase and a phase of decrease; the former, as we have seen, is abrupt or sudden from one part to another; the decreasing phase is much more gentle. The same agents modify the wave and shock in the same manner; heat renders both these actions more speedy and more energetic up to a certain point at which both electric reaction and muscular reaction disappear; cold acts equally upon movement and electric action, rendering both more slow, more feeble, more extended, and at last extinguishes them when the temperature is lowered to about zero C.

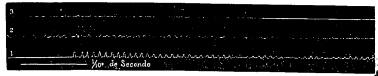


Fig. 11.

In the complex muscular act which is called contraction, as in the electric act which constitutes the discharge, the elementary phenomena which we have just been comparing, the waves and the shocks are added on one to another in the same manner; they succeed each other with a rapidity so great that each has not time to complete all the phases before its successor is produced. The floor and the shock are interrupted during their decreasing period by a new wave or shock coming to join on its effect to what remained of the preceding act. But, as there are imperfect muscular contractions, cases of tetanus where the shocks are not completely fused together, not being rapid enough in their succession, so in the same way certain electric discharges present a remarkable discontinuity, such that the elements of the perfect act are seen arranging themselves, the waves following each other with less rapidity, the shocks separated from each other by a larger interval of time.

Fig. 12.

Let us now compare the effects of fatigue upon muscular contraction and upon the discharge, as we have compared them upon the muscular shock and upon the electric wave; we shall see the two acts modified in the same direction. It is even possible to see the torpedo-wave and discharge gradually becoming extinguished, just as muscular shocks disappear under the influence of exhaustion. This gradual extinction of the electric waves is very evident in Fig. 11, obtained by means of the electro-dynamograph.

Poisons which act directly or indirectly upon the muscular function modify in the same manner the electric function. Thus strychnine, for example, which in a very special manner exaggerates the excito-motor power and that which might be termed the excito-electric power of nervous centres; a complex reaction, a muscular tetanus on one side and a real electric tetanus on the other, is produced in reply to a simple excitation, the mere touch of the skin, or a slight noise.

Fig. 12 shows a type of muscular strychnine contraction in the frog. Here we observe a diminution of intensity produced in the middle of the muscular tetanus between two maxima, one at the beginning and the other at the close.

In agreement with this characteristic phenomenon, the cause of which is unknown, we observe in torpedo poisoning by strychnine a weakening or interruption towards the middle of the discharge. Fig. 13 shows on line A a type of this species of interruption which must be compared with that which we have just seen on the tracing of muscular tetanus.

We might still further extend the comparison of those two functions, the electric and the muscular, by studying the action of other fishes, such as the *Gymnotus*, the electric ray, &c.; and by showing that the results are identical when heat and cold act upon muscular contraction and upon the discharge of the torpedo. The preceding paragraphs are sufficient to justify the functional assimilation which, let us hasten to say, is in accordance with the anatomical assimilation.

Fig. 13.

We shall only add that these identifications are of higher interest than curiosity; the more our knowledge of muscular phenomena and electric phenomena becomes perfected, the more enlightened is our knowledge of the motor nerves. Does the fact that a voluntary discharge of the torpedo is a complex act not prove that the voluntary contraction of the muscles is also a complex act? Very certainly, the comparison of the voluntary contraction of the muscles with the tetanic phenomena produced by electricity or by strychnine, the existence of a muscular sound during the contraction, the quivering or

two external magnets upon several small magnets fixed to the back of the mirror.[2]

One great merit of our method is the rapidity with which observations can be made. Three readings were in general taken for each entry. The mean of these is very probably free from any error due to accidental variations in the passage of the spark. An extensive series of observations have been printed

satisfies the equation—

$$V = 608 \cdot 1 r^{-1} - 42 \cdot 26$$

for values of r greater than 24 centimetres; but for less values of r the function requires to be corrected by being multiplied by—

$$\cdot 524 + \cdot 02r.$$

Sparks were taken through air at the atmospheric pressure between parallel metal disks of 4 inches diameter for distances up to 1·2 centimetres. The function for V, the difference of potential in terms of s, the length of the spark is—

$$V = 66 \cdot 94 \sqrt{\{s^2 + \cdot 2051\}},$$

[1] Abstract by the author of thesis for D.Sc. and other papers printed in the recently issued part of the *Transactions* of the Royal Society of Edinburgh. By Alexander Macfarlane, M.A., D.Sc.

[2] Our results were reduced to absolute measure by means of the absolute electrometer represented on the table.

dissociation of the shocks which are produced under the influence of cold, all these seem arguments in favour of the theory which considers muscular contraction as the result of very frequent shocks; but the complexity of the voluntary discharge of the torpedo, the manner in which the waves composing it succeed each other and are added together, forms a very important confirmation of the numerous presumptions already made.

FRANCOIS FRANCK

SCIENCE IN LANCASHIRE AND CHESHIRE

AT Liverpool the annual associated *soirée* of the Literary, Scientific, and Art Societies, eighteen in number, of which twelve are scientific, held at St. George's Hall on the 31st, was a marked success, and will tend much not only to foster scientific tastes in this district, but inculcate an element of scientific co-operation, in the various institutions of the town, that will be of the highest practical value. The fourteenth Winter Course of Free Lectures for the People, given at the Free Library and Museum, by order of the Corporation, commenced on the 6th of last month. Amongst the forty-one lectures announced, thirteen are on scientific subjects, given by the Rev. W. H. Dallinger, Mr. Moore (Curator), Mr. De Rance, Rev. H. H. Higgins, and others. The Liverpool Geological Society is also doing good work; a valuable paper on the carboniferous limestone of Denbighshire was lately read by Mr. Morton, and a short but important mineralogical paper was given by the President, Mr. Semmons. Geological knowledge has been increased by a boring at Bootle, sunk to determine the water-bearing properties of the new red sandstone at great depths, by Messrs. Mather and Platt, for the Liverpool Corporation, who were urged to this course by Alderman Bennett. The boring has reached a depth of 1,300 feet, is 25 inches in diameter, is filled with water up to a height of 50 feet from the surface, and, according to Messrs. De Rance and Morton, has proved the pebble beds of the Bunter to reach the extraordinary thickness of 1,200 feet, and the existence of the lower mottled sandstone beneath. The pumps not yet being fixed, it is impossible to judge how far the well will add to the supply of 6,000,000 gallons a day at present pumped from the corporation wells.

At Wigan, in addition to the ordinary course of lectures given at the Mining and Mechanical School, a special course has been arranged for candidates for colliery managers' certificates, and gives to the teaching of the school a special technical direction. The extension scheme for turning the very numerously attended evening classes of this school into a Mining Collegiate Centre for Lancashire, has necessarily languished under the unexampled and continued depression in the coal trade, though from the number and extent of the promised subscriptions and donations to the building-fund, there can be little doubt that, when better times again visit this country, this school will develop into an important centre of technical education. The town has lately had the good fortune to have presented to it a magnificent library, stored in a handsome building erected for the purpose, the former being the bequest of the late Mr. Winnard, the latter the gift of Mr. Thomas Taylor. The reference library is well stored with standard scientific works in all branches, and the selection reflects great credit on the industry and acumen of Mr. Gerrard Finch, barrister-at-law, who selected them, under the terms of the will. Some important works are of course conspicuous by their absence, but doubtless this will soon be remedied. The reference portion of this library will henceforth be opened on a Sunday to readers who have asked for special tickets, the extra cost of assistants being defrayed for three years by Mr. Taylor, the donor of the building. This town has also now a flourishing Literary and Scientific Society, with Lord Lindsay as president; it is divided into botanical, microscopical, and other sections, at which papers are read by the members, and discussed, and, in addition, special lectures are given to the united sections; amongst those delivered have been "Spectrum Analysis," by Lord Lindsay, and "Local Geology," by Mr. de Rance: others are announced by Prof. McKenny Hughes and Prof. Rudler.

At Southport there is at present little done for fostering a taste for either technical or scientific education, but the very fine aquarium is maintained in great efficiency, the contents of the table tanks, to which we have previously referred, being especially beautiful.

At Preston, meetings of the Scientific Society have been numerously attended, and the president, Dr. Arminson, and others, do good microscopical work. The meetings are held at the Avenham Institution, which is well filled with scientific works, including the natural history library of a defunct Naturalists' Society, and it is a matter of regret that the town, in adopting the Free Libraries Act, should not have carried out an amalgamation scheme, instead of running a new and inefficient library in opposition to the existing useful and self-supporting institution. The Gilchrist Trust lecturers here and at Burnley have been listened to with much interest by large audiences; and at the latter place Prof. Boyd Dawkins has inoculated his hearers with his taste for cave-hunting investigations, and searches have been organised into the wild hills which fringe the county boundary of Lancashire and Yorkshire, and form the backbone of England, a district which for the most part appears to be above the level of the glacial sea deposits.

At Chester the flourishing Natural Science Society that looks back with pride to Kingsley, its founder, and forward with hope to its president, Prof. McKenny Hughes, is divided into several sections like a small British Association. The most noticeable paper read was one by Mr. Shrubsole, on the Fenestellæ of the carboniferous limestone, which was an important and valuable contribution to our knowledge of this group, proving from perfect specimens that several supposed species are, in fact, portions of the same organism. General lectures have been given to the united sections by Prof. Judd and Mr. De Rance, who opened the winter session. The Society possesses a very good local museum, but unfortunately it is exhibited in the disused ball-room of an ancient hotel in an out-of-the-way part of the city, and is known to few of the scientific visitors of Chester, and is but seldom visited by the inhabitants. The collection would, however, form an admirable nucleus of a museum for teaching purposes, should the Corporation ever recognise the need of technical education in this town, and erect a building to hold a library, museum, and science and art schools by the side of their fine town hall. Towards filling museums of this class, great advantage would accrue if the duplicate specimens at the British and Jermyn Street Museums were either given, or allowed to circulate, in the same manner as the art treasures from South Kensington Museum. For valuable as are *local* collections for the scientific *specialists*, no one can doubt the importance of giving wide and varied knowledge to the general public, such as, perhaps, can only be imparted by the inspection of typical specimens of the natural and artificial products of all countries. Such a collection may be seen on a small scale in the admirable little museum at Castleton, in Derbyshire, formed by Mr. Rooke Pennington, which at once furnishes the visitor with all that can be collected for forming a mental local picture of the past, and affords the inhabitants of the district an opportunity of knowing something of the world around them.

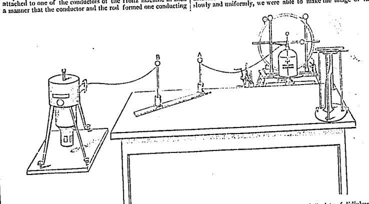
At Manchester the museum at Owens College now includes the entire collections of the Manchester Natural

THE DISRUPTIVE DISCHARGE OF ELECTRICITY[1]

BY means of the following method we have been able to investigate the laws of the disruptive discharge of electricity of high potential—a subject of investigation which is the complement of that in which Drs. Warren de la Rue and Müller have been simultaneously engaged. In making these experiments I have had the able co-operation in succession of Messrs. Salvesen, Connor, Stewart, Simpson, and Playfair.

The method essentially consists in connecting the prime conductor of the Holtz machine, not with the electrometer directly, but with an insulated spherical ball placed at some distance from an equal spherical ball, the latter being connected with the electrometer. The woodcut represents, *in situ*, the apparatus which was used in the case of the gases. The receiver of the air-pump, which has a rod capable of moving air-tight, was attached to one of the conductors of the Holtz machine in such a manner that the conductor and the rod formed one conducting system. Projecting from the plate of the air-pump was a short metal rod, which formed one conductor with the metallic parts of the air-pump, and, by means of a wire, with the uninsulated conductor of the Holtz machine. Electrodes of various forms were made to screw on to the ends of the rods. Of the two insulated brass balls one, A, was fixed; the other, B, could be moved along the connecting board. The wire joining A to the collar of the receiver is insulated with gutta-percha. The electrometer in connection with B is one of Sir W. Thomson's divided ring reflecting electrometers.

When the potential of A is raised by driving the machine, the potential of B is also raised, and this goes on until a discharge takes place between the electrodes inside the receiver. Hence the maximum deflection of the spot of light from zero is an indication of the difference of potential of the two surfaces between which the spark passed immediately before the discharge. By breaking the contact between the conductors of the Holtz machine before beginning to turn the wheel, and, by turning slowly and uniformly, we were able to make the image of the



wire move up continuously, and to be at rest at the instant of discharge. After the discharge took place the image fell back to zero, or a point near zero. We always noted the position taken up by the image when the conductor of the machine was completely discharged.

The force resisting the deflection of the mirror is the action of two external magnets upon several small magnets fixed to the back of the mirror.[2]

One great merit of our method is the rapidity with which observations can be made. Three readings were in general taken for each entry. The mean of these is very probably free from any error due to accidental variations in the passage of the spark. An extensive series of observations have been printed in full in the *Transactions* of the Royal Society of Edinburgh. The following are the more important results:—

A spark was taken through air between plates at a constant distance, and the distance between the balls A and B varied. Let V denote the induced potential, and r the distance between the centres of A and B; then the experimental curve obtained satisfies the equation—

$$V = 6081 r^{-1} - 42{\cdot}26$$

for values of r greater than 24 centimetres; but for less values of r the function requires to be corrected by being multiplied by—

$$\cdot 524 + \cdot 02 r.$$

Sparks were taken through air at the atmospheric pressure between parallel metal disks of 4 inches diameter for distances up to 1·2 centimetres. The function for V, the difference of potential in terms of s, the length of the spark is—

$$V = 66{\cdot}94 \sqrt{\{s^2 + \cdot 205 s\}},$$

[1] Abstract by the author of thesis for D.Sc. and other papers printed in the recently issued part of the *Transactions* of the Royal Society of Edinburgh. By Alexander Macfarlane, M.A., D.Sc.

[2] Our results were reduced to absolute measure by means of the absolute electrometer represented on the table.

70

the equation of a hyperbola whose semi-transverse axis is ·1025 centimetres, and semi-conjugate axis 6·8623 C.G.S. units. From the above equation we infer that—

$$R = 66·94 \sqrt{\left\{1 + ·205 \frac{1}{s}\right\}}$$

where R denotes the electrostatic force; from which it is evident that as s becomes smaller R becomes greater. A similar curve was obtained when hydrogen was substituted for air.

When the disks were heated before taking the sparks, the curve obtained satisfies the equation—

$$V = 87·04s - 19·56s^2,$$

a parabola, from which we deduce—

$$R = 87·04 - 19·56s.$$

It was found that when the capacity of the charged conductor was changed, the difference of potential required to produce a spark remained constant.

When the discharge was continued so as to keep the spot of light at a fixed deflection, the reading was always less than for the corresponding single discharge, but the curves were similar.

Readings were taken of the difference of potential required to produce a ·5 centimetre spark through air at different pressures from the atmospheric to 20 mm. They give—

$$V = ·0458 \sqrt{\{p^2 + 203p\}}$$

where p denotes the pressure in millimetres of mercury.

The electric strengths of several gases were determined by comparing the differences of potential required to pass a ·5 centimetre spark through the gas at the atmospheric pressure.

Dielectric.	Electric Strength.		
	Macfarlane.	De la Rue and Müller.	Faraday.
Air...	1	1	1
Carbonic Acid ...	·95	1·06	·91
Oxygen	·93	1	·71
Hydrogen... ...	·63	·54	·53
Coal Gas	·93	—	·71

"Electric strength" is the term used by Prof. Clerk-Maxwell to denote the physical constant in question. I have added, for the sake of comparison, values deduced from the results of De la Rue and Müller and of Faraday, but the ratios given do not strictly give the relative electric strength, but the ratio of the lengths of spark when the difference of potential is kept constant.

The difference of potential required to produce a spark between two spherical balls is approximately proportional to the square root of the length of the spark. This we have verified up to 15 cm.

On proceeding to investigate the discharge through insulating liquids, we first took up oil of turpentine. The liquid was placed in a glass jar of 7 inches diameter and 5 inches height. A screw passing through the bottom of the jar served to fix the lower electrode, and also to afford conducting connection with the earth. We observed four modes of discharge: by means of threads of solid particles, by motion of the liquid, by a disruptive discharge, and by motion of gas bubbles. When a chain was formed the index of the electrometer behaved as if a current were passing. The discharge, when sufficiently great, broke the thread and turned into a spark. The liquid was more easily set in motion when its surface was not much higher than the upper plate. The bubbles of gas appeared to be formed by the passing of the spark. They were always attracted to the negative electrode. When the electrification was neutralised they of course adhered to the under surface of the upper disk; when the disk was electrified negatively they still adhered; when positively they were repelled so as to remain suspended in the liquid or to adhere to the lower electrode, according to the greater or less distance between the electrodes. At a diminished pressure the bubbles produced at the upper surface were observed to effect the discharge by carrying the electricity with them to the negative electrode. The fact that it is possible to cause a shower of electrified bubbles to descend and produce a flash and sound on impinging on the lower surface appears to throw some light upon the nature of lightning balls.

Similar phenomena were observed in paraffin oil, excepting that the gas bubbles produced were generally attracted to the positive surface.

We observed the differences of potential required to pass a spark through paraffin oil and oil of turpentine between plates for distances up to ·5 cm. It was impossible to observe for greater distances, as our insulated wire allowed the charge to escape. For paraffin oil,

$$V = 750s - 15;$$

therefore,

$$R = 750.$$

The above has not been reduced to absolute measure. Thus R is constant in the case of the liquids, but variable in the case of the gases.

Electric Strength of Liquid Dielectrics

Air	1
Paraffin Oil (kind used for burning)	4
Oil of Turpentine	3·7

Sparks were taken between two platinum wires placed at right angles to one another. When one of the wires was heated by a voltaic current the electrometer deflection was diminished by about one-fourth of its amount.

We have also investigated the effect upon the electric spark of heating the air round the disks, the pressure being kept constant. The deflections of the electrometer for a constant spark for temperatures from 20° C. to 280° C. indicate a curve which slopes down gradually as the temperature is increased, while the deflections during cooling give a curve which is somewhat lower at the lower temperatures.

These experiments were made in Prof. Tait's laboratory, to whom we are indebted, not only for the use of apparatus, but also for ever ready advice.

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ON THE MINUTE MEASUREMENTS OF MODERN SCIENCE.

By Alfred M. Mayer.

Article XVIII.

On the Application of Rotating Mirrors to the Measurements of Minute Lengths, Angles, and Times.

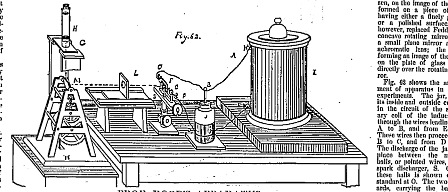
THE EXPERIMENTS OF FEDDERSEN, HENRY, ROOD, AND MAYER ON THE NATURE AND DURATION OF THE ELECTRIC DISCHARGE.

If we except a remarkable discovery made by Joseph Henry in 1841, nearly a quarter of a century elapsed before anything of value was added to the information which Wheatstone had given us about the nature of the electric discharge.

In the year 1858, Professor Feddersen, of Leipsic, began a series of elaborate and refined experiments on the electric spark. The peculiarity of his method consisted in replacing the plane mirror, which Wheatstone had used, by a concave mirror (of one-half meter radius), which gave an image of the spark by reflecting its rays on to a piece of finely ground glass. In this image the observer could see the structure of the spark. This is an improvement of prime importance, and the want of it prevented Wheatstone from really seeing what his mirror otherwise would have revealed to him. In fact, as we shall soon see, the spark, as observed by Wheatstone, was so brilliant and minute that its more feebly luminous and colored parts could not be seen. As this brilliant part of the spark has a very minute duration—less than the millionth of a second—it followed that Wheatstone decided that the whole of the electric spark has a duration less than the above fraction of a second.

Feddersen studied the images of the electric spark given by the concave mirror when it was stationary, and then when it was revolving 100 times per second. He made both drawings and photographs of these appearances. Feddersen divides electric discharges into three kinds:

1st. *The continuous discharge.* The rotating concave mirror gives an image of this, composed of a brilliant narrow line joining the electrodes, and parallel to the axis of rotation of the mirror. At the ends of this line, and at right angles to it, appear two faintly luminous bands. The noise given by this kind of discharge is a sharp crack.



PROF. ROOD'S APPARATUS.

2d. *The intermittent discharge*, formed of a series of luminous lines (parallel to the line joining the electrodes), and separated by dark spaces which become wider as the lines are further from the electrodes. This discharge makes a crackling or rustling noise, and appears to the naked eye as "the electric brush."

3d. *The oscillating discharge*, composed of a series of luminous brushes or cones, which start from two lines drawn at right angles to the ends of the line which joins the electrodes. These brushes curve around till they are parallel to these lines, and are alternate in their positions. Fig. 61 shows the appearance of this character of discharge, which was predicted by Henry in 1841, and first actually seen by Feddersen in 1862.

With his mirror running with a velocity of 100 revolutions per second, Feddersen saw the image of the spark of a discharging Leyden jar drawn out to the length of 20 to 30 millimeters. Using a larger jar, he observed that the spark was elongated to 20 millimeters more by the addition of a reddish tail formed of the gradually cooling metal volatilized from the electrodes. He found that an increase of "the striking distance" between the electrodes, as well as an increase of surface of the Leyden jar, gave the spark a longer existence. Thus, with a jar of 2·2 square feet of surface, and the electrodes 1½ millimeter apart, the spark's duration was 1-25,000th of a second; but on separating the electrodes till the spark was 3½ millimeters long the entire discharge lasted about 1-14,000th of a second. Feddersen also found that by increasing the resistance of the conductor leading from one coating to the other of the jar he greatly lengthened the time of the duration of the discharge. Thus, with a column of water of 9 millimeters in length, placed in the circuit, the duration of the discharge was 1-714th of a second; when a column of water 180 millimeters long, and of the same area of section, was interposed the duration lengthened to 1-54th of a second.

The most remarkable, however, of Feddersen's discoveries was that of the oscillatory character of the discharge of a Leyden jar, the discharge appearing to act like an elastic fluid, which alternately rebounded from the inside and outside coatings of the jar. Fig. 61 is a reproduction of an engraving contained in one of Feddersen's papers, and made from a photograph obtained from the image of the spark, thrown by the rotating concave mirror on to a sensitive plate. No one who examines this remarkable picture can fail to see the oscillatory character of this discharge. The spark was taken from a battery of 16 large Leyden jars with a conductor of high resistance connecting the inside and outside coatings. The electrodes were balls of iron, coated with varnish except at two points, between which flashed the spark. In this picture the positive electrode was at the right, the negative on the left. The spark is not only greatly elongated in a direction at right angles to the line joining the electrodes, but it is discontinuous and formed of curved brushes of light which appear alternately from the electrodes: first, a discharge takes place from the right hand electrode, then from the left, then from right, then from left, and so on. We also remark that the light which forms the brush coming from the negative electrode (and shown in the lowest part of the figure to the left) is streaked or ribbed, while that which next comes from the opposite or positive electrode is continuous and nebulous in its appearance. Then these appearances change places in the next act in the discharge, and the ribbed brush is now on the right and the nebulous one on the left, and so on.

I regard this photograph as one of the notable results of the modern art of photography. Here is a permanent record of the most transient of phenomena engraved by Nature herself, and giving the life history of intense physical actions whose whole existence is crowded into the duration of a hundred-thousandth of a second. Yet, in that short time, law has its reign; each circumstance of the transaction, from the generation of the spark till its final impress on the "sensitized" plate, follows in its allotted order and with its proper direction, duration, and intensity.

Speaking of the above experiments, those of Henry naturally recur, for this remarkably talented experimenter saw with his mind's eye in 1841 what Feddersen, twenty years afterwards, succeeded in getting on his photographic plate. In a communication to the American Philosophical Society of Philadelphia, in 1841, Henry says: "The discharge, whatever may be its nature, is not correctly represented (employing the theory of Franklin), by the single transfer of an imponderable fluid from one side of a jar to the other; the phenomena require us to admit the existence of a principal discharge in one direction, and then several reflex actions backward and forward, each more feeble than the preceding, until the equilibrium is obtained. All the facts are shown to be in accordance with this hypothesis, and a ready explanation is afforded by it of a number of phenomena which are to be found in the older works on electricity, but which have, until this time, remained unexplained."

Henry was led to the above conception of the nature of the discharge of a Leyden jar by the observation of the magnetizing action of the discharge of the jar on needles, which were placed in a glass tube, around which a conducting wire was wound like a helix. Now when a needle, placed as above, has an electric discharge sent around it, it is magnetized, and the direction of its magnetism, that is, which of its ends will be N. or S. polarity, depends on the direction of the electric flash through the enveloping helix. But, to Henry's surprise, he found that the same end of the needle was sometimes of north and at others of south polarity, till, after many hundred experiments, he found that there was a connection existing between the direction of the polarity and the amount of charge the jar had, and on the distance over which its spark passed. Then it occurred to Henry that these phenomena could only be explained by the supposition that there were several flows, or oscillations, of the electric fluid, first from one coating to the other of the jar, then back again, and so on, and that the number of these alternate oscillations decreased with the striking distance, and increased with the surface of the jar. Thus the final magnetic condition of the needle depended on the direction and intensity of the last flash of electricity which encircled it. After Henry had premised all this he soon had such mastery over the phenomena that he could at will give to the end of a needle either polarity he wished.

Researches of Prof. O. N. Rood on the nature and duration of the discharge of a Leyden jar connected with an induction coil.—It must have been noticed that Feddersen gives for the duration of the discharge the length of time during which the whole electric explosion lasts; but this explosion is of a complex nature, and the separate acts which compose it now require our attention. The thorough study of the composite nature of the discharge (at least of one form of it) was the subject of a series of skillful researches made in 1869, 1871, 1872, and 1873, by Professor Rood, of Columbia College, New York, of which we will now give an account.

Feddersen's experiments were made on the spark of the Leyden jar kept charged with electricity from a frictional electrical machine. Rood's researches are on the nature and duration of the electric discharge of a Leyden jar which was charged and discharged while in the circuit of the secondary wire of an induction coil. The circumstances of the charging and discharging of a jar placed as in Rood's experiments, are quite different from those which had place in Feddersen's, for, while in Feddersen's the two coatings of the jar were always insulated, in Rood's these coatings were always in metallic co[illegible] through the secondary coil of the inductorium, both [illegible] charging and discharging of the jar—"a circ[illegible] as Rood remarks, "which alone might be supposed to modify the duration of the discharge and its nature; besides this, it is known that the electricity from the coil continues to flow for a considerable fraction of a second along the terminal wires into the jar, which fact renders it questionable whether the duration of the discharge of the jar itself may not be proportionately lengthened. Hence it is evident that it would not be safe to conclude, without experiment, that the results obtained by Feddersen with jars charged with ordinary frictional electricity were applicable to those connected with an induction coil."

Professor Rood in his experiment worked, like Feddersen, on the image of the spark formed on a piece of glass having either a finely ground or a polished surface. He, however, replaced Feddersen's concave rotating mirror with a small plane mirror and an achromatic lens; the latter forming an image of the spark on the plate of glass placed directly over the rotating mirror.

Fig. 62 shows the arrangement of apparatus in Rood's experiments. The jar, J, has its inside and outside coatings in the circuit of the secondary coil of the inductorium through the wires leading from A to B, and from E to D. These wires then proceed from B to C, and from D to P. The discharge of the jar takes place between the metallic balls, or pointed wires, on the spark discharger, S. One of these balls is shown on the standard at O. The two standards, carrying the balls or points, can be placed at determinate distances apart by means of a micrometer screw which moves them. The head of this micrometer screw is shown at R.

The rays of light from the spark pass through the achromatic lens, L (of 9 inches focal length), which forms an image of the spark on the ground or plane glass at G, after their rays have been previously reflected from the stationary or revolving mirror at M. The mirror generally used was about one half inch square, and was formed of two silvered mirrors placed back to back. Thus two reflections were obtained from the mirror for one revolution. The image of the spark on G was examined by a microscope, H, which magnified about five times.

The mirror, M, was rotated by the wheel-work, W. Driven by a weight of 80 lb., the mirror could be brought up to a speed of 340 rotations in a second. To measure the rate of its rotation the cylinder on the lowest wheel of the train wound up a fillet of paper, on which dots were made by a Morse register, through which a current was sent by a pendulum at each second. The number of rotations made in a second by the mirror was readily computed from the record thus made on the fillet.

Two Leyden jars were used in Professor Rood's experiments. The larger of these had a coating of 114·4 square inches of foil, the smaller had only 11 square inches of surface. The discharge of the larger jar differed from the smaller both in its nature and in its duration.

Professor Rood first began a careful study of the structure which the spark presented when its image was formed by reflection from the stationary mirror.

Placing the larger jar in the circuit and sending its sparks between pointed brass wires one millimeter apart, the image of the spark on the glass surface at G appeared as in Fig. 63 *a*; "a central white portion surrounded by a yellowish envelope, which in the figure* is shown by the coarse shading; the second envelope, more densely shaded, being green and much inferior in brightness. With a striking distance of ten millimeters, the green envelope was produced only in the neighborhood of the electrodes, as shown at B of Fig. 63. In both cases a number of minute jets of white light were seen to issue from the electrodes; these are only partially shown in the figures. The green color was due to the heated particles of metal, and the bright points of light to successive discharges, as will be shown further on."

With fine platinum wires for electrodes the appearance was the same as with the pointed wires, except that the green tint was replaced by a gray, or violet-gray hue.

* This and the remaining figures describing Professor Rood's work I owe to the kindness of Professor Dana, editor of the *American Journal of Science*.

actual duration of the discharge, another effort was made. A second lampblack plate was prepared, in which the breadth of the image of a line, black or white, on the observing plate, was 1-600th of an inch. These lines were viewed with the terrestrial eye-piece of a small telescope; it enlarged them ten diameters and care was taken with all the adjustments so that a good clean image should be produced. Platinum wires of 1-80th of an inch in diameter were used, with a striking distance of five millimeters. By gradually increasing the driving weight it was proved successively that the duration was less than eighty, sixty-eight, fifty-nine,

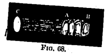


FIG. 68.

fifty-five billionths of a second; and finally, the lines, after growing fainter and fainter, entirely disappeared, giving as the result a duration of forty-eight billionths of a second. In a large number of observations I could detect no discharge lasting during a smaller interval, though the apparatus was now fully capable of making evident much smaller periods of time.

"When the striking distance was reduced to one millimeter, the duration was shorter; in the case of 5-6ths of the sparks, the duration was slightly greater than forty-one billionths of a second, the remaining 1-6th being slightly less than this figure.

"With a striking distance of three millimeters, the duration was between forty-one and forty-eight billionths; and when the striking distance was increased to ten millimeters, it was between forty-eight and fifty-five billionths of a second.

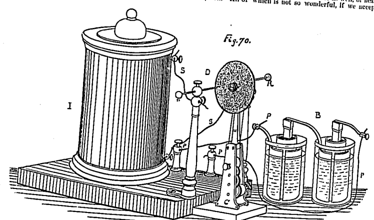
"It has thus been shown that the duration of the first act of the electric discharge (of this small jar) is in certain cases only forty billionths of a second, an interval of time just sufficient for a ray of light to travel over forty feet."

Professor Rood adds: "With another ruled plate I found it practicable to measure intervals as small as twenty-eight billionths of a second; and the mere act of increasing the focal length of the lens, L, would admit of the experi-

FIG. 69.

menter reaching a quantity as small as ten billionths—probably without much difficulty—though it would be necessary to pay more attention to the correction of the optical part of the apparatus, and the observations would naturally consume threefold as much time."

Professor Rood gives, in his paper, the accompanying curve, Fig. 65, by which he shows the duration of the whole discharge and the relative brightness of its various parts. The time during which the discharge lasts is represented by the length of the horizontal line, A C, and the relative degrees of brightness of the discharge at points of time, measured on the horizontal line, A C, are represented by the perpendicular distances of the curve (the unbroken line) from those points on the horizontal line. This curve shows that there is no break in the discharge; it is a continuous act. The steep peak, A B, stands for "the first and most brilliant act of the discharge;" though with the larger jar, of 114 square inches, it is neither so steep, as in the present case, nor so solitary, being followed by a series of minor elevations, while with the small jar the effective luminosity of the discharge is almost wholly concentrated in it; the far greater brilliancy of the light at the beginning of the discharge practically separates it from what follows, and makes



MAYER'S APPARATUS FOR ANALYZING THE ELECTRIC DISCHARGE.

it a first distinct act, whose duration, as we have just seen, Rood measured, and showed that its existence lasts for only forty billionths of a second.

After the success of his remarkable experiments, in which Rood showed that the flash of light from the small jar lasted for only forty billionths of a second, he made some very curious reflections on the very short time necessary for distinct vision. We will give his own words: "I obtained and measured sparks the duration of whose main constituent was only forty billionths of a second. With their light distinct vision is possible; thus, for example, the letters on a printed page are plainly to be seen; also, if a polariscope be used, the cross and rings around the axis of crystals can be observed with all their peculiarities, and errors in the azimuth of the analyzing prism noticed. There seems also to be evidence that this minute interval of time is sufficient for the production of various subjective optical phenomena: for example, for the recognition of Loewe's rings (using cobalt glass); also, the radiating structure of the crystalline lens can be detected when the light is suitably presented to the eye."

Hence, it is plain that forty billionths of a second is quite sufficient for the production on the retina of a strong and distinct impression; and as the obliteration of the micrometric lines in the experiment referred to could only take place from the circumstance that the retina retains and combines a whole series of impressions, whose joint duration is forty billionths of a second, it follows that a much smaller interval of time will suffice for vision. If we limit the number of views of the lines presented to the eye in a single case to ten, it would result that four billionths of a second is sufficient for human vision, though the probability is that a far shorter time would answer as well, or nearly as well. All of which is not so wonderful, if we accept the doctrines of the undulatory theory of light; for according to it, in four billionths of a second, nearly two and a half millions of the undulations of light reach and act on the eye.

On the multiple character of the discharge of the induction coil.—In the course of his experiments on the electric discharge Professor Rood observed that the explosive act of the induction coil was not concentrated into a single spark, but was formed of several distinct flashes, which, it is true, to the naked eye appear as a single flash; but on examination in the revolving mirror this apparent single spark appears as formed of several distinctly separated sparks. Professor Rood used two instruments in his study of these multiple discharges, viz., the revolving mirror already described, and a rotating disk with a slit cut out of it in the direction of one of its radii. If we look at a sheet of white paper through this slit while the disk is rotating, and the paper is illuminated by one instantaneous flash, we evidently will see the slit on the disk appear as a white radial band. If, however, the discharge, as usually is the case, is formed of several distinct and separated sparks, each spark will in

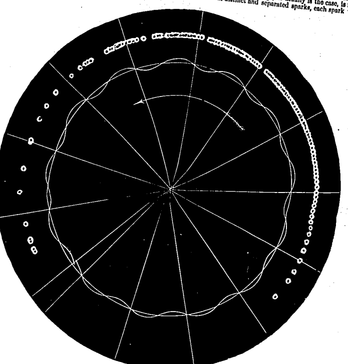


FIG. 71.

order illuminate the slit, and we will see a white radial band on the disk for each separate spark; provided, however, that these sparks do not follow one another so rapidly that the disk has not time enough to carry the slit far enough to prevent the bright radial bands from blending into one broad band.

To facilitate the observations on these complex phenomena Professor Rood devised what he called a micrometer-disk, formed of two disks superposed. Each disk had a radial slit cut in it, and one of these disks revolved on the other so that the slits could be placed at various angular distances apart. Fig. 66 shows the disks of blackened card-board with the two slits. On viewing through the revolving disk the white paper surface, illuminated by the electric flash, the slits in the disk appeared as in Fig. 67. By revolving the inner disk on the larger one the two fan-like images of the multiple slits could be brought together so that the end of one just touched the beginning of the other, and thus the angular breadth of the set of multiple slits was readily measured. This measure, with the knowledge of the velocity of rotation of the disk, gives us the data for computing the total duration of these discharges.

Flashing the discharge of his coil between brass balls one millimeter apart, and viewing the discharge in the rotating mirror, the appearance of the flash was as in Fig. 68, showing that sometimes the discharge was formed of three separate sparks, and sometimes of four. The duration of the whole discharge was about 1-165th of a second, the interval separating the sparks being about 1-500th of a second. With a striking distance of two millimeters he observed only one spark.

With platinum points as electrodes, and separated 1, 2, 3, 4, and 5 millimeters, the number of sparks observed at these respective distances of the electrodes was 4, 3, 2, 1 and 1, showing that an increase in the striking distance of the discharge diminishes the number of its component sparks. Placing in the circuit of the induction coil the small Leyden jar of eleven square inches of surface, and sending the discharge between brass balls separated by one millimeter, the character of the discharge, as shown by the revolving mirror and of the rotating disk, was more complex. Fig 68 shows the appearance it presented on the revolving mirror. Here we see that the act of discharge was formed of a bright spark followed by a violet discharge, extending from C to A, and the latter followed by four sparks, extending from A to B. The total duration of these discharges was 1-50th of a second. The violet portion, C A, lasted for 17-1000th of a second, and the four sparks, between A and B, lasted the 9-1000th of a second. Other forms were sometimes present, like that in Fig. 69, consisting of a faint violet streak terminated at each end by a spark, the whole duration being about 1-35th of a second.

On increasing the striking distance between the balls to 2, 3, 4, 5, 6, 7, 9, and 10 millimeters, the total number of sparks forming the discharge for these striking distances was respectively 5, 8, 4, 3, 3, 3, 2, and 1 spark.

Professor Mayer's Experiments on the Electric Discharge of the Induction Coil.—Professor Rood's mode of experimenting is not competent to unravel the tangle of sparks composing a flash from an induction coil, for the number of separate electric actions forming the discharge are far too many ever

L'ÉLECTRICITÉ

REVUE SCIENTIFIQUE ILLUSTRÉE

BEAUX-ARTS — INDUSTRIE — MARINE — ART MILITAIRE — MÉDECINE

2e SÉRIE — N° 5 — 5 MARS 1879

LA PHILOSOPHIE DE L'ÉLECTRICITÉ

—

Les unités électriques et la pesanteur

On nous demande de toutes parts en quoi consiste la comparaison des différentes unités électriques, sujet que l'on peut dire entièrement neuf en France, car les traités de physique élémentaire n'en parlent que d'une façon tout à fait superficielle. Mais avant de répondre à nos correspondants, nous devons commencer par bien définir la portée philosophique du problème dont ils nous demandent de nous occuper, afin de ne donner prise à aucune des ambiguïtés dont se servent certains physiciens pour jeter une confusion regrettable dans les notions les plus simples, les plus élémentaires et les plus claires.

Qu'il nous soit permis de prendre un exemple :

Les astronomes entassent chiffres sur chiffres et raisonnements sur hypothèses sans prendre garde qu'ils ont omis d'adopter une *unité spéciale*, oubli qui paraîtra singulier de la part de savants prétendant que leur science doit servir de modèle à toutes les autres, suivant l'orgueilleuse expression de M. Auguste Comte.

L'auteur de la *Philosophie positive* ne paraît pas avoir soupçonné même l'avantage qu'il y aurait à faire pour l'astronomie ce que l'on fait pour les besoins vulgaires du commerce et de l'industrie. Il n'a pas vu que depuis l'établissement du système métrique, les simples épiciers possédaient, à cet égard, un immense avantage sur les élèves les plus dociles de Laplace et de Newton.

Nous allons essayer de réparer cette omission, non point pour obéir au futile plaisir de les prendre en flagrant délit, mais afin de leur faire comprendre notre pensée, s'ils daignent nous lire.

Quelle doit être l'unité de masse astronomique ? Est-ce la masse du soleil, ou celle de la terre, comme on le fait chaque année dans les tableaux que publie la *Connaissance du Temps?*

En aucune façon, il faut que ce soit la quantité de matière qui, concentrée en un point unique, donne à une masse pondérable quelconque, se mouvant dans le vide, l'unité de vitesse après avoir agi pendant l'unité de temps, ladite masse attirée ayant été placée à l'unité de distance du centre attirant.

Si les astronomes veulent obéir à la logique dont les électriciens reconnaissent depuis longtemps la nécessité, ils ne peuvent agir autrement.

C'est, en effet, à ces différentes conditions que les physiciens ont reconnu la nécessité de se soumettre pour comparer les différentes forces dont ils ont à s'occuper.

Rien n'est plus logique, plus normal, plus conforme au génie de la mécanique, plus impérieusement exigé par la logique à laquelle les astronomes n'ont pas le droit de se soustraire.

Mais n'a pas une unité de matière, qui veut.

Pour avoir une unité de matière, il faut, nous venons de le montrer, avoir une unité de distance, une unité de temps, une unité de vitesse.

Quelle est l'unité de distance pour les astronomes? Les uns prennent l'année de lumière, ce qui est beaucoup, d'autres la lieue, ce qui est très-peu. Les uns prennent tantôt l'une, tantôt l'autre, mais aucun n'a senti le besoin d'une règle uniforme.

Quelle est l'unité de temps? A ce propos, même incertitude et cacophonie plus grande encore s'il est possible.

Les uns prennent la seconde sidérale, les autres le jour solaire moyen; quelques autres, l'année solaire moyenne. Les uns prennent indifféremment, avec une désinvolture tout académique, plusieurs unités qui n'ont point de rapport commensurable.

Quant à l'unité de vitesse, certains astronomes prendront le mètre, d'autres la lieue.

Nous ne nous chargerons point de les mettre d'accord. Nous dirons seulement qu'un certain nombre d'astronomes anglais, prenant le pied pour unité de longueur et la seconde pour unité de temps, ont été amenés à prendre comme unité de

76

ON THE SPECIFIC INDUCTIVE CAPACITIES OF CERTAIN DIELECTRICS.

By J. E. H. GORDON, B.A. Camb.*

79

As it would be impossible within the limits of an abstract to give any intelligible account of the new method of experiment (due to Professor Maxwell) which has been employed, I will merely give the table of results, reserving all discussion and explanation until the publication of my paper in full.

I may, however, state that the method is a zero method, that the electrified metal plates never touch the dielectrics, and that the electrification, which is produced by an induction coil, has an electromotive force equal to that of about 2,050 chloride of silver cells, and is reversed some 12,000 times per second.

RESULTS.

Dielectric. Glass, Slabs about 1 in. thick.			K.
Chance's optical glass.	Double extra dense flint		3·1639
	Extra dense flint		3·0536
	Light flint		3·0129
	Hard crown		3·1079
Common plate, 2 slabs.	No. 1	3·2581	3·2431
	No. 2	3·2282	
Ebonite, 4 slabs, ¾, ½, ½, ¼ inch.	No. 1	2·2697	2·2838
	No. 2	2·2482	
	No. 3	2·3097	
	No. 4	2·3077	
Best quality gutta-percha			2·4625
Chatterton's compound			2·5474
India-rubber	black		2·2200
	vulcanized		2·4969
Solid paraffin, sp. gr. at 11° C. ·9109. Melting point 68° C. 6 slabs cut in planing machine. Results corrected for cavities.	No. 1	1·9940	Mean ... 1·9936*
	No. 2	1·9784	
	No. 3	1·9969	
	No. 4	2·0126	
	No. 5	1·9654	
	No. 6	2·0143	
Shellac			2·7464
Sulphur			2·5793
Bisulphide of carbon			1·8096†

The following table compares the refractive indices of the transparent dielectrics with the square roots of the specific inductive capacities. In cases where there is a wide difference μ is taken from books on physics; wherever there was a close agreement it was carefully determined by the author, except in the case of paraffin, where the value is that given in Maxwell's "Electricity."

Dielectric.	$\sqrt{K}$.	Nearest value of μ.	Ray for which μ is nearest.
Double extra dense flint glass	1·7783	1·7460	Band in extreme violet in magnesium spark spectrum.
Extra dense flint	1·7474	1·6757	
Light flint	1·7343	1·5113	
Hard crown	1·7629	1·5920	
Plate glass	1·8009	1·543	
Paraffin	1·4119	1·422	Rays of infinite wave length.
Sulphur	1·6060	2·115	
Bisulphide of carbon	1·3456	1·6114	

[These results are, we understand, a correction of those given before by Mr. Gordon. See TELEGRAPHIC JOURNAL for July 15, 1878.—ED. T. J.]

* Proc. of the Royal Society.

* Messrs. Gibson and Barclay, "Phil. Trans." 1871, using a method entirely different from mine, obtained K=1·977 for paraffin. Correcting for a slight difference of density, I find that if they had used my paraffin their result would have been 1·9833.

† I am not quite certain of the accuracy of this result.

77

absorption spectra only indicate the component parts of a compound so long as the colour of a given substance is characteristic of its chemical composition.

WE notice an interesting discussion which arose at the last meeting of the Russian Society of Hygiene. M. Malarevsky, pointing out the yearly increasing myopy of scholars, proposed to print books with white letters on a black field, and proved the superiority of this system by experiments he has made with fifty scholars, as well as by experiments on the facility of discernment of black drawings on a white field and of white drawings on a black field, these last always being better seen from a greater distance than the former.

WE have received a very full Catalogue of Official Reports upon Geological Surveys of the United States and Territories and of British North America, by Mr. F. Prime, assistant-geologist of Pennsylvania. It seems to be an enlarged continuation of the Catalogue by Prof. O. C. Marsh, published in the *American Journal* for 1867. The present list covers 50 pp.

AT the last session of the U.S. Congress an appropriation of 250,000 dols. was made for the construction of a fire-proof building for the reception of such collections belonging to the National Museum as cannot be at present accommodated in the Smithsonian Building; and as the plans have already been prepared, it is understood that the work will be begun without delay. The design contemplates a building 301 feet square, with certain projecting corners, the whole covering a space of about 97,000 square feet. Although not quite equal to the area of the Government Building at the Centennial, it is capable of containing a much larger mass of material. The general plan is that of a pavilion, of one story, with brick walls and iron roof, the floor to be of concrete. The corner buildings or projections constitute offices connected with the administration of the Museum, to include a library room, a small lecture-room, and others. It is expected that the entire edifice will be completed and ready for occupation by April 1, 1880.

THE whale whose bones have been so long exposed in the court-yard of the Jardin des Plantes at Paris, is to be demolished in compliance with a report from M. Quatrefages, who shows that the original number of vertebræ has been enlarged, and a series of important alterations have been successively made.

THE publishing office of *Science News*, hitherto published at Salem, Mass., will shortly be removed to New York.

MANY of our readers might like to know of Dr. Karl Möbius' address on March 5 last, on his assumption of the rectorship of the University of Kiel. Its subject is the passage from Goethe—"Leben ist die schönste Erfindung der Natur, und der Tod ist ihr Kunstgriff viel Leben zu haben."

THE Second Annual Report of the Board of Trustees of the Western Pennsylvania Institution for the Instruction of the Deaf and Dumb is one of great interest, and we are sure would be perused with pleasure and profit by all who are interested in the important subject. The Institution seems to be conducted on thoroughly scientific principles, and its success seems very marked. The Report is published by Stevenson, Foster, and Co., Pittsburgh.

WE have received a cheap edition of "The Caves of South Devon and their Teachings," by Mr. J. E. Howard, F.R.S., in which he endeavours to combat the long chronology assigned to the human race by Mr. Pengelly and others. Hardwicke and Bogue are the publishers.

THE *North British Daily Mail* of March 29 contains reports of recent meetings of the Geological and Natural History Societies of Glasgow. In the former Mr. Young gave a descriptive notice of an interesting specimen of *Elephas primigenius* discovered about four years ago when sinking a pit-shaft on Mainhill Farm, near Baillieston, east of Glasgow. In the latter Mr. Harvie-Brown read a paper on the Mammalia of the Outer Hebrides.

"NEW Views in Astronomy, illustrated by Working Models and Diagrams, and Demonstrated by Inductive Philosophy," is the title of a quarto pamphlet by Mr. John Harris, published by Wertheimer, Lea, and Co., of Finsbury Circus.

THE additions to the Zoological Society's Gardens during the past week include a Yak (*Bison grunniens*) from Bhootan, presented by the Hon. Ashley Eden, K.C.S.I.; a Japanese Goat Antelope (*Capricornis crispus*) from Japan, presented by Mr. H. Pryer, C.M.Z.S.; a Rhesus Monkey (*Macacus erythraeus*) from India, presented by Mr. J. Roberts; a Grivet Monkey (*Cercopithecus griseo-viridis*) from West Africa, presented by Mr. W. B. Greenfield; a Common Seal (*Phoca vitulina*), British Isles, presented by Capt. Chas. Rawle; a Red-throated Diver (*Colymbus septentrionalis*), British Isles, presented by Mr. J. S. Thompson; a Masked Parrakeet (*Pyrrhulopsis personata*) from Fiji, an Entellus Monkey (*Semnopithecus entellus*), from India, deposited.

THE RESULTS OF RECENT RESEARCHES IN ANIMAL ELECTRICITY[1]

I.—INTRODUCTORY OBSERVATIONS

The State of the Subject Ten Years Ago

UNTIL the year 1867 certain theoretical conceptions based upon the classical investigations of du Bois-Reymond prevailed in the whole department of animal electricity. It may indeed be said that du Bois-Reymond created this branch of modern physiology, for it was he who first struck out the modern method of research and gave the lead to recent investigation. To his individual labours we owe not only the establishment and the orderly arrangement of many facts which had been left ill-defined by his predecessors, but also the actual discovery of a still greater number of fundamental value. These fundamental facts, briefly summarised, were the following:—

1. Muscular fibres and nerve-fibres when cut across exhibit a current directed within them from the transverse to the longitudinal surface, the electromotive force of which may equal one-twelfth of a Daniell's cell.

2. The negative potential of the transverse section also belongs, though in a less degree, to the natural terminations of the fibres of muscle ("natural transverse section"); but in this case it may be wanting, or even be changed to a positive potential. This diminution, absence, or reversal, of the common condition, to which the term "parelectronomic state" is applied, would seem to be favoured by the continued action of cold.

3. If a certain portion of a nerve-fibre be traversed by a galvanic current, the remaining portions, or the extra-polar regions, become the seat of an electromotive force which has the same direction as the traversing current, and which is strongest in the vicinity of the poles (electrotonus). This influence extends only so far as the structural integrity of the fibre is complete.

4. Muscles and nerves with artificial transverse sections exhibit during the period of stimulation a diminution ("negative variation") of their proper current. In uncut muscle the negative value of the diminution or variation becomes algebraically added to whatever current may be already present in the natural termination of the muscle.

Upon these facts du Bois-Reymond had based the following theory:—

1. Muscle- and nerve-fibres contain electromotive molecules suspended in an indifferent conductor, which present positive surfaces to the longitudinal surface or section, and negative surfaces to the transverse surface or section.

2. At the natural terminations of the muscular fibres are arranged particles of a peculiar kind, the presence of which is

[1] A lecture delivered on February 2, 1878, before the Medical Society of Zurich, by Dr. L. Hermann, Professor of Physiology in the University of Zurich, and published in the "Vierteljahrsschrift d. naturf. Ges. in Zurich," 1878. All the papers referred to in this lecture which have no author's name attached are papers of the author himself.

the forces of the local currents are, on account of the usual oblique application of the muscular fibres to their tendons, generally summed into currents of inclination.

III.—Electrotonus

Considerations opposed to the Molecular Theory of Electronus

The explanation adduced in the Introductory Remarks, in order to elucidate the electrotonic condition of nerves has many theoretical difficulties which cannot be here entered upon. The theory appears, however, to be amenable to an experimental proof. If, namely, the molecules of the portion of a nerve traversed by a current arrange themselves in the direction of the current, the electromotive force of the current should receive a very appreciable increase; or, in other words, the current should become very much greater when it passes through a piece of living nerve than when it traverses a dead piece of similar dimensions. On trying this experiment, however, I find no such difference; or the differences found are far from agreeing with the molecular theory.[1]

Electrotonic Phenomena observed in Conductors with Polarisable Cores

An experiment of Matteucci's[2] gave the clue to an explanation of electrotonic phenomena. He found that a metallic wire which is surrounded by a moist envelope exhibits currents possessing the characters of the electrotonic currents of nerves, whenever a galvanic current is passed, at any point, through the moist envelope. Matteucci discovered, in addition, that the currents cease when the wire is of amalgamated zinc and the envelope is moistened by a saturated solution of zinc sulphate. Hence it follows that the phenomenon depends upon a polarisation between the core and the fluid.

I examined the phenomenon more closely,[3] passing metallic wires through a glass tube filled with fluid and possessing lateral processes for the conduction of currents, and my experiments confirm the fact that electrotonic currents only occur when a polarisable core is present. Further, it was seen that the currents only extended so far as both core and envelope possessed unbroken continuity, whereas continuous contact of the two was not necessary. Lastly, I determined the laws regulating the time of development of these currents, their duration, their cessation on opening, their dependence upon the distance, and the length of the portion of core traversed by the polarising current, their combination and superposition, &c. All the phenomena may be grouped without difficulty under a simple theory.

As the current *a* E *k* (Fig. 4) applied to the envelope endeavours to reach the core K K, it splits up, if no polarisation be present,

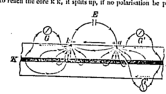


Fig. 4.

in such a manner that only the conducting threads in the immediate neighbourhood of the electrodes are able to catch an appreciable branch of the current. If on the other hand polarisation occurs at the surface of the core, this surface opposes a considerable and evenly distributed resistance; and, as in relation to it, the resistance offered by the length of the conducting wires is small, the current, under the influence of polarisation, extends much further along the conductor than when no polarisation takes place. If a galvanometer-circuit is arranged as shown in the diagram (at G, G', or G") it receives an offset from the main current as if there existed in the region examined an electromotive force of like direction with that of the polarising current.

[1] "Untersuchungen," Heft iii. p. 67, 1868; "Arch. f. d. ges. Physiol.," vi. p. 328, 1872.
[2] Matteucci, *Comptes Rendus*, lvi. p. 760, 1863; lxv. pp. 151, 194, 884, 1867; lxvi. p. 580, 1868.
[3] "Arch. f. d. ges. Physiol.," v. p. 264, 1871; vi. p. 312, 1872; vii. p. 302, 1873.

This polarisational extension of the current only continues where both core and sheath are uninterrupted.

The abducted currents are at the same time, on mathematical grounds, a measure of the degree of polarisation at the points touched; and thus afford a means of tracing the extent of polarisation along the core. The curve representing the polarisational values at various points of the core—in general an exponential curve—has at the positive pole a positive maximum and a negative at the negative pole. In the region traversed by

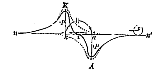


Fig. 5.

the current the curve cuts the axis at the so-called "indifferent point" (Fig. 5, *i*); and in the extra-polar regions it approaches the axes on both sides asymptotically. The curve is represented in Fig. 5, where, as a matter of subsequent convenience, the ordinates of positive polarisation are taken below the axis instead of above.

Internal Transverse Polarisation of Muscles and Nerves

In the year 1871 I discovered that the resistance offered by muscles and nerves to the passage of a current across their fibres was from five to nine times greater than the resistance offered by a current passing in direction of the fibres.[1] In the case of muscle this difference disappears almost entirely when rigor sets in; whilst in dead nerves it certainly persists, though reduced to one half. Further investigation of these facts disclosed their dependence upon a specific internal polarisability, which, in the case of muscle, is entirely associated with the living condition, and, in the case of nerve, in great part so associated. This fitness for polarisation by transversely-directed currents can only be due to a stratification of heterogeneous conductors across the tissue, which is wanting in its longitudinal axis. And since it is common to muscles and nerves, the stratification on which it depends must be sought in the typical structure which is common to the two organs, viz., the tubular nature of the fibres. We may assume, therefore, that polarisation takes place between the peculiar, active, substance of muscle- and nerve-fibres and the indifferent tissue ensheathing it.

Explanation of the Electrotonus of Nerves

As, accordingly, there exist in nerve-fibres all the essential conditions of the electrotonic extension of currents in conductors with polarisable nuclei, it may be assumed that the electrotonus of nerves is fully explained.[2] It is true that the core-substance of nerves is no better a conductor of electricity than the sheath-substance, while in the sheathed wire of Matteucci's experiment the core was of metal. But theory teaches that the electrotonic extension occurs even when the conducting powers of sheath and core are equal, if only polarisation takes place between the two.

This explanation of electrotonus, as I have shown in detail, completely covers all the phenomena. Especially does it account for the facts that the electrotonic state requires no appreciable time for its establishing;[3] and that it cannot extend past a ligatured spot. Whenever a nerve is crushed, the continuity of the core is broken, since, at the crushed spot, the core is killed and converted into indifferent tissue.

As muscle-fibres also possess polarisable cores, they must be endowed with electrotonic properties; nevertheless, neither du Bois-Reymond nor I at first succeeded in demonstrating them by galvanometric means; though, truly, just as little could their absence be distinctly affirmed. But theoretical considerations disclosed the reasons why muscle was less favourable to electrotonic phenomena than nerve;[4] and lately I have suc-

[1] "Arch. f. d. ges. Physiol.," v., p. 223, 1871.
[2] *Ibid.*, vi. p. 328, 1872.
[3] "Helmholtz, "Monatsber. d. Berliner Acad.," p. 323, 1854; L. Hermann, "Arch. f. d. ges. Physiol.," viii. p. 272, 1874.
[4] "Arch. f. d. ges. Physiol.," vi. p. 350, 1872.

functional current. These forces were assumed to be located in the two extremities of the muscular fibres and to be directed each to the correspondent end of the fibre, on which account they would of necessity overlap. The descending functional current belonging to the lower end was supposed to arise more quickly and to disappear earlier than the ascending current of the upper end; and hence the appearance of phases. Inasmuch as injury to one of the ends of a muscle (or in other words, removal of the parelectronomic layer), according to Du Bois-Reymond, intensifies the functional current proper to that end, it is clear that, when the inferior extremity is injured, the lower (descending) functional current obscures the upper.[1]

My own explanation[2] is essentially different from du Bois-Reymond's. According to my views the muscle must exhibit a descending current when the excitatory wave is at the upper end of the muscle, and an ascending current when at the lower end. Hence it is not the first, but the second phase, which is proper to the lower end of the muscle. The former, as I have shown, pertains to the moment when the excitatory wave is in the neighbourhood of the upper electrode—a condition most advantageously secured, owing to the peculiar structure of the gastrocnemius, by placing the electrode so as to abduct a current from the mid point of the fibres rather than from their upper end.

According to this theory it is clear that the descending phase must precede the ascending: for every excitatory wave is started at the middle point of the muscular fibre where the nerve enters, and only reaches the ends of the fibres at a later period. If, however, the lower end of the fibre have suffered injury, the excitatory wave running towards the injured part will be powerless to cause a current, owing to the constant negative potential of the injured end, and hence the second, ascending phase comes to nothing.

The fitness of this explanation was placed beyond doubt by experiments on the phasic functional current of regularly-constructed muscles.[3] In such muscles there invariably appeared in each half first an atterminal and then an abterminal phase

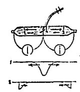


FIG. 6.

(Fig. 6). The atterminal phases in both halves (1 in Fig. 6) coincide in time, arising, as they both do, in the mid-point of the fibre at the starting of the excitatory wave; in other words, the middle point of the fibre becomes negative in comparison with either end.

In like manner the abterminal phases of both halves coincide (2 in Fig. 6), being produced by the arrival of the excitatory waves at the extremities of the fibre: in other words, either end of the fibre becomes negative in comparison with the mid-point.

In this manner the wave-like propagation of the excitatory condition in muscle was established for the case of muscle stimulated through nerves, and, at the same time, another proof was afforded that the force of the functional current does not exclusively reside in the ends of the fibres.

Furthermore, it was directly shown in these experiments that the excitatory-wave in excised muscles, while traversing the fibres, experiences a diminution; for the second, abterminal phase was invariably much weaker than the atterminal, as is indicated in Fig. 6 by the length of the arrows and the height of the representative curve, and it invariably further diminished in the course of an experiment.

The Functional Current in wholly Uninjured Muscle in Man

In the case of man the currents of normal resting muscle were secured from investigation by the obstacle of the skin. But Du Bois-Reymond found, during the violent voluntary contraction of the muscles of an arm or a leg, that the limb exhibited an ascending current. This he took to be the algebraical sum of the tetanic functional currents of all the muscles exerted, although such an explanation only became very probable by the exclusion of certain other experiments designed to elucidate the matter.[1] But the current could never be demonstrated under the most favourable conditions of abduction, viz., by the application of the galvanometer wires to individual groups of muscles.[2]

The question whether the diminution of the excitatory wave only occurs in excised muscles as a result of death changes, could, of course, only be settled by experiments on living human beings. And since the manifold disturbances inseparable from the method of experiment rendered the tetanic functional current almost useless for this investigation, I undertook to examine the *phasic* current in the muscles of the fore-arm.[3] I found that the same relationship held for the muscles of man as had before been shown to exist in the case of the frog. The first phase is an atterminal current in which the region of the nervous equator—about 10 cm. below the elbow—becomes negative in comparison with the two ends; the second phase is abterminal, *i.e.*, the ends of the muscles become negative in comparison with the equator (Fig. 7). But in the perfectly

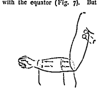


FIG. 7.

normal muscles of man the second phase was *not* weaker than the first—a relation which was constant in the excised muscles of the frog. And hence we may conclude that in absolutely normal muscles the excitatory wave does not diminish in intensity. These experiments, which constitute the first regular examination of muscular action in living man, further taught approximately the rate of propagation of the excitatory wave in human muscles, viz., from 10 to 13 metres per second.

The Absence of the Functional Current when none of the above Conditions of Electrical Inequality exist in Muscle

If an uninjured, currentless muscle be thrown into the active condition by a stimulus affecting its whole mass at once, it never exhibits any functional current,[4] whether the stimulus be single or tetanic. The explanation of this is obvious. In such a totally excited muscle the whole substance passes at the same moment into the same degree of excitation; and, hence, is nowhere the opportunity given for the contact of excited with non-excited or imperfectly excited tissue.

If, on the other hand, the muscle possesses an artificial transverse section with the associated boundary current, then indeed a levelling or equalising functional current arises on total excitation and diminishes the current of injury.[5]

When muscles are tetanised through their nerves, functional currents only appear where the excitatory wave has not the same intensity throughout the tetanised mass. Hence in man, whose muscles when under absolutely normal conditions exhibit no diminution or decrement of wave, it is impossible to demonstrate a tetanic functional current. I have, indeed, when using very powerful and fatiguing stimulation, now and then succeeded in getting indications of such a decremental functional current, but from some cause or other, we cannot depend upon this experiment to lead to a constant result, perhaps for the reason that the conductivity of human muscles is but slightly hampered by fatigue, or possibly because the collateral effects of stimulation mar the experiment.[6] I may be allowed to remark here that certain experiments now in course of publication show very clearly that stimulation of human muscles causes a secretory cutaneous current directed from without inwards. This current is the true

[1] Du Bois-Reymond, *loc. cit.*, 1873-76.
[2] "Arch. f. d. ges. Physiol.," xvi. p. 236.
[3] *Ibid.*, p. 239.

[1] Du Bois-Reymond, "Untersuchungen," ii., Abth. 2, p. 267.
[2] "Arch. f. d. ges. Physiol.," xvi., p. 257, 1877.
[3] *Ibid.*, xvi., p. 410, 1878.
[4] "Arch. f. d. ges. Physiol.," xvi., p. 203, 1877.
[5] *Ibid.*, xv., p. 238; xvi., p. 203, *et seq.*, 1877.
[6] *Ibid.*, xvi., p. 416, 1878.

82

the fibres in the neighbourhood of the section, owing t[o] extension of the demarcation-current along the nerve.[1]

By this electrotonic extension we can explain—or for the part explain—the so-called "weak currents" of the longitu[dinal] section.[2] A stimulus applied to the nerve near the line of

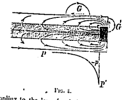


Fig. 8.

tion, according to the law of polarisational increment, s[hould] have a greater effect than when applied to points more re[mote]; and this experiment shows to be the case. Finally, an excit[ation] wave travelling along the nerve towards the cut end of it [must,] according to the same law, gradually diminish before it d[isap]pears entirely in the area of section itself.

V. Concluding Remarks

The whole of the electrical phenomena of muscle and n[erve,] therefore, may be readily deduced from a few very simple [pro]positions. Irritable protoplasm responds both to destr[uctive] and to exciting influences by an electromotive sign. [The] altered substance takes on a negative potential with respe[ct to] the unaltered. This, together with the doctrines of int[ernal] transverse polarisation and of the polarisational incremen[t of] excitation, appears fully competent to explain all the facts hitl[erto] observed.

That these fundamental doctrines have the closest referen[ce to] the whole life of irritable tissues no one will be dispose[d to] doubt. Yet much examination will be needed to disclose [the] exact nature of the interdependence.

Although it must now be confessed that the theories w[hich] were based upon facts discovered more than thirty years [ago] have failed to withstand the criticism of a wider experience, [the] domain of animal electricity has not lost, but rather gaine[d] interest. And the services of the man who not only discov[ered] this region of physiology, but created the means of conque[ring] it, and who made himself master of its most important fu[nda]mental features, are in no danger of becoming dimmed in [our] estimation by the theoretical changes we have been compell[ed to] accept.

posed that nitric and nitrous acids, and their ammoniacal salts, were produced only by the electricity of heavy thunder showers. It is now evident that the reactions between vegetables and the atmosphere, under feeble electric tensions, are the most important, the smallness of the effects being compensated by their duration, and by the extent of the surfaces influenced.

These researches have attracted a great deal of attention in France, and other scientific men are investigating the subject. Among the forms of apparatus that have been devised for experimenting on the action of electricity on living plants, that invented by M. Celi appears to be one of the best. It consists of a large bell-jar, into which electricity is admitted in a very ingenious manner. An insulated metallic vessel is placed on a support about six feet high, and filled with water, which is then allowed to flow out by a very narrow tube. The vessel thus becomes charged with electricity, positive or negative, according to the state of the atmosphere,—commonly the former. A collector, formed of metallic wire, is attached to this vessel, and penetrates into the bell-jar, where it is connected with a crown of sharp metallic points for distributing the electricity. Under the bell-jar are placed plants in vessels communicating with the ground. The bell-jar is supported on glass, and air can be admitted or withdrawn through tubes arranged for the purpose. For comparison, plants similar to those under electric action are inclosed by another bell-jar of the same size without application of electricity, but otherwise treated in precisely the same way. On the 30th of July M. Celi sowed some grains of maize in the manner described. On the 10th of August the plants in the electrified air had a length of 17 centimetres, while those in the unelectrified air were only 8 centimetres long.

Further experiments are now in progress, the results of which we hope to report to our readers at a future time. That the electrical action is an important factor in the development of plant-life would appear to have been already proved, and when the *modus operandi* comes to be understood it is probable that it may suggest some important applications of electricity in practical agriculture. Electricity may come to the farmer's aid, as chemistry has already done; and "lightning fertilizers," warranted to stimulate plant-growth "at a shocking rate," may erelong be as familiar as guano and phosphates now are.

KEEP YOUR MILK-CANS CLEAN.

We have several times referred to the danger of spreading certain infectious diseases, such as typhoid fever, scarlet fever, etc., through the medium of the milk-can. Even a want of proper care in keeping the cans clean may prove the cause of sickness on the part of those who use the milk conveyed therein. Dr. John Muter, [F.] C. S., in an English sanitary journal, gives the following case illustrating this:—

I have been lately consulted by a gentleman, whose family suffered an attack of sickness and purging after partaking of the usual morning's milk, with the view, if possible, of tracing the cause of the attack. The quantity saved was unfortunately very small, and was delivered to me in the can in which it came, but a larger amount of the same [milk] which had been boiled, was also submitted

The latter enable[d] poisons, but with[out] ing for the prob[able] boiling) showed added. On open[ing] by the strikingly and on putting t[he] though I found n[o] ances indicating which appeared t[o] my attention to t[he] although partly c[leaned] existed chiefly in ing the can I obt[ained] goid growths an[d] joints, which were decomposing milk that the milk had placed in this di[rty] municated its sept[ic] I reported accordi[ngly] probably of a f[ew] vessels when the[y] in them, and are rinse. Our publi[c] brightness of thei[r] why should not o[ur] a little sand and " milk-can is too of[ten] receptacle, capabl[e] a dangerous ferme[nt] sist on having m[ilk] (both outside and to do likewise, or trying to obtain s[o] saw, and hope to nutely at a future odor of the can w[as] milk, but somethi[ng] sive.

THE GER[MINATION OF SEEDS]

Complaints a[re] sprout," when th[e] who has planted look at a seed, an[d] conditions the d[evelopment] within depends, w[hich] less hands it ofte[n] The depth at wh[ich] tant matter; hea[t] trolling influence Mr. A. H. Ward, the following tab[le] some of the most

	Lowe[st]
Wheat	41°
Barley	41
Pease	41
Corn	48
Beans	49
Squash	44

He also gives mum amount of absorb, stated in time taken for eight to seventy-

Mustard	
Millet	
Corn	
Wheat	
Buckwheat	
Barley	
Turnip	
Rye	

Seeds will n[ot] cient air, heat, must operate

83

The English Mechanic
AND
WORLD OF SCIENCE AND ART.

FRIDAY, APRIL 11, 1879.

ARTICLES.

ELECTROMOTIVE FORCE.—RESISTANCE AND CURRENT.—I.

By J. T. Sprague ("Sigma.")

THE purpose of the present article is to develop the inter-relations of the three fundamental expressions and units of dynamic (or moving) electricity, to give to them somewhat more of definiteness than is usual in the ordinary text-books, and to do this mainly by showing what physical realities underlie the terms and formulæ used by electricians.

Of course, the text from which these practical lessons are to be drawn is the well-known formula of Ohm $\frac{E}{R} = C$. The current is proportional to the electromotive force divided by the resistance; or, employing the received units of the British Association system of measurement, $\frac{E\ \text{Volt}}{R\ \text{Ohm}} = C$ Veber.

The very first point to be considered is whether these symbols have any reality behind them. Are they mere mathematical abstractions, simple tools of thought, or are they concrete realities? Now, this is really a very serious question, because these scientific formulæ are now so extensively employed and so completely relied upon that they acquire a kind of imaginative actuality, just as the creations of popular writers do. Thus Scott's "Ivanhoe" is possessed, to most readers, of as distinct a personality as Richard Cœur de Lion, and probably the personality of the latter, notwithstanding the fact that he had an actual living existence, is built much more strongly upon Scott's "Ivanhoe" and "Talisman," than upon what are supposed to be the actual chronicles of history.

Now mathematical formulæ have just such a pseudo-reality. They may be mere idealities and yet true, and they may be given actual existence and become false.

I give an abstract form to the formula, and write $\frac{6}{2} = 3$. Here we have a well-known truth. But if I attach a concrete value to the figures the result may be mere nonsense; for instance $\frac{6\ \text{Sheep}}{2\ \text{Butchers}} = 3$. ?

In fact, the concrete values must be of one order, or must have a natural relation among themselves.

Now let us see whether and why the abstract $\frac{E}{R} = C$ represents concrete facts and truths. To this end we must clearly understand *what the symbols represent*. Of course everyone knows that E stands for Electromotive Force; R for Resistance; C for Electrical Current. But if these are three distinct actualities, concrete existences, how come they to hold among themselves the relations involved by the formula? E, then, is electromotive force. But what is electromotive force? A force tending to set electricity in motion; or, to use a better phrase, to set up that motion which we call electricity. Here it will be seen we have at once two considerations presented to us: an effect, the motion produced; a cause, the force producing the motion. Of these the first, the motion, is of necessity an actual thing, though we may hold different ideas as to what the thing itself really is. But does the force exist, that is to say as a special force? There are actual forces having real existence, such as the various attractions of which we may take gravitation as the type; these are, so to speak, self-existent—we know not their causes. But there are other agencies which we call forces, yet which have only a temporary existence; they are, in fact, simply transfers of energy.

Any agency may be called a force which is capable of setting up motion, or altering the conditions of motion in a mass of matter. Thus, if we take a ball of lead and let it fall, motion is imparted to it by gravitation: we may push the same ball of lead along a table, or by muscular energy hurl it to a distance; we may strike it as a cricket-ball is put in motion, by a percussive blow; or we may, by aid of a gun, set it in motion by means of compressed air or by the explosion of gunpowder. In all these cases motion is produced, and we may call the agent in each case a force. We may even embody all these agencies in one expression, and attribute the motion generated to the action of a "Mechanico-motive Force," the intensity of which we can measure by the amount of motion produced. Such an expression might be correct enough mathematically, but physically it would be a delusion, for only in one instance, that of gravitation, is there an actually existing agency, properly called a force, at work. But any mechanico-motive force can be compared to gravity, because all can be expressed in terms of the velocity which has been set up, or which can be imparted to a unit mass of matter in a unit space of time; the force of gravitation on this earth being such as to generate a velocity of 32 feet per second in round numbers, or an actual motion of 16 feet per second.

But gravitation, and all similar natural forces of the nature of attraction, are constantly acting (and such attractive forces as electricity and magnetism increase during their action, because the distance diminishes), and, in consequence, its effects are cumulative, and result in a regularly accelerating motion, while the other forms of force noticed are simple impulses, and set up a fixed velocity at the origin of the motion. We may, however, for some purposes of reasoning, ignore this property of gravitation, and consider only its unit action, as I shall do presently, in order to make some comparisons with electromotive force.

Now, then, what is electromotive force? When we dissolve zinc in a battery, this force makes its appearance. It is said by some to be due to the contact of the two dissimilar metals; that at the point of contact there is a sort of attraction or repulsion which decomposes the supposed natural or normal electricity, and sends the two halves to seek reunion through any roundabout or difficult path. But one thing is certain:—This force can do no work unless it is maintained by an equivalent supply of energy, and as a matter of fact easily proved, the degree of electromotive force produced is measurable in terms of the chemical actions which occur; and, speaking roughly, it is proportional to the difference of the tendencies of the two metals to combine with the radicals of the acids acting; that is to say, to the heat generated by these metals in the act of combination.

But if we expose the junctions of two different metals to heat, we find electromotive force set up in degrees depending (1) upon some inherent property of the metals (which has an appearance at all events of supporting the contact theory of its origin), and (2) upon the different temperature produced, which means in fact the quantity of energy which can be thrown into the circuit.

Again, if we move a conducting body in the neighbourhood of a magnet in certain directions, we find electromotive force in action: here no contact of different metals exists, to account for the fact; but an amount of energy is absorbed proportionate to the forces.

On examining the various modes of developing electromotive force, we find in fact that it always involves an absorbtion and distribution of energy, and that the same principles are involved as in the case of what I have called mechanico-motive force; but we find in no case (except apparently in the attractive force of static electricity) any force analogous to gravitation, or to any of the natural attractive forces. Electromotive force is constantly acting upon the circuit, but it has no accelerating action. We are therefore forced to the conclusion that it has no actual existence, but that, like mechanico-motive force, it is simply an application of energy.

E, then, in Ohm's formula is simply an expression, valuable in use for calculations, but symbolising not a thing, but a value, a quantity of energy applied in a specific mode, to produce a definite molecular disturbance in a conductor and a propagation of electrical action. This will be seen more completely by-and-by.

A New Phenomenon in Statical Electricity.—M. E. Duter, in a paper read before the French Academy in December, showed that when a Leyden jar is charged with either positive or negative electricity, its internal volume increases, and that this effect is a new phenomenon, unexplainable by either a theory of an increase of temperature or of an electrical pressure. The experiment was performed by means of a flask-shaped Leyden jar, with a long tube attached to its neck, and containing a liquid which served as the inner armature. The author's attention had been called to the fact that this phenomenon had been observed 10 years ago by M. Gori. His researches, just made public, leave no doubt of the accuracy of M. Duter's view, that the glass of the jar really expands. According to the theory of elasticity, the effect of an internal pressure in a hollow sphere is in the inverse ratio of its thickness. M. Duter, therefore, had three flasks made of the same volume, but of thicknesses of 4 mm., 0.8 mm., and 0.5 mm. respectively. They were filled with water and enveloped with tin foil. Each carried a capillary thermometer tube, in which the variations of the hight of liquid served to measure the changes in volume due to electrification. He found that these changes were imperceptible in the thick glass, very marked in the flask of mean thickness, and rose to 30 mm. in the thinnest. The variations in volume were very nearly in inverse ratio of the square roots of the thickness.—*Scientific American.*

The English Mechanic

AND

WORLD OF SCIENCE AND ART.

FRIDAY, APRIL 25, 1879.

ARTICLES.

ELECTROMOTIVE FORCE.—RESISTANCE AND CURRENT.—II.

BY J. T. SPRAGUE ("SIGMA.")

WE have now to consider the meaning of the second symbol R, or Resistance. If we have at command an inexhaustible supply of water at a given height, say, for instance, the Falls of Niagara, that body of water continues falling as long as it is not prevented from doing so, and it is evident that even a small height would give an infinite current of water across an infinite space. But let us have the power of controlling our Niagara (and one advantage mathematicians possess over experimental philosophers is just that very thing—they can assume any condition of things which suits their purpose). Let us provide a measured outlet, which will permit only a fixed current of water to pass. We may now consider this condition of affairs from two points. Looking at the actual current generated, we may speak of the conducting power or capacity of the outlet. Looking at the restraint put upon the power of the source, we may speak of the resistance presented to its action. Each mode will be correct to some extent; both can be made to give the same results as to the actual flow of water. Now let us give this figure definiteness by reducing it to units of measurement. As gravity will cause a fall of 16 feet per second, let that be the unit value of the mechanico-motive force which I now represent by the symbol M. This force will, therefore, generate a current of 16 feet of water per second; but to give any value to that statement we must know what is the area or section of the current of water. One square inch 2 feet in height is nearly 1lb. of water—it is actually ·980; but, availing ourselves of the mathematical license, we will call it 1lb. We thus get two other units, 1 square inch, the unit of conducting capacity, and 8lb. the unit quantity or current per second. Let us symbolise these by A or area for conducting capacity, and the unit flow of water or current by C. Then we have:—

Mechanico-motive force M acting through conductor A producing current C,

$$\text{or } M \times A = C,$$
$$16 \times \cdot5 = 8,$$
$$\text{or } 8 \times 1 = 8.$$

A is ·5 or ½ because it is, of course, related to the terms of M by the necessities of any unit system and M, although originating in gravitation, is here not a natural, but a mathematical force, based upon the action of gravity during one second, but isolated from the accelerating force of real gravity. It is just a force which, acting in the unit conductor of 1 square inch, produces a current of 8lb. of water per second; we may call M = 16 and A = ·5 because the 16 feet in length contain and transmit the unit 8lb. current; or we may call M = 8 and A = 1 because that force and conductor will generate (by actual gravity) a velocity of 16 feet per second, and therefore a current of 8lb. For the convenience of having the unit conductor A = 1 the latter mode is preferable.

Now M remaining constant, the flow of water C will be proportionate to A. If we provide a double conductor we have M × 2 A = 2 C or 8 × 2 = 16, and so on.

But it is an arithmetical fact that, if instead of multiplying by a number, we divide by its reciprocal, the same result is attained. The reciprocal of a number is of course 1 divided by that number.

Now let us take the reciprocal of A, our unit of conductivity, and we have 1 ÷ 1 = 1 and 1 ÷ 2 = ·5. If we now symbolise this reciprocal of the conducting power by R used as a divisor in place of A used a multiplier we get the formula

$$\frac{M}{R} = C \; \frac{8}{1} = 8 \text{ and } \frac{8}{\cdot5} = 16.$$

But this is simply Ohm's formula, and the fact of the matter is that what is called electrical resistance is in truth simply the reciprocal of the conducting capacity. If this were all, it would be merely a matter of names; but, unfortunately, it involves a great confusion of thought and much practical misconception. The electrical unit of R or so-called resistance, the Ohm, is in truth a conductor of definite capacity perfectly analogous to our supposed square inch pipe 16 feet long, and, in fact, a wire carrying an electric current bears many close physical analogies to a pipe conveying water. We always call wires conductors, and then instead of estimating their value in terms of their conducting capacity, we measure and think of them in terms of their resistance.

The consequence of this, which is really a mere matter of form, is that, as is so common in law and theology, the form becomes a reality, and upon it is based the monstrous doctrine, now calmly accepted by electricians, that a conductor offers no more resistance to a large current than to a small one. Hence it is also that the laws of transmission of electricity are supposed to be quite different from those of, say, water; whereas the fact is that they are identical, and that this mistaken idea is due simply to the giving of the name "resistance" to what is only a mathematical fiction.

True resistance is that which opposes a force doing work and which needs the expenditure of energy to overcome it: that resistance we meet with in our conductors, and it is, as in all other similar cases, with a given conducting capacity (that is in a fixed conductor) proportionate to the square of the current passing: that molecular disturbance which results in the heating of the conductor is the true electrical resistance analogous to friction and other resistances in mechanics: that which is called resistance in electricity is simply an artificial figure, the reciprocal of the conducting capacity and the analogue of the dimension of pipes in hydraulics.

In the third element of our formula, C, or Current, we have something actual, although by a strange perverseness this one thing which is an actual natural fact, obvious to the sense, and furthermore the very one which is the most important, because it is the basis of all electrical work, is the one which the devisers of our systems of measurement passed by. The electric current has definite relations to nature, it has a fixed equivalent in connection with chemical actions, it has a definite relation to magnetism, it does a fixed quantity of work, and generates a fixed amount of heat. All these reasons point to this, the measure of current, as the one natural base upon which the whole system of measurement should be constructed. But this was overlooked, and the system of measurement, instead of being connected to natural laws and the atomic system of matter, is based upon purely artificial mathematical considerations. It is true that, as a consequence, it is really a system of measurement of energy, but then energy would have been equally measurable had the natural unit been employed as the foundation. The only difference would have been this. The unit adopted is what is called the absolute unit, the metre-gramme second; that is to say, the force which would in one second give a velocity of one metre per second to a mass of one gramme.

This being fixed, all other forces and actions may be expressed in it, but necessarily by some fractional value. Thus the force of gravitation is equal (at London, that is to say, gravitation varying at different parts of the earth) to 9·811 such units, and in like manner the heat and other units of energy may be expressed in absolute units, and so can the chemical and magnetic relations of electricity. But had the system of measures been based upon the natural relations of electricity, just such a fundamental unit could have been used for other purposes, only it would have contained within itself one fractional part; the measure of length, for instance, would have been something more or less than a meter, but once defined and being merely an instrument of calculation, the unit would have been just as serviceable as the actual metre-gramme second, while the relations of energy and matter would have been rendered apparent.

In my book, "Electricity: Its Theory, Sources, and Applications," I have already pointed this out, and, in fact, I found myself compelled to use such a unit on my own authority, because my aim throughout was to make manifest the natural physical basis and relations of electricity, which are left wholly out of sight in the now fashionable arbitrary and mathematical teachings on the subject. The unit I used was for practical reasons based upon the grain atomic weights, 1 grain of hydrogen in 10 hours. A similar unit of electrical quantity, based on the metric atomic weights, is commonly used by Continental writers, viz., one-tenth of a gramme of hydrogen, and whether one hour or ten, one gramme, or one-tenth is used, is merely a question of placing the decimal point, and of the actual physical value of the principal unit and its multiples. It so happens that the actual absolute unit closely approximates to such a system, and I believe that in this fact there exists a grand natural truth, at present hidden from sight, purely by the arbitrary unit adopted, this truth being the fundamental connection of matter and energy by which energy is related to the atomic system of matter. Our measures are not as yet exact enough for full working of this out, but, so far as is at present known, the Veber unit of current, which is ·01 of an absolute unit, releases ·00001022 of a gramme of hydrogen; so that an absolute unit itself represents ·001022 of a univalent atom of matter.* It may well be that various errors of observation result in an error of 2 per cent., seeing that there is a good deal of uncertainty about the absolute value of the Ohm and other measures of resistance. But if our mathematical masters had but based their system upon this actually existing, easily measurable thing—the chemical action of electricity—instead of building it up from a purely theoretical and arbitrary basis, much less experimental work than has been given to the valuing of the Ohm would have established the exact relations of resistance and energy to chemical combination, and we should have had a unit of energy equivalent to 1 gramme (or any decimal submultiple) of univalent atomic affinity. *Matter and energy expressed in one unit.* Who can foresee what vistas of knowledge such a standpoint would present?

* I take the opportunity here of mentioning that owing to the confusion caused by some writers using the metre-gramme absolute unit, and others having most needlessly employed a centimetre-gramme system, I made a mistake in the table, p. 212 of my book. The value in water of the Veber is ·00022 instead of ·0002. As a consequence, all the values of the last column require an additional ·2. This is also the cause of the different values given in different books to the B. A. units, as to which frequent inquiries have been addressed to me.

86

Electricity in Air.—Recent experiments of M. R. Nahrwold tend to demonstrate that it is the dust in air and not the air itself which becomes electrified. When air is sifted of dust by means of glycerine, it takes only a very feeble charge. M. Nahrwold also remarked that positive electricity discharges itself more readily in air than negative, a result contrary to those of Wiedemann and Ruhlman, and we think also of Thomson. During the electric discharge, when viewed by the light of the mechanical theory of gases, would seem to show that the discharge, besides increasing the *vis viva* of the moving molecules, also increases the *vis viva* of the oscillatory motion of the ether envelopes. Different spectra got from different points in the width of the gaseous tube are therefore not to be referred only to the different temperatures of the gas, but to the amounts of electricity of which the passage causes the oscillation of these ether envelopes.

An electric water-level indicator has been fitted up by the Silvertown Company at the New Water Works, Leamington. A rise or fall of the water level applies the positive or negative pole of a battery to the indicator for a certain time, and causes the hand to indicate the new level in feet. A similar instrument, designed by the Postal Telegraph Engineers, was fitted some months ago to a reservoir of the Nottingham Waterworks Company, and has given great satisfaction.

Animal Electricity.—In a remarkable lecture delivered before the Medical Society of Zurich on February 2nd, 1878, and published in our contemporary, *Nature*, for April 17th, Dr. L. Herman summarises that "the whole of the electrical phenomena of muscle and nerve may be readily deduced from a very few simple proportions. Irritable protoplasm responds both to destructive and to exciting influences by an electro-motive sign. The altered substance takes on a negative potential with respect to the unaltered. This, together with the doctrines of 'internal transverse polarisation, and of the polarisational increment of excitation, appears fully competent to explain all the facts hitherto observed."

LES MOUVEMENTS MOLÉCULAIRES ÉLECTRIQUES

May — 79

C'est un désir qu'on entend souvent exprimer, que celui de pouvoir s'endormir pendant un siècle, pour jouir d'un seul coup au réveil de la masse des découvertes, des progrès de toute nature accumulés pendant cette longue suite d'années. L'électricité est assez féconde pour fournir dans le cours naturel du temps des joies scientifiques de cette espèce; à certains moments, des expériences, jusque-là isolées et qui semblaient plus curieuses que fertiles, se rapprochent, se complètent, et, par leur groupement, ouvrent soudain de vastes perspectives, et mettent sur la voie des conséquences les plus étendues.

Dans cet ordre d'idées, il faut signaler les expériences relatives aux mouvements produits par l'électricité.

Il y a longtemps qu'on a obtenu des mouvements à l'aide de l'électricité, les attractions, les déviations des aiguilles

aimantées, les transmissions télégraphiques, etc., datent déjà de loin; mais dans ces effets on passe par l'intermédiaire de l'action magnétique, et bien que celle-ci ne soit, en somme, qu'un état particulier de l'électricité, ces mouvements peuvent n'être pas considérés comme résultant immédiatement de la variation de celle-ci.

Il ne s'agit pas non plus des dilatations qui peuvent naître de la chaleur produite par l'électricité; dans ce cas, il y a transformation du fluide, s'il est permis d'employer ce terme qui n'a plus beaucoup de sens; il s'agit de mouvements, d'effets mécaniques produits dans les corps sans intermédiaire, liés directement et immédiatement à l'électricité.

Ces effets, bien que d'une extrême importance, sont naturellement très-petits en grandeur, et on ne doit pas s'étonner qu'ils aient échappé longtemps dans leur généralité à la sagacité des savants.

C'est la vibration sonore qui, la première, les a dénoncés. On aurait pu s'y attendre, on savait bien que des variations de forme que nos instruments de mesure sont impuissants à constater, peuvent, en se répétant, produire des sons très-appréciables, qui en rendent sensible l'existence. Vers 1837, un Américain, M. Page annonça qu'un fil de fer entouré d'un conducteur isolé produisait des sons lorsqu'on faisait passer des courants fréquemment interrompus dans ce conducteur. Cette très-curieuse expérience fut reprise, discutée par Wertheim, de la Rive, et il fut établi que, sous l'action de ces courants répétés, le fil influencé subissait des variations de forme donnant lieu à des vibrations sonores. On saisissait ainsi le mouvement électrique; sans aucune de ces actions qu'on nomme mécaniques, on produisait un déplacement de matière rendu sensible par les sons émis. C'est sur cette propriété que fut fondé le premier en date des téléphones, celui que Reiss construisit en 1860 et dont le récepteur consistait en un fil de fer tenu par ses deux bouts et entouré d'une bobine où passaient des courants interrompus par les vibrations sonores du transmetteur.

Une autre forme curieuse des vibrations résultant du seul passage de l'électricité est due à M. Varley, qui construisit un téléphone où le corps vibrant était un condensateur formé de lames conductrices et isolantes alternées et renfermé dans un tambour renforçant. C'est cette expérience reprise et ingénieusement variée par MM. Pollard et Garnier qui a donné naissance au singulier condensateur chantant qui causa tant d'étonnement l'année dernière.

Mais il n'est pas nécessaire de recourir à la forme délicate des vibrations sonores pour accuser les mouvements moléculaires dus à l'électricité. M. Edison en a donné dans son électro-motographe une application qui les rend sensibles d'une façon très-frappante. On sait que cet appareil se compose d'une pointe métallique sous laquelle passe, d'un mouvement continu, une bande de papier imbibée d'hydrate de potasse. Le mouvement du papier trouve naturellement une certaine résistance dans le frottement exercé sur la bande par la pointe de métal. M. Edison a reconnu qu'à chaque passage d'un courant dans la pointe, ce frottement change de valeur. Il se produit dans les corps en contact une modification dans l'état des surfaces telle que la force retardatrice n'est plus la même. Edison a employé ce mouvement à produire des signes dans son électro-motographe, et des sons dans son curieux récepteur téléphonique (1).

Les mouvements électriques sont ainsi clairement manifestés; mais ils sont susceptibles d'une démonstration plus nette encore. Dans des expériences récentes, mais dont M. Govi a réclamé la priorité, M. Duter a fait voir qu'un vase rempli de liquide n'a pas la même capacité quand ce liquide est électrisé et quand il ne l'est pas. Il a établi que dans une bouteille à col très-fin, si l'on électrise le liquide qu'elle contient en la tenant à la main, de façon à constituer une sorte de condensateur, le niveau dans le col change brusquement si l'on vient à décharger l'appareil. La forme du vase subit une altération qui a pu être mesurée. Il convient de citer aussi, comme manifestation curieuse de mouvements de même genre, les expériences par lesquelles lord Raleigh a fait voir que la forme d'écoulement d'une veine liquide est modifiée par son état électrique.

Les mouvements moléculaires dus à l'électricité sont ainsi rendus directement visibles et mesurables, et de ces expériences jointes aux faits précédents où on les voit manifestés indirectement, on serait déjà en droit de conclure que toute variation électrique entraîne une variation moléculaire, mais on en peut fournir bien d'autres preuves.

D'abord la démonstration par l'inverse qui est très-probante: si l'électricité produit par ses variations des mouvements moléculaires, réciproquement les mouvements moléculaires doivent amener des variations électriques. Or, en 1856, les travaux de M. du Moncel ont établi que dans les corps médiocrement conducteurs toute variation de pression entraîne une variation de conductibilité et sur ce principe, repris et généralisé par lui, Edison a fondé le transmetteur de son téléphone. On sait que, dans cet appareil, les vibrations de la plaque parlante sont transmises à un bouton de charbon à travers lequel passe un courant, et que toutes les vibrations produisant de légères pressions sur le charbon amènent des variations électriques. C'est sur le même principe que repose son micro-tasimètre où les dilatations très-faibles d'un corps sont rendues sensibles par la pression qu'il exerce sur une plaque de charbon traversée par un courant.

Le microphone de Hughes nous montre aussi un courant influencé par les différences de pression de deux corps vibrant l'un sur l'autre.

On trouvera encore une curieuse manifestation des mêmes faits dans l'électromètre de Lipmann et dans le téléphone à mercure de Bréguet qui repose sur le même principe. Dans ces appareils, on interpose dans un circuit deux tubes renfermant du mercure. On sait que ce métal, à sa surface libre, présente une forme bombée, une surface courbe que l'on nomme ménisque. M. Lipmann a montré que, si par un moyen mécanique quelconque, on modifie la forme de l'un de ces ménisques, le courant en est affecté et reproduit dans le deuxième tube la déformation réalisée dans le premier. Cette expérience est remarquablement concluante, puisqu'elle

(1) Voir ci-dessus l'article « *Nouvelles découvertes en téléphonie* » Th. du Moncel.

87

ous montre l'action mécanique produisant la variation élec-
rique, et celle-ci à son tour rendant le mouvement qu'elle a
reçu.

Dans tous ces appareils, des modifications moléculaires très-petites, résultant de pressions extrêmement faibles, sont immédiatement manifestées par des changements très-sensibles dans le courant. D'où il résulte sans aucun doute la preuve de la liaison intime et absolue qui existe entre la constitution intérieure d'un corps et son état électrique.

Ces recherches ont pris une extension très-grande et une importance de premier ordre depuis l'invention des téléphones parlants. Depuis qu'il a été reconnu que dans l'appareil de Bell on pouvait supprimer la plaque en fer sans détruire le son; depuis qu'il a fallu, par conséquent, renoncer aux attractions magnétiques auxquelles on avait d'abord attribué les vibrations, la théorie de ces appareils a dû entrer dans une autre voie, et on a reconnu là de nouvelles et générales manifestations des mouvements moléculaires électriques.

Les études et les expériences remarquables en ce sens sont si nombreuses, qu'il ne faut même pas essayer de les résumer ici; signalons seulement les résultats frappants obtenus par M. Ader, d'où il résulte qu'un fil quelconque parcouru ou entouré par le courant, en reçoit des vibrations si nettes qu'elles peuvent, convenablement recueillies, transmettre la parole, complément bien remarquable de l'expérience de Page qui a été l'origine de toutes ces recherches.

Signalons les faits si curieux qui ont établi qu'un liquide même peut servir de récepteur téléphonique, et qu'il éprouve par le passage de l'électricité des ébranlements assez sensibles pour être recueillis et transmis à l'oreille.

De tous ces faits on conclut qu'une liaison absolue existe entre la situation relative des molécules d'un corps et son état électrique, et qu'aucune variation si faible que ce soit ne peut se produire dans l'un de ces éléments sans que l'autre en soit affecté suivant une loi régulière.

Ce résultat est d'une haute importance, en ce qu'il semble nous offrir un moyen de pénétrer cette constitution intime des corps dont la connaissance nous est si difficile. Dès à présent il met dans un curieux relief l'extrême instabilité de cette constitution. Il en résulte, en effet, que si les molécules des solides se meuvent dans de très-étroites limites, elles s'y déplacent avec une extrême facilité, et sous l'influence d'actions excessivement faibles. Leur situation relative, la forme en un mot des corps solides, ne peut, sans des forces importantes, subir des modifications sensibles; mais elle en subit de très-petites sous l'action des plus petites forces, et, bien que nous ne le voyons pas, est en réalité dans un état de continuel changement.

Au reste, il est généralement inutile de chercher à prévoir à l'avance les résultats qui sortiront d'une nouvelle série d'études; ils sont quelquefois bien différents de ce qu'on attendait; ce qu'on peut seulement presque toujours affirmer sans crainte, c'est qu'ils existeront, et à cet égard l'ensemble des faits qui viennent d'être rapidement rappelés offre toutes garanties et présente aux recherches un champ qui ne peut manquer d'être fécond.

FRANK GÉRALDY.

L'ÉLECTRICITÉ

REVUE SCIENTIFIQUE ILLUSTRÉE

BEAUX-ARTS — INDUSTRIE — MARINE — ART MILITAIRE — MÉDECINE

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LES MESURES ÉLECTRIQUES

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Comparaison pratique des mesures de l'intensité du courant

Une des méthodes les plus simples dont nous puissions recommander l'usage, est celle qui a été proposée la première fois par Jacobi et qui consiste à recueillir la quantité de gaz inflammable produite par la décomposition de l'eau acidulée.

Suivant cet éminent électricien, le nombre de centimètres cubes obtenus en une minute représentera numériquement la force du courant.

Il n'est pas difficile de deviner quelles sont les précautions nécessaires pour que ces comparaisons aient un degré de précision suffisant pour une pratique éclairée.

On nous dispensera certainement de faire remarquer qu'il faut opérer avec des voltamètres identiques, en employant de l'eau distillée, toujours acidulée avec la même quantité d'acide chimiquement pur, etc., etc.

On sait que le volume des gaz varie en raison inverse de la pression et qu'il augmente par suite de la chaleur. Il faudra donc réduire par le calcul la quantité de gaz recueillie, jusqu'à ce qu'elle soit sous la pression normale de 76 cent. et à la température normale de 0° centigrade.

Mais, malgré toutes les précautions les plus minutieuses, il n'est point possible d'obtenir une exactitude indéfinie.

En effet, le mélange gazeux formé d'un volume d'oxygène contre deux volumes d'hydrogène se dissout en partie dans le liquide, et la fraction ainsi absorbée varie, suivant la température et la pression atmosphérique. En outre, une portion plus ou moins grande du gaz produit par la décomposition de l'eau acidulée adhère aux électrodes de platine, par suite de la polarisation, qui est d'autant plus énergique que le courant est plus fort ou qu'il agit pendant un temps plus ou moins prolongé.

Deux autres appareils, également simples et aussi souvent employés, sont les boussoles dites des tangentes ou des sinus, instruments trop connus pour qu'il soit nécessaire d'en donner ici une description.

Il est inutile d'ajouter que, pour donner aux comparaisons faites avec ces instruments [illegible] sérieuse, il faut se mettre dans des conditions identiques et, par conséquent, définir la force directrice du globe, dans la station où l'on opère, au moment des observations.

En effet, c'est à cette dernière que l'énergie des courants est rapportée, à l'aide de la loi du sinus ou de la tangente, suivant que le limbe dans lequel passe le courant est mobile ou ne l'est pas, et qu'il reste dans le plan du méridien ou passe dans celui que l'aiguille de boussole prend lorsqu'elle est soumise à l'action du courant.

Le galvanomètre doit être choisi de telle sorte, que la résistance qu'il oppose soit négligeable.

En conséquence, il faut un fil court et gros, quand le courant à mesurer est de faible tension.

Au contraire, il faut un fil long et fin, replié plusieurs fois sur lui-même, lorsque le courant est de faible quantité, mais de grande intensité.

On comprend qu'il ne soit pas très-commode de ramener les unes aux autres les mesures prises avec des instruments si différents.

La difficulté est d'autant plus sérieuse que la construction des appareils entre pour beaucoup dans les résultats obtenus.

Non-seulement il faut se préoccuper de la manière dont l'aiguille est placée dans sa chape, mais encore de l'intensité absolue de son magnétisme qui varie avec bien des circonstances difficiles à déterminer. Enfin, le diamètre du cercle sur lequel les fils de cuivre sont enroulés influe lui-même d'une façon appréciable sur les indications.

Toutes ces considérations font qu'il ne faut attacher qu'une médiocre importance à la rigueur exa-

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a *quantity x of force.* Force—the true mathematical force—exists not as a quantity, but as a degree. The instant you express force as a quantity it becomes energy. Now, Mr. Moberly in his following explanations shows correctly the relation which does exist between force multiplied by distance and energy, only he misses the fact that it is this very relation I was employing in my articles.

I do not feel myself called upon to defend my description of the values of the Volt, Ohm, and Veber in absolute units. *I gave those values as the report of their originators, the B.A. Committee, gives them.* Mr. Moberly may be quite correct in his conception of them from the abstract mathematical standpoint, but he must settle that with the mathematicians. My object is simply to make the subject intelligible to ordinary people, and to show what actual natural truths underlie the mathematical theory. But I have none of that "contempt for mathematics" attributed to me. They are invaluable in their own sphere. I only insist that formulæ are not final truths; that their meaning, as well as their use, should be understood, and that they must not be regarded as explanations of nature's mode of action when they are only artificial modes of calculating her results. Hence, therefore, I never professed to reject them as untrue. Let us admit them as true mathematically; then Mr. Moberly says they become true physically, if we assume conventions in accordance with the definitions. Be it so; we then come to the question what are the true conventions? The mathematicians prefer to express them as $L^{\frac{1}{2}} M^{\frac{1}{2}} T^{-1}$, and so on. But satisfactory as these may be, there are some people who humbly whisper, Yes, that is true, no doubt; in fact, it must be so, *but what does it mean?* Now it is my ambition to answer *that* question, and if Mr. Moberly will shift his view to my standpoint he will see that I do this. The Volt is a force: it is not energy; yet it is defined by dimensions as above of space, mass, and time, and this combination is *energy*. The definition implies the *quantity of energy* which under given conditions constitutes a definite *degree of force*, or, in other terms, this definite degree of force acting in those dimensions generates that quantity of energy. In this sense, then, force and energy are the same thing; so that I only ask Mr. Moberly to assume my convention in accordance with my definition, and what I say is that he will then see some aspects of truth not visible from his own standpoint.

Gravitation is, as far as we know, an actually existing force. Head of water is a form of gravitation, and is a force definable by its pressure or potential. In that definition it is abstract—it is a degree, not a quantity. In like manner steam pressure is a force; pounds per square inch is a degree, not a quantity; but this is a mathematical, not a real force. It is dependent for its existence upon the *quantity of energy* concentrated within given dimensions. If we combine with steam pressure one dimension, area of piston, we have energy as pounds per space traversed; if we add this second dimension we have energy in foot-pounds. So if we add a corresponding dimension to head of water, which itself includes one dimension, viz., a unit area corresponding to the piston area, we have gravitation expressed as energy. Now I hold as to electricity certain views:—

1. Electricity is not a fluid or an existing thing, material or etherial.

2. Electricity is not a force. It does not resemble gravitation in having an inherent existence.

3. Electricity is energy charged upon material molecules. It resembles heat and motion.

My object, then, was to trace out the mode in which energy becomes force in the electric circuit, and as correctly as expressed in mathematical formulæ, to discover, in fact, its analogy with energy developed as force in the steam-boiler. I have long worked at this with more or less success, till at last it occurred to me that the analogy was to be found in head of water. That analogy has long been employed as relates to tension or potential, but its true bearing has never before been observed so far as I know. When I saw that the square root of head of water fulfils in hydraulics exactly the same function as electromotive force does, as the Volt in electricity, I saw that the laws of the current of electricity and of liquids are identical, instead of being, as every one has always said, quite different. I have long foreseen that it must be so, but I have only now been able to prove it. That, and the truth that resistance, as defined electrically, is a misnomer, are the real subjects of my three articles, and I await with some little curiosity to see who is going to attack those heresies of mine—heresies and paradoxes to-day—truths accepted of all to-morrow.

Sigma.

ELECTROMOTIVE FORCE—CURRENTS AND RESISTANCE.

[15718.]—I am under some little difficulty in replying to Mr. Moberly, 15686, p. 253, because where I am at present I have not with me the articles referred to, or a single book relating to the subject, not even my own; I can, therefore, only treat it generally at present. I will leave out of consideration therefore my thesis that the Volt, Ohm, and Veber are the same quantities of energy, but I may remark thereon, as well as concerning other points, that everything has several sides; truth takes account of all the accessible sides, although for special purposes now one and now another aspect may be most important. My purpose was to indicate a very important part of the electrical system, which is entirely ignored in the usual way of dealing with it. Now, Mr. Moberly says that I repeatedly use force and energy as interchangeable terms. The distinction is so clear in my own mind that I doubt that; but then that distinction is only of recent growth, and the terms are colloquially so similar in meaning that there is a borderland in which the real distinction is lost; in some such slight matters I have noted instances in which I should change the terms on revision, though the change would have but little significance. But my very object in the articles referred to was to show that from a certain aspect force and energy are identical. For mathematical purposes, that is, in the legitimate field of mathematics—calculation—the expression of facts and operations in formulæ, it is essential that force and energy be kept as two distinct conceptions, having each its own symbolic expression and its own function in formulæ. None the less, force when acting becomes energy, and energy often has to be formulated as a force. What I aimed at doing was to make manifest the results following upon the consideration of force acting in a unit space, by which the abstract force is converted into concrete energy. Why did I do this? To show in what manner energy is converted into mathematical force. It is because Mr. Moberly, in common no doubt with many others, has missed this that he can go with this "fundamental error; a quantity x of force can never be equal to or identical with a quantity y of energy." Now the error here is, I think, his own; there cannot exist

EXTERNAL RESISTANCE AND INTERNAL CURRENT.

[15791.]—There is one part in the otherwise correct letter of "Humble Bee," 15717, p. 290, which I think will be misleading to many readers who are not well acquainted with the subject; it is this.

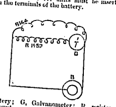
"To reduce the current flowing through a galvanometer to one-twelfth of its strength, the galvanometer must be shunted, with a resistance of twelve units, the galvanometer resistance being 132 units."

This gives one the idea that if the internal current was not in question, such would be the way to reduce the current in the galvanometer. The result of such an arrangement would be this.

The current in the galvanometer would be *unaltered*, while the internal current would be increased twelve times.

To reduce the current flowing in a galvanometer of 132 units resistance to one-twelfth of its strength, a resistance of 1,452 units must be introduced in the circuit.

To keep the internal current unaltered, a shunt with a resistance of 144 units must be inserted between the terminals of the battery.



B, battery; G, Galvanometer; R, resistance coil; S, Shunt.

H. Dominy.

The English Mechanic
AND
WORLD OF SCIENCE AND ART.

FRIDAY, MAY 9, 1879.

ARTICLES.

ELECTROMOTIVE FORCE.—RESISTANCE AND CURRENT.—III.

By J. T. Sprague ("Sigma").

Using the received system, we can calculate the conditions of the electric circuit and current, by means of the formula of Ohm, employing either the absolute system of measures or the practical system of the British Association usually employed. I do not propose to treat of the absolute system, because it would of itself take up an entire article. The practical system is based upon it as the units are large multiples of the absolute unit.

The unit of electromotive force is the Volt, named after Volta, of the value of 100,000 absolute metre-gramme-second units. This value was selected because it is pretty close to the force of the Daniell cell, which has long been employed as a unit of electric force. Electromotive force is a theoretical absolute force resembling a pressure or a tension in that it is abstract, and means nothing till its area of action is defined. Hence it is independent of the dimensions of its source; an enormous electromotive force can be developed by a small electric machine, and the electromotive force of a cell of a fixed type is the same whether the cell be large or small. This is readily seen by opposing them to each other, and questions are so frequently asked on this point that I will describe a simple but very striking experiment I have often used to illustrate it. Take a small copper wire and the smallest strip of zinc which can be cut; wrap the latter in 2 or 3 folds of blotting paper, and fix them on a strip of wood as a support. Dip them in the zinc solution of a Daniell's cell so as to soak the paper, and then place them in a vessel containing solution of sulphate of copper; connect the copper wire to the copper of a large Daniell cell, and the zinc to the zinc, inserting a galvanometer in one of these connections. No current will pass, though if the cell and the micro-cell are connected separately to the galvanometer, it will show that the large cell can furnish a current hundreds of times greater than the little one. The reason of this is shown in the formulæ, thus—$\frac{E-e}{R} = C$. Now, if E and e are of equal value, they negative each other, and there is no force in action. Should two cells of different forces be so opposed, the force in action is the difference between them. Thus, in electro-metallurgy, there is usually what is called "Polarisation" set up in the depositing vat when the solution near the anode is saturated with metal, and that near the cathode exhausted; then there is a tendency to re-dissolve the cathode, and this sets up an electromotive force opposed to that of the battery; then the formula comes into action, and the current is reduced. If in these circumstances you have a galvanometer in circuit, you will see this reduced current. Now if you stir the liquid, so as to equalise the solution, you will see the galvanometer instantly mark an increase of current. This is one reason (not the only one) why it is advantageous to have the objects in motion while deposition is going on.

The Volt is also the unit measure of tension or sum of + and − of tension (and of potential or difference of potential—more fashionable names for the same thing), which are the first products and evidences of the presence of an electromotive force. In fact, tension is very often compared to pressure in the form of head of water, though the comparison is not quite correct, as double tension doubles current, while double head of water acts in a different proportion, because in that case the same force, gravity, is acting in both heads, while a double tension implies a doubled force. But when we look behind the names of things and forces to what they really represent, we often find hidden meanings. Head of water is pressure in one sense, but, as it also represents the height through which the water falls under the influence of gravity, it is also equivalent to the energy due to that fall. Head of water is therefore in one sense a force, and a force is measureable by the velocity it can generate, and head of water, as a well-known fact in hydraulics, generates velocity, that is to say current or flow of water in the ratio of the square root of the head. But, on the other hand, velocity implies also energy in the ratio of its squares. Hence, as energy due to head of water generates a velocity in the ratio of its square root, so velocity in its turn returns that energy in the ratio of its squares. Hence M, our symbol of mechanico-motive force, is seen to mean the same thing as the square root of head of water, and consequently 2M, while called a double force, means energy supplied or expended in fourfold degree, or as the square of M. In like manner E, the symbol of electromotive force, is but an expression for the square root of the energy supplied to the circuit. This is to be seen at once in batteries where if we use two cells, which means 2E, to double the current, four times the quantity of zinc is consumed, and consequently four times the quantity of energy supplied. Here, then, we have at once the reason why current varies in Ohm's formula directly as the electromotive force. E is a symbol for the square root of the energy; C, current or velocity, expresses the square root of the energy expended in carrying the current through the resistance.

The unit of resistance, the Ohm, fairly named after the man who really introduced the idea of resistance in its present form, is equal to ten million absolute units of force. It was selected as the nearest multiple to the largely employed unit of resistance, the Siemens mercury unit, which is a square centimetre of mercury 1 metre long. Now this unit itself is obviously a conductor of defined capacity; it is a most round-about way of dealing with it to call it a resistance. The analogy is perfect between it and the square inch conductor of water which I employed to illustrate the true nature of resistance.

The Ohm is, in fact, a wire of definite conducting power, but the actual Ohm, as used, doubtfully fulfils the intentions of its producers, there being good reason to believe that it differs possibly more than 1 per cent. from its intended value. At all events, the Ohms in actual use differ a good deal among themselves, partly from difficulties in adjusting them at first, and partly from changes which take place in the wires. They are usually made of German silver because its resistance is considerable, and does not change largely with variations of temperature. But German silver is a brass in which nickel to some extent replaces zinc. Brass is subject to some very strange changes, and probably German silver is so also, though not to the same extent. In fact, I have only had one sample of German silver wire (and that of low quality containing little nickel) assume the extremely brittle state which is a common thing in brass wire. In this particular case the wire, No. 35, fell into pieces on unwinding, though it was quite soft when wound on the reel.

To obtain resistances, either Ohms or multiples, it is necessary to measure the several wires against a standard, by means of the Wheatstone bridge. It is an operation involving an amount of patient labour and skill honestly applied, such as no one can conceive who has not himself taken the work in hand.

We have already seen that what is called electrical resistance is misnamed. The Ohm, the unit of this measure, is really a defined conductor which allows a current of electricity of definite amount to pass under the defined unit force. But it has a definite ratio to energy: all conductors, such as pipes carrying water, really present a resistance; in the case of water this is due to the friction of the particles of water upon each other and upon the surface of the pipe; in the case of electricity it is due to a molecular friction probably, consequent upon that molecular motion which accompanies, if indeed it is not itself the current. This resistance, be it to water or to electricity, increases as the square of the current passing. The unit Ohm is then a conductor which presents so much of *this true resistance* as absorbs all the energy of a unit current produced by unit force. Hence, the Volt, the Ohm, and the Veber are simply different relations of, or different expressions for, *the same amount of energy.* Therefore, in multiplying them together, or dividing one by the other, as in Ohm's formulæ, we are not multiplying or dividing different concrete entities, which is really an impossibility, but simply working out an ordinary arithmetical calculation.

The energy put in the form of a Volt of electromotive force acting through a conductor of 1 Ohm develops 1 Veber of current *in that conductor*, and converts the whole of the energy into heat. This must be clearly realised. Under these conditions there is no development of what is called electrical action or electricity. The current can do nothing besides heating the conductor. If any external work is done, such as developing magnetism, the conditions are altered, the current is lowered just as if an additional resistance were inserted in the circuit. In fact *the work is an extra resistance*, and if it is valued in foot-pounds, or other unit of work, it can be expressed either as Ohms of resistance or as Volts of electromotive force, either of which may be the true expression according to circumstances.

I must now return to a statement just made that the Volt, Ohm and Veber are the same quantities of energy, which will no doubt take by surprise almost every one, because the volt is 10,000 absolute units, the Ohm, 10,000,000, and the Veber ·01, and the absolute unit is ·000,737,335lb. To explain this curious result of mathematical mystification I must use the table, p. 217, of my "Electricity: its Theory, Sources, and Applications," showing the convertible values of various units.

The Volt, as I have fully shown in that work, is a force derivable from chemical action in such manner that 4,673ft.-lb., maintains it under unit conditions for 6,338 seconds, that is to say, 4,673 ÷ 6,338 = ·737,335ft.-lb. per second. The energy of a Veber is ·01² × 10,000,000 = 1,000, and 1,000 absolute units = ·737,335ft.-lb. The heat developed in 1 Ohm by 1 Veber current is by experiment, calory ·24,065 which, converted by the mechanical equivalent of heat, is ·737,335ft.-lb. Q. E. D.

Hence we learn that the simple ratio of the elements of Ohm's formulæ $\frac{E}{R} = C$ furnishes us correct results because (1) each of

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Electricity in Air.

Recent experiments of M. R. Nahrwold tend to demonstrate that it is the dust in the air, and not the air itself, which becomes electrified. When air is sifted of dust by means of glycerine, it takes only a very feeble charge. M. Nahrwold also remarked that positive electricity discharges itself more readily in air than negative, a result contrary to those of Wiedeman and Ruhlman, and we think also of Thomson. During the electric discharge, when viewed by the light of the mechanical theory of gases, would seem to show that the discharge, besides increasing the *vis viva* of the moving molecules, also increases the *vis viva* of the oscillatory motion of the ether envelopes. Different spectra got from different points in the width of the gaseous tube are therefore not to be referred only to the different temperatures of the gas, but to the amounts of electricity of which the passage causes the oscillation of these ether envelopes.

June 79

Engineer July 1879

By means of the formula given by Mr. D. G. FitzGerald in the *Electrician* for August 24th, 1878, it may be calculated that 1 lb. of zinc consumed in a Grove's cell—taking 1·80 volts as the average electro-motive force—would do 1,932,840 foot-pounds of work, and that 1 lb. consumed in a Daniell's cell—taking 1·09 volt as the electro-motive force—would do 1,170,500 foot-pounds, assuming the whole of the heat produced to be utilised in both cases. But, even theoretically, we cannot assume that more than half this heat would take the form of work. It has been found that 1 lb. of hydrogen combining with its equivalent of oxygen is capable of raising 51,146 lb. of water 1 deg. Fah.; 1 lb. of carbon, 14,500 lb. of water; 1 lb. of phosphorus, 11,900 lb. of water; and 1 lb. of sulphur, 2800 lb. of water. One grain of zinc was found to raise only 8 lb. 1 ft. high by means of an electro-magnetic machine. One grain of coal in the furnace of a Cornish engine will raise 143 lb. through the same distance.

Engineer July 1879

A paper, "On the Electric Dilatation of the Armatures of Leyden Jars," by M. Duter, was recently read before the Académie des Sciences. He finds the law verified, which is expressed by the equation $u = \frac{K V^2}{e}$, where u is the increase of volume of the jar, e its thickness, V the difference of potential of its armatures, and K a coefficient characteristic of the apparatus. He considers that electric pressure is not the cause of the phenomenon, but that there is here a new phenomenon of electricity. On the same subject, a paper was read by M. Righi. He distinguishes instantaneous dilatation, due chiefly to polarisation of the glass, from persistent dilatation, not before observed, and due to development of heat; and he thinks it probable that at the same time the polarisation, and perhaps also the attraction between the armatures, produce in the glass a diminution of thickness.

The following method of constructing a voltaic couple or a home-made Daniell cell may be of interest to the student:—Select a small round earthenware jar, such as is used for keeping preserves, and having lined the bottom with gutta-percha, or some suitable cement, to the depth of ½in., fix upright in this a rod of zinc, of equal height with the jar, to which a length of copper wire has been attached by passing it through a hole drilled in the upper part of the zinc rod, or by soldering. Make a cylinder of pipeclay, or other porous clay, larger than the zinc rod, and having dried it, make it hot in the fire by degrees, till it attains a red heat. Let this cylinder cool gently, and when cold place it in the jar round the centre rod encircling it at a little distance. By moderately heating the end of the cylinder it will, when placed on the gutta-percha, make a groove which will fix the tube, and prevent infiltration of the fluids. Line the inside of the jar with a plate of thin copper bent into a cylindrical form and having a few holes punched in it, through which may be threaded the extremity of another length of copper wire. On the top of this cylinder place a flat ring of copper pierced with holes, and nearly, but not quite, touching the porous cylinder. This forms the battery. To charge it, the *Electrician* gives a saturated solution of sulphate of copper poured between the copper and the clay tube, and some crystals of the same salt are placed upon the perforated ring so as just to be in contact with the solution. The zinc compartment is then to be filled with a solution of sulphate of zinc, sal-ammoniac, or common salt.

Engineer July 18 1879

Several remarkable results have been recently obtained by Herr Kohlrausch in his researches on the electric conductivity of aqueous solutions, and especially on the influence of temperature on the conducting power of liquids, as given in the *Annalen der Physik*. Thus concentrated soda-lye, which, at a temperature of — 10 deg. conducts badly, acquires, under action of heat, a conducting power which increases regularly and with very great rapidity, so that at + 80 deg. the liquid conducts a hundred times better than at — 10 deg. A solution of bisulphate of potash behaves quite differently; its conducting power increases very slowly with the temperature, up to a temperature of 60 deg., at which there is a maximum. From this point the conductivity remains nearly constant, as the temperature is raised. Studying solutions of sulphate of soda, which are known to present at 33 deg. a remarkable peculiarity, due to the proportion, more or less, of water of crystallisation, Herr Kohlrausch found nothing peculiar in the conducting power. This, it is considered, seems to prove that water of crystallisation does not play any part in the conductivity of liquids for electricity. Engineer July 18 1879

~~Journal of~~ Telegraphic Journal July 15 1879

Prof. Rowland of Baltimore made some observations on the new theory of terrestrial magnetism of Profs. Ayrton and Perry. He said the experiments on which the theory was founded had been attributed to Helmholtz, but they were entirely his own, he having gone to Berlin to make them. The new theory had occurred to himself. On making these experiments out he had rejected it because he found that the potential which the earth's surface would require to have would not only cause violent planetary disturbances, but by mutual repulsion drive objects off the earth. He had made also an experiment to see if absolute motion of electricity would cause magnetisation, but failed to get any effect from it. Then he resorted to calculation to find the magnetic effect of relative motion by rotation of a charged sphere of perfect magnetic permeability that is more magnetic than iron. He found that when the sphere was uniformly charged and rotating there would be a magnetic field in its interior; but instead of the result of Messrs. Ayrton and Perry that if the earth were charged to a potential of, he believed, 10^8 volts relatively to interplanetary space, the earth's magnetism would be what it is. He found the necessary charge to be 61×10^{15} volts. In the ordinary atmosphere this potential would produce a spark nine million miles long, and discharge across to the moon. If the moon were electrified to the same degree the mutual repulsion would overcome the force of gravity between them. He therefore considered terrestrial magnetism to be still a mystery.

He had also thought that the aurora borealis might be explained by supposing the upper regions of the earth's atmosphere electrified; the winds carrying the upper strata towards the poles, electricity would condense there. This hypothesis is tenable still.

Prof. Ayrton said that whether or not the new theory of magnetism should be so rejected depended on whether or not, Prof. Rowlands calculations or those of himself and Prof. Perry were wrong. It had been found by Sir William Thomson from experiments at Arran, that the earth was electrified with respect to the earth and that there is a difference of potential of 30 volts between earth and air for each foot of ascent. This gave 1360×10^{12} centimetre-gramme-second electrostatic units as the potential of the earth. The new theory required the potential to be 1011×10^{11} supposing the earth to be of solid iron, or about 14 times more—a wide margin.

Prof. Rowland said he had not seen the calculations of Profs. Ayrton and Perry yet, but he believed his results to be correct, as he had checked them.

Mr. Bailley exhibited a modification of Avago's experiment, in which a copper disc is caused to rotate continuously by changing the polarity of four electro-magnets underneath by a revolving commutator.

Mr. Conrad Cooke exhibited a single voltaic element showing the internal current. This is done by forming the glass vessel containing the element into a helical tube between the poles, and hanging a galvanometer needle in the interior of the helix; the internal current deflects the needle.

Rotary Magnetic Power of Gases.—M. Henri Becquerel finds that lighting gas, sulphide of carbon vapour, oxygen, and other gases shift the plane of polarisation of light under a powerful magnetic influence. Oxygen behaves like a highly magnetic body, and gives a negative rotation. M. Bichat also finds that the vapour of sulphide of carbon gives a decided result of this kid.

3676. "Magnets and armatures for producing motive power." H. E. Newton. Dated Sept. 17. 6d. A disc of metal or other material carrying a number of armatures is made to revolve either in a horizontal or vertical direction. A number of magnets equal to the number of armatures are arranged round it and each is attracted in succession by the permanent magnets. Each of the latter is temporarily neutralised after performing its attractive duty.

~~Journal of~~ Telegraphic Journal July 15 1879

The Thermal and Galvanometric Laws of the Electric Spark in Gases.—To study this subject M. Villari has constructed a glass globe thickly coated with shellac, and furnished with four tubes, two vertical and two horizontal. These last are traversed by two brass electrodes, interiorly terminated by short wires of platinum or silver, with knobs of silver or platinum, and exteriorly terminated by brass balls. To the upper tubes is fitted a cock which allows different gases to be introduced. To the lower tube is fitted a long glass tube, of about 3 mm. diameter externally. This last tube is maintained vertical and plunged at its lower extremity in a glass which holds a mixture of glycerine and water. The apparatus is enclosed in an insulating box. This novel thermometer was placed in the circuit of a battery of eighteen Leyden jars. In the same circuit is placed also an electrometer jar, and a hand key. The battery was charged by the aid of a Holtz machine; the discharge produced a spark in the globe, and the heat resulting from it depressed the level of the glycerine in the vertical tube. With this apparatus (the electrometer serving to measure the quantity of electricity furnished by the battery), M. Villari finds that for nitrogen, oxygen, hydrogen, and carbonic acid (1) the heat developed in the gas by an electric spark is directly proportional to the quantity of electricity which produces the spark. With a galvanometer in circuit, M. Villari also found that (2) the deflections produced by the discharges of the jar were proportional to the quantities of condensed electricity. Further (3) the deflections produced by the discharge of condenser are constant and independent of the length of the spark produced in any part of the circuit; (4) the quantity of heat developed in a gas by the electric spark increases in proportion to its length, a result which implies that the temperature of the spark at its different points is independent of its length, and that the electric resistance of the gas is proportional to the thickness of the gaseous bed traversed by the discharge. (5) When the charge which produces the spark remains the same the quantity of heat developed by that spark is independent of the surface of the condenser. (6) The galvanometric deflections produced by the discharge of a condenser is independent of its surface. To sum up, the thermal and galvanometric deflections produced by spark or by discharge of condenser, are proportional to the quantity of electricity which produces them, and at the same time to the length of their active circuits, that is, the length of the spark or the length of the galvanometer wire.

~~Journ~~ Tel. Aug 1 1879

Intrinsic Energy.

By means of the formula given by Mr. D. G. FitzGerald in *The Electrician* for August 24, 1878, it may be calculated that 1lb. of zinc consumed in a Grove's cell (taking 1·80 volts as the average E.M.F.) would do 1,932,840 foot-pounds of work, and that 1 pound consumed in a Daniell's cell (taking 1·09 volt the E.M.F.), would do 1,170,500 foot-pounds, assuming the whole of the heat produced to be utilized in both cases. But, even theoretically, we cannot assume that more than half this heat would take the form of work. It has been found that 1lb. of hydrogen combining with its equivalent of oxygen is capable of raising 51,146lb. of water, 1 deg. Fah.; 1lb. of carbon, 14,500lb. of water; 1lb. of phosphorous, 11,900lb. of water; and 1lb. of sulphur, 2,800lb. of water. One grain of zinc was found to raise only 8lb. 1 foot high by means of an electro-magnetic machine. One grain of coal in the furnace of a Cornish engine will raise 143lb. through the same distance.—*The Electrician.*

Nature July 24 1879

At a recent meeting of the French Physical Society M. Bouty described the action of heat on metallised thermometers. The contraction produced at the moment of deposit of the metal is entirely compensated by the difference of the dilatations of the glass and the metallic envelope, at a temperature which is higher the greater the contraction, and the smaller the difference of the dilatations, but independent of the thickness of the deposit. Above this critical temperature traction takes the place of pressure on the bulb; ruptures presently occur at the surface of contact, and the result is permanent deformations, which produce a new displacement of zero. This latter effect is never produced when the critical temperature is not exceeded. A metallised thermometer may be used to measure temperatures, if it have been compared with a typical thermometer, from which it does not differ sensibly unless the metallic deposit be of considerable thickness. When sulphate of copper is electrolysed between two very sensitive thermometers, coated with copper superficially, the thermometer attached to the positive pole is found to be at a temperature superior, the negative thermometer at a temperature inferior, to that of the surrounding liquid. The same phenomenon is observed in electrolysing sulphate of zinc between two thermometers covered with zinc. M. Bouty recalled the fact that when two plates of zinc or of copper are kept at different temperatures in the corresponding sulphate, a current arises, and the warmer metal is the positive pole. There is between the production of these currents and the phenomena studied by M. Bouty a relation of reversibility similar to that which connects Peltier's phenomenon and ordinary thermo-electric currents.

Nature 7 1879

The following is the prize theme given by the physico-mathematical class of the Royal Academy of Sciences of Berlin:—According to Faraday's theory of electrodynamics, as worked out mathematically by Prof. Clerk Maxwell, the generation and disappearance of dielectric polarisation in isolating media as well as in celestial space, are phenomena which possess the electrodynamical effect of electric currents, and which can be called forth like the latter by electrodynamical induction forces. The currents in question would, according to the theory, be equal in intensity to that one which charges the boundary surfaces of the conductors electrically. The Academy now demands that decisive experimental proofs be given for or against the existence of electrodynamical effects of nascent or disappearing di-electric polarisation, of the intensity supposed by Prof. Maxwell, or for or against the generating of di-electric polarisation in isolating media by means of electromotoric forces induced magnetically or electrodynamically. The term for sending in solutions of the theme ends on March 1, 1882.

The Sun as an Electric Focus.

Mining & Sc Press Aug 2 1879

The problem of the source whence the sun derives its heat and light is perhaps no nearer a practical solution now than it was a hundred years ago. It is true our knowledge of the constituent elements of the sun has increased, but that knowledge is only abstract. It has been contended that the sun is a burning mass, which, in the course of time, will "burn out," and leave the planets dependent upon it, uninhabited—dead. All of the combustible elements of this earth are said to be stowed-away sunbeams. The coal so largely used as a steam generator and for economical purposes, a product of the sun. Concentrated sunbeams, the hidden heat of which has been brought forth by the industry and genius of man for purposes of comfort and utility. Some writers have declared the sun to be pure fire, not fed by any supply, while others declare it to be the rendezvous of comets, the absorber of dead planets.

Prof. Proctor estimates that in each second of time the sun distributes as much heat as would be produced by the consumption of eleven thousand eight hundred millions of millions of tons of coal. He further estimates that if the sun consisted entirely of coal, burning at this rate, it would burn out in less than 5,000 years.

If the sun derives its combustion from material within itself, it would seem as if there would be some diminution, and since Herschel looked at the orb and calculated its conflagration, such an enormous waste of gases would surely have been noticed by succeeding astronomers whose calculations are quite exact. But the light and heat of the sun is not on the wane.

The latest theory is that the sun is an emitter and receiver of electricity at one and the same time. It is contended that there is a mighty outpour of magnetic currents from the north and south poles of our planet, and that these currents meet and form a complete circuit, the sun being the point of meeting, as it is with the earth, so, also with all the other planets, only the outpour is greater, or less, according to size. Focality produces luminousness, and the currents are sent back to the planets and their satellites in proportion to their respective wants. Scientifically put, the new theory is that the planetary system is a vast magnetic-electric machine, or "generator," the planets being permanent magnets, which, while in motion, generate electricity enough for their own light and heat, with some to spare, the sun is the carbon point" where all these currents meet and become luminous. Thus, the sun, instead of depending on the combustion of coal meteors or other fuel or friction, or "contraction" of its own surface, which would soon leave us in darkness, is dependent upon the electricity generated by the planetary system for its light and heat. This disposes of the non-eternity of the sun as a light-bringer to planets, and buries for an indefinite time Proctor's melancholy theory that the earth will breathe its last and give up the ghost as a life-producing and life-bearing body at a day somewhat too early for happy contemplation. It gives a possible solution of another vexed question, the origin of the aurora borealis, by assuming that when the electric currents are interfered with by meteoric or other bodies, the back-flow produces that splendid phenomenon. Altogether, the theory is worthy the attention of astronomers, who are as much in the dark about the sun's heat and light as unscientific persons.

Galvanic Dilatation.

Tel Journal Aug 1 79

In order to test Edwards' hypothesis that the passage of a galvanic current produces a mechanical elongation, M. Blondlot has contrived a delicate experiment. He takes a strip of copper, thoroughly annealed, which he bends into a kind of quadrangular spiral, fastened at its upper end and carrying at its lower extremity a shaft which plunges into mercury. When a current is passed through the spiral, all the angles should vary if there is any dilatation, and as all the variations are culminative the terminal stalk should turn through an angle which could be easily measured by Poggendorff's method. An elongation of ·0000025 could be readily detected in this way, but as he found none, Blondlot concludes that the hypothesis is incorrect.—*La Nature.*

Tel Journ Aug 1 1879

The Electromotive Force of Mercury Alloys.—Mr. Hockin and Mr. Herbert A. Taylor have been engaged in a long series of experiments suggested by the curious, but well-known fact, that the amalgamation of a zinc plate generally renders the zinc more electro-positive than it was before amalgamation, while at the same time it protects the plate to a great extent from the action of dilute sulphuric acid. Their results show that potassium, sodium, cadmium, tin, and copper, are rendered more electro-negative by amalgamation. Lead and the other electro-negative metals are little altered. Iron and zinc are rendered distinctly more electro-positive in dilute sulphuric acid. In zinc sulphate zinc is not altered by amalgamation. The authors conclude that, within narrow limits, mercury alloyed with any number of metals takes the place in the scale of electromotive force of the most electro-positive metal that it may contain, if the amount of the electro-positive metal present is not less than about $\frac{1}{10000}$th in weight of the mercury. This seems explained by the facility with which a mercury surface becomes polarised, and the tenacity with which it retains the hydrogen. Also, if any zinc or other impurity exists on a portion of the surface of a mass of mercury exposed to an electrolyte, the whole service will fall to the potential of the zinc or other the most electro-positive impurity present. These laborious and important experiments of Messrs. Hockin and Taylor, are fully published in an original communication in the last number of the Journal of the Society of Telegraph Engineers.

Transformation of Energy.*

Journ of Tel Aug 1 1879

The subject I propose to bring before your notice this evening is one to the development of which we owe the great strides which science has taken during the last half century. Though peculiarly physical, the modern doctrine of energy has an important bearing upon all branches of science, and it is well that those whose professional duties touch in any way upon any of these branches of science should have clear notions of what is really meant by energy. Philosophers are wont to speak of matter and mind as if they were only things which could be reasonably assumed to exist in the universe. We believe in the existence of matter because it affects our senses; but the great argument in favor of the objective existence of matter is its indestructibility—that is, the impossibility as far as our experience goes, of destroying matter or of creating matter. We can only shape matter, transfer or transform matter, but never has matter by pure physical means been called into existence. Now, in nature there is another something far subtler than matter, but possessing this same property of indestructibility,—a something, too, which can be traced in its actions in the material universe, and this something which we call energy, has as real and objective an existence as matter itself. The energy of a material system is usually defined as the capacity the system possesses for doing work. For example, in lifting a stone I do work against its weight, and the energy required to do that work was originally stored up in my muscle. The work I do is measured by the product of the force overcome into the distance through which it is overcome—*i. e.*, by the product of the weight of the stone into the height through which it is raised. Say I raise a pound weight twenty feet, then I perform twenty foot pounds of work. In raising the stone I have suffered a certain fatigue, I have lost energy, but this energy, though lost to me, is not lost to the world, it is stored up in the raised weight which has now, because of its position above the earth's surface, a certain capacity for doing work. This energy of position in the mass is measured by the amount of work which I originally performed on it—namely 20 foot pounds; but if the mass be permitted to descend it, in its turn, will lose this stored up energy which will become transformed more and more into energy of motion as the mass, descending, gains in velocity. At the instant the mass touches the earth, the stored up 20 foot pounds of energy will be wholly transformed into energy of motion, which the mass still possesses. After the impact, however, the mass is brought to rest; it has been unable to overcome the resistance offered to its motion by the earth's surface; it has lost its energy, but this energy reappears in the heat and sound which are developed at the instant of impact. I have thus traced a certain portion of my muscular energy through a variety of transformations which ultimately end in the generation of heat. Throughout it all, however, the quantity of energy has been unaltered. Illustrations might be multiplied indefinitely. To-night I shall confine myself to electrical illustrations.

* A lecture by Mr. Cargill G. Knott, D.Sc.

Let us consider a galvanic battery as our source of energy, and let us follow the transformations of part of this energy as exemplified in well known electrical experiments. The energy of the galvanic current is derived in the first place from the combustion of the zinc in the Bunsen cells which form the battery, and this combustion depends upon chemical action, which is simply a transformation of potential energy of molecular distribution. Into this we cannot enter at present, but pass on to the consideration of the electric current and the various ways in which it may be employed to do work. A current flowing along any conductor experiences a certain resistance, to overcome which it does work, and the energy which it so loses is transformed into heat. By passing the current through a thin iron wire, the heat generated is sufficient to make the wire glow till it melts. This process is familiar as a method by which mines are frequently blasted. Electrolysis or decomposition of a liquid (such as dilute acid) by the passage of a current affords another striking example. Here the energy of the current is expended in pulling the molecules asunder so as to separate them into their constituents. The hydrogen and oxygen into which acidulated water is decomposed may be collected in a vessel and exploded, when the sudden expansion of the water vapor produced by the combustion of the hydrogen in the oxygen causes a violent disturbance in the air, which is evidenced as sound. In this form we partly recover the energy which the current originally lost in affecting the decomposition. The discovery by Oersted, in 1820, of the motion of a magnet by a current flowing near and parallel to it, supplied the link which was wanting between electrical and magnetic phenomena. An electric current is as much the seat of magnetic action as a magnet is, and by suitable means the energy of the current may be transformed into the energy of magnetism. Wherever a current is flowing, there, of necessity, is a magnetic field; and if any system is acted upon energetically when placed in this field, as is the case with a magnet or a piece of iron, the current loses a certain part of its energy, which is first transformed into energy of motion, ultimately, as in all transformations, taking the form of heat. Thus, by passing a current through a wire coiled round a soft iron bar, the iron acts for the time as a magnet, and, indeed, all the phenomena of magnetism can be produced by means of helices or spirals of conducting wire. But not only does a current affect a magnet in its vicinity, but a magnet moving in the vicinity of a coil generates a current in the coil. More generally, if a magnet and conductor are in relative motion, currents are induced in the conductor, which, by the attraction or repulsion upon the magnet, tend to stop the relative motion. This is the explanation of the damping effect which a conductor, set below a vibrating magnet, has upon the vibrations of the magnet, and of Arago's famous experiment in which a magnet placed upon a rotating horizontal copper disk is dragged round after the disk. All these are special cases of induction, the nature of which was first thoroughly studied by Faraday, and all are included under the following general proposition. When the magnetic field in which a conductor is set is in any way altered, currents are induced in the conductor, which by their magnetic action tend to resist the alteration. This alteration may be effected by moving a magnet near a conductor, or a conductor near a magnet, or by mutual motion of a current-traversed coil and conductor, or by altering the intensity of the current flowing in the vicinity of a conductor. Upon this principle depends the action of the various forms of magneto-electric machines which are now so much used in the production of the electric light, as well as of the Ruhmkorff's coil or inductorium, whose working, as affording interesting examples of transformations, we shall consider in great detail. The induction coil consists essentially of two coils, the thicker internal one being the primary, and the thinner, but longer external one, the secondary. Inside the interior of the inner or primary is a bundle of iron wires, terminated at its extremities by disks of soft iron. When a current is passed through the circuit, the iron core becomes an electro-magnet, attracts a small iron disk, which forms the extremity of one arm of a lever, whose other extremity is consequently displaced, and by its displacement break the primary circuit. The current accordingly ceases to flow, the soft iron core loses its magnetism, and the lever returns to its original position, thus completing the circuit, and permitting the current anew to flow. The same cycle of operations takes place again, and thus an automatic or self-governing arrangement is produced, by which the current is made and broken in rapid succession. But at each make and break of the primary an alteration of the magnetic field results, and alternating secondary currents, rendered the more intense by the presence of the iron core, are induced. By this means

96

a rapid series of sparks is obtained between the terminals of the secondary coil. To overcome the great resistance which the air presents to the passage of the spark, the second current must do work, and the energy so lost reappears as light, heat, and sound, which are the invariable accompaniments of the spark. The beautiful combinations of colored and stratified lights produced by passing the currents through Geissler vacuum tubes illustrate the same principles, and in all these varied transformations of our original source of energy the grand conservation law holds without exception. Naturally, however, energy, in whatever form it may exist, tends to the ultimate form of heat, which cannot be prevented from diffusing gradually all round. But this diffusion diminishes its power of being transformed, diminishes its availability for doing work. Hence at every transformation energy becomes degraded, or, as it is commonly expressed, dissipated, that is to say, though its total quantity remains constant, its entropy or availability for doing work is diminished. Ultimately, then, unless the energy of the material universe is infinite, its entropy will become zero, and the universe be reduced to a lifeless, motionless, characterless mingling of matter at a uniform temperature.

(3122) ELECTRICITY AS A MOTIVE POWER.—The motive power used for the plowing you refer to is not electricity, but steam; the electricity is only used to transmit the power of a stationary steam engine to those points of the field where the traction of the plow is to be applied, for which purpose flexible and movable conducting wires are far more available than rigid, fixed steam tubes or belts. The operation consists of the use of two or three dynamo-electric machines, such as we described on page 145 of our July number. One of them is placed in the building containing the steam engine, revolved by the same, and the electric current generated is conducted by isolated copper wires to the field where the plowing is to be performed, the wires are there connected with the other machines placed in the field; the electric current has here an inverse action—it makes these machines revolve, and this with a power which, if compared with that of the steam engine from which it originally is derived, shows no more loss than is incidental to any other method of transmission, and certainly less than would be the case if the transmission had to be effected to such distances, and under such continually variable circumstances, as the positions of the other machines in the field have continually to be shifted; one is placed at each side of the line in which the plow is to be moved, and they are started alternately to pull the plow in both directions in which it crosses and re-crosses the field. These machines, of course, work by wire ropes wound on revolving drums, and are placed on wheels and gradually moved forward while furrow after furrow is being made. As hand-labor is somewhat scarce throughout all France, and water power plentiful in many localities, it is expected that this method of transmitting the latter has a great future before it. It has already been successfully introduced in beet-root sugar manufactories for hauling and unloading material, and has been found to be far better for plowing than the steam plow, which can by no means be considered a success, but rather the contrary, and this for various reasons—their great first cost, weight, difficulty in moving, managing in the field, their necessary water supply, etc.; while the dynamo-electric machine, having no boiler, requires no water, costs far less than a portable engine for a steam plow, and does not weigh one-tenth as much as a steam engine of the same power. There is no doubt but that this new method of transmitting power has a great future before it, especially in those sections in this country where circumstances favor its application.

(3122) ELECTRICITY AS A MOTIVE POWER.—Have you not always been teaching that it was absurd to attempt the use of electricity as a motive power, on account of the great expense of electric batteries as compared with steam generators? How is it then that, as the papers report, plowing by electricity is now being introduced very successfully in France? Please explain.—ONE OF YOUR OLD COOPER INSTITUTE STUDENTS, New York City. Manufacturer & Builder Aug 1879

D'ÉLECTRICITÉ EN LUMIÈRE

DESIDERATA NUMÉRIQUES. — 1er ARTICLE.

La Lumière ~~Scientifique~~ Electrique

Rendements absolu et relatif des machines électriques en travail mécanique proprement dit dans le cas de sources de forces électromotrices déterminées ou indéterminées. — Transport du travail mécanique à distance.

Aug 15 1879

Soit un circuit fermé quelconque comprenant les résistances successives R, R_1,... R_n... R_n respectivement animées par des forces électromotrices représentées en signe et en grandeur par les quantités E, E_1,... E_n... E_n — Appelons I l'intensité commune de la circulation électrique qui s'établit dans le système.

Le travail de chacune des forces électromotrices sur le circuit total pendant l'unité de temps peut, en unités absolues et avec son signe, être représenté par chacun des produits correspondants EI, E_1I,... E_nI,... E_nI.

Le travail thermique rendu manifeste sur chacune des résistances par la circulation effective sera I^2R, I^2R_1... I^2R_n... I^2R_n. — Les termes correspondants de ces deux séries peuvent être deux à deux très-différents les uns des autres, mais la somme des termes de l'une des séries est forcément et rigoureusement égale à la somme des termes de l'autre série.

Cela est vrai quelles que soient les relations de dépendance réciproque de ces quantités, et quelles que soient les causes génératrices des forces électromotrices.

Si nous réduisons l'équation qui exprime cette égalité à n'avoir que 3 termes dans chaque membre et si nous supposons que l'une des forces électromotrices soit nulle, désignant par r la résistance correspondante à cette force nulle, l'équation deviendra :

$$IE + IE_1 = I^2 (R + R_1 + r)$$

Si E et E_1 sont de signes contraires et que nous dégagions les signes, la formule peut s'écrire :

$$IE - IE_1 = I^2 (R + r + R_1) \text{ ou : } IE = IE_1 + I^2 (R + r + R_1)$$

$$\text{ou } IE =: \frac{E-E_1}{R+r+R_1} E = \frac{E-E_1}{R+r+R_1} E_1 + \frac{(E-E_1)^2}{R+r+R_1} \quad (*)$$

Cette formule exprime précisément ce qui se passe dans le cas d'un moteur électrique de résistance R_1 actionné à distance correspondante à la moitié de la résistance d'un conducteur de résistance r le reliant à une source de force électromotrice E et de résistance R, lorsqu'un travail extérieur d'ordre mécanique développe intérieurement dans la résistance R_1 une force électromotrice E_1 de sens contraire à celui de E.

Le premier terme est le travail total dépensé par la source le deuxième terme le travail pris par le moteur, c'est-à-dire la raison d'être d'un tel arrangement, enfin le troisième terme est le travail thermique qui, dans ce genre d'applications, peut être considéré comme un travail perdu et nuisible. Ces trois expressions représentent des nombres d'unités absolues électro-mécaniques et doivent, bien entendu, être multipliées par les coefficients indiqués dans un de nos articles précédents pour exprimer des kilogrammètres ou des calories lorsque les forces électromotrices et les résistances sont comptées en volts et en ohms.

Le travail dépensé peut d'ailleurs être fourni par une source quelconque, pile ou machine électrique actionnée elle-même par une puissance mécanique. Il y a de nombreuses observations à faire sur ce sujet, tout d'actualité, puisque l'attention publique s'est enfin fixée sur la belle solution, par l'électricité, du transport du travail mécanique à distance, solution à laquelle l'avenir appartient sans aucun doute.

Si dans la formule (*) nous faisons $E_1 = o$, tout le travail dépensé par la source sera employé thermiquement; au contraire, si E_1 augmente graduellement, le travail thermique perd de son importance et tend vers zéro pour $E_1 = E$.

En partant de la limite $E_1 = o$ correspondant à la seconde machine immobile, c'est-à-dire au moteur électrique stoppé, et, au moins pendant une certaine période des accroissements de la variable E_1, il y a donc accroissement du travail recueilli sur le moteur jusqu'à un maximum très-facile à déterminer algébriquement pour une valeur déterminée de E, lequel maximum est réalisé pour $E_1 = \frac{E}{2}$. Pour ce maximum il y a répartition égale du travail dépensé en travail thermique et en travail du moteur ou travail recueilli. Lorsque la variable dépasse $\frac{E}{2}$, le travail recueilli diminue en valeur absolue, mais augmente en valeur relative par rapport au travail dépensé et tend à l'égaler à la limite $E_1 = E$, limite à laquelle, d'ailleurs, chacun des trois travaux devient nul.

Notre but est de mettre le lecteur à même de suivre sans peine la trinité du régime des variations correspondantes des termes de cette simple et intéressante formule, et de généraliser les conclusions en y comprenant le cas où la source est une machine électrique extérieurement actionnée (E pouvant par suite être indéterminé).

Nous conviendrons des appellations suivantes :

Le rendement absolu sera la valeur absolue du travail mécanique recueilli par le moteur électrique pendant l'unité de temps.

Le rendement relatif sera le rapport du rendement absolu au travail dépensé par l'intermédiaire de la source pendant l'unité de temps.

$$\text{Par définition : rendement absolu} = K \frac{E_1 (E-E_1)}{R + r + R_1}$$

$$\text{Travail thermique} = K \frac{(E-E_1)^2}{R + r + R_1}$$

$$\text{Travail total ou dépensé} = K \frac{E (E-E_1)}{R + r + R_1}$$

$$\text{Posons} \quad \frac{E_1}{E} = \frac{m}{n}$$

$$\text{Il vient : } \frac{\text{rendement absolu}}{\text{travail thermique}} = \frac{m}{n-m}$$

$$\frac{\text{Rendement absolu}}{\text{Travail dépensé}} \text{ ou rendement relatif} = \frac{m}{n}$$

$$\frac{\text{Travail dépensé}}{\text{Travail dépensé pour rendement absolu maximum}} = 2\left(1 - \frac{m}{n}\right)$$

97

$$\frac{\text{Rendement absolu}}{\text{Rendement absolu maximum}} = 4\frac{m}{n}\left(1 - \frac{m}{n}\right)$$

Nous pouvons donc construire le tableau suivant basé seulement sur des variations de rapports; ainsi nous ferons varier de 1 à o le rapport $\frac{m}{n}$ en passant par un certain nombre d'interpolations fractionnaires usuelles telles que $\frac{99}{100}$, $\frac{9}{10}$, $\frac{8}{9}$, $\frac{7}{8}$, $\frac{6}{7}$, $\frac{5}{6}$, $\frac{4}{5}$, $\frac{3}{4}$, $\frac{2}{3}$; $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, $\frac{1}{6}$, $\frac{1}{7}$, $\frac{1}{8}$; $\frac{1}{9}$, $\frac{1}{10}$, $\frac{1}{100}$; les valeurs correspondantes de ces divers rapports deviennent celles portées au tableau ci-contre.

Il importe d'ailleurs de ne pas perdre de vue les distinctions et les liaisons qui existent entre les travaux d'ordre mécanique dont il est question dans la formule et le tableau, et le travail perdu soit en circulation électrique dans tout circuit autre que celui utilisé, soit en frottements; c'est-à-dire que, dans le cas de deux machines, il ne faut pas oublier que le travail total dépensé que nous considérons est le travail emprunté au moteur diminué du travail électrique qui peut être produit ailleurs que dans le fil de cette machine, si ladite machine électrique est plus ou moins imparfaite, et diminué aussi du travail absorbé par les frottements des coussinets de la première machine électrique. Tandis que la valeur considérée du travail recueilli sur la seconde machine comprend non-seulement le travail recueilli proprement dit, mais encore le travail absorbé par les frottements de l'arbre de cette seconde machine faisant fonction de moteur électrique.

Le travail du frottement absorbé dépend beaucoup, toutes choses égales d'ailleurs, du mode de relations de la machine électrique et de l'organe de transmission : ainsi, avec les transmissions dites par courroie, les raisons théoriques d'ordre électrique qui, ainsi que nous allons le voir, militent en faveur des grandes forces électromotrices de réaction E_1, se trouvent encore corroborées par les intérêts mécaniques qui demandent de grandes poulies, de grandes vitesses et de faibles tensions des courroies ou des câbles. On sait que dans cette sorte d'artifice mécanique réside tout le mérite des transmissions suisses et allemandes de travail moteur à grande distance qui réduisent autant que possible la traction sur les arbres et l'usure des coussinets. S'il s'agissait d'un travail en connexion directe avec l'arbre de la machine électrique, dans des conditions de symétrie d'efforts, il n'y aurait plus, de ce chef, le même intérêt à l'augmentation de la vitesse. Ce n'est du reste pas le moment d'insister davantage sur ce côté de la question.

Les formules et le tableau qui en est l'expression nous montrent à première vue que, pour un générateur donnant une force électromotrice déterminée : pile hydro-électrique Bunsen, pile thermo-électrique Clamond ou machine électrique d'induction dont le système magnétique serait, par exemple, constitué par des aimants permanents et dont le nombre de tours par unité de temps serait déterminé, on ne pourrait

(1) MM. Mascart et Angot l'appellent force d'induction. (*Journal de physique* de M. d'Almeida).

Force électromotrice de réaction (1) divisé par Force électromotrice de la source.	Rendement absolu divisé par Travail thermique.	Rendement relatif.	Travail dépensé divisé par Travail dépensé pour le rendement absolu maximum.	Rendement absolu divisé par Rendement absolu maximum.
$\frac{m}{n}$	$\frac{m}{n-m}$	$\frac{m}{n}$	$2\left(1-\frac{m}{n}\right)$	$4\frac{m}{n}\left(1-\frac{m}{n}\right)$
1	∞	1	0	0
$\frac{99}{100}$	99	$\frac{99}{100}$	$\frac{2}{100}$	$\frac{99}{2500}$
$\frac{9}{10}$	9	$\frac{9}{10}$	$\frac{2}{10}$	$\frac{9}{25}$
$\frac{8}{9}$	8	$\frac{8}{9}$	$\frac{2}{9}$	$\frac{32}{81}$
$\frac{7}{8}$	7	$\frac{7}{8}$	$\frac{2}{8}$	$\frac{7}{16}$
$\frac{6}{7}$	6	$\frac{6}{7}$	$\frac{2}{7}$	$\frac{24}{49}$
$\frac{5}{6}$	5	$\frac{5}{6}$	$\frac{2}{6}$	$\frac{5}{9}$
$\frac{4}{5}$	4	$\frac{4}{5}$	$\frac{2}{5}$	$\frac{16}{25}$
$\frac{3}{4}$	3	$\frac{3}{4}$	$\frac{2}{4}$	$\frac{3}{4}$
$\frac{2}{3}$	2	$\frac{2}{3}$	$\frac{2}{3}$	$\frac{8}{9}$
$\frac{1}{2}$	1	$\frac{1}{2}$	1	1
$\frac{1}{3}$	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{4}{3}$	$\frac{8}{9}$
$\frac{1}{4}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{6}{4}$	$\frac{3}{4}$
$\frac{1}{5}$	$\frac{1}{4}$	$\frac{1}{5}$	$\frac{8}{5}$	$\frac{16}{25}$
$\frac{1}{6}$	$\frac{1}{5}$	$\frac{1}{6}$	$\frac{10}{6}$	$\frac{5}{9}$
$\frac{1}{7}$	$\frac{1}{6}$	$\frac{1}{7}$	$\frac{12}{7}$	$\frac{24}{49}$
$\frac{1}{8}$	$\frac{1}{7}$	$\frac{1}{8}$	$\frac{14}{8}$	$\frac{7}{16}$
$\frac{1}{9}$	$\frac{1}{8}$	$\frac{1}{9}$	$\frac{16}{9}$	$\frac{32}{81}$
$\frac{1}{10}$	$\frac{1}{9}$	$\frac{1}{10}$	$\frac{18}{10}$	$\frac{9}{25}$
$\frac{1}{100}$	$\frac{1}{99}$	$\frac{1}{100}$	$\frac{198}{100}$	$\frac{99}{2500}$
0	0	0	2	0

augmenter le rendement relatif au delà de 1/2 qu'en diminuant la valeur du rendement absolu; mais nous voyons en même temps que, pour un même rendement relatif, nous pouvons augmenter le rendement absolu jusqu'à toute valeur déterminée, pourvu que nous puissions faire varier convenablement, dans le même sens, la force électromotrice mise en jeu par la source. C'est le cas dans lequel nous pouvons nous placer si la force électromotrice est indéterminée, par exemple, lorsque la première machine est actionnée de façon à pouvoir absorber constamment une puissance mécanique déterminée. Dans cette hypothèse, le rendement absolu peut donc, à la limite, égaler le travail dépensé.

Il n'existe entre ces deux faits rien de contradictoire, mais la question mérite quelque attention, car elle n'est généralement pas très-bien comprise.

Afin de procéder méthodiquement, considérons d'abord la simple donnée d'une source électrique quelconque à force électromotrice déterminée animant un circuit métallique. Cet unique générateur d'électricité est une pile hydro ou thermo-électrique ou une machine d'induction. Le circuit de la circulation électrique considérée comprend la résistance intérieure de la source et une résistance extérieure inanimée, c'est-à-dire une résistance exploitée qui n'est le siége d'aucune force électromotrice.

Il est certain que le maximum de travail recueilli sur le circuit extérieur (pour fixer les idées, en chaleur dans un calorimètre) est obtenu lorsque la résistance de ce circuit extérieur égale la résistance intérieure effective de l'électromoteur et ce maximum est le quart du travail qui représente ce que nous avons appelé l'énergie de l'électromoteur (travail de la force électromotrice déterminée animant un circuit dont la résistance est égale à la résistance intérieure de cet électromoteur), comme nous l'avons établi dans notre article du 15 juin 1879, page 53, du nº 3 du Journal universel d'électricité *la Lumière électrique*.

Si donc, dans de telles conditions, nous faisons varier de zéro à l'infini la résistance extérieure r, le travail recueilli extérieurement, ou ce qu'on pourrait appeler le rendement absolu thermique variera de zéro à zéro en passant par un maximum égal au quart de l'énergie pour une résistance extérieure r égale à R résistance intérieure, le travail total ou dépensé correspondant variera de l'énergie à zéro, c'est-à-dire ira constamment en diminuant entre ces deux limites en passant par une valeur égale à la moitié de l'énergie, valeur correspondant au rendement absolu maximum. Le rendement relatif variera de zéro à un, c'est-à-dire ira toujours en augmentant jusqu'à cette limite. Si maintenant nous supposons la force électromotrice indéterminée, et que nous appliquions à la machine électrique dont il s'agit une puissance mécanique déterminée, le nombre de tours devra être d'autant plus grand que la résistance totale extérieure et intérieure sera plus considérable et, pendant que la résistance extérieure variera de zéro à l'infini, le rendement absolu thermique varira de zéro à la valeur du travail fixe dépensé, et le rendement relatif correspondant variera de zéro à un.

Ainsi, à ce point de vue, laissant de côté les influences pratiques secondaires, il n'y aura donc pas d'empêchement théorique à réaliser un fonctionnement de machine magnéto-électrique permettant de recueillir extérieurement, en chaleur régénérée, la majeure partie du travail dépensé, les neuf dixièmes, par exemple, du résultat de la transformation du travail moteur en courant.

Sans doute, si l'on voulait appliquer une organisation de cette sorte, je suppose à la production de la lumière avec arc voltaïque (je prends l'arc comme type des dispositifs recueillant la chaleur régénérée exposés à infliger des variations accidentelles considérables à la résistance extérieure, contact des charbons par exemple), la chose pourrait être dangereuse en ce sens que, lors d'une grande diminution de la résistance extérieure, le fil constituant la résistance intérieure de la machine serait aussitôt échauffé, pourrait même être brûlé, et cela d'autant plus sûrement que, dans la construction de la machine on aurait mieux réussi à la rendre apte à supporter juste la circulation électrique du régime prévu, avec un minimum de poids de métal conducteur.

Cependant, dans les cas où la résistance extérieure totale peut être maintenue sûrement entre des limites rapprochées, il n'y aura pas témérité à poursuivre simultanément toutes ces possibilités de maxima relatifs et spécifiques, et il est permis de supposer que ce pourra être précisément le cas pour les systèmes de production de lumière basés sur l'incandescence réalisée dans des conditions de constance suffisante des résistances exploitées.

Grssé.

(A suivre.)

SUR LES COURANTS D'AMPÈRE

RECHERCHES DE M. LE CAPITAINE DE VAISSEAU TRÈVES

L'importance des communications du capitaino do vaisseau Trèves, dans les doux dernières séances, suffirait amplement pour satisfaire les personnes curieuses des nouveautés scientifiques. Nous allons résumer les résultats obtenus par ce physicien éminent qui marche d'un pas sûr et rapide dans la voie entrouverte par Ampère.

On sait qu'Ampère s'est demandé si les courants moléculaires des aimants se créent de toutes pièces dans les corps magnétiques pendant l'aimantation, ou si la cause qui aimante ne fait que déterminer une circulation de courants préexistant dans les métaux à l'état naturel et il conclut dans le sein de la préexistence des courants dans les métaux magnétiques.

Les expériences ingénieuses de M. Trèves répondent parfaitement à cette conception d'Ampère, le courant *polarisateur*, circulant à travers les métaux magnétiques eux-mêmes, s'attaque directement à leur état physique, au lieu d'agir par influence.

Le savant marin prend deux hélices de même diamètre intérieur et de même section, l'une en cuivre, l'autre en fer doux, un même courant, circulant dans chacune d'elles, leur donne un pouvoir d'aimantation très différent. L'hélice en fer doux est

près de cinq fois plus énergique que l'hélice en cuivre. Cela
prouve que ce courant trouve dans le métal magnétique un
milieu d'action mieux préparé au phénomène de l'aimantation.
Le courant de la pile, cause de l'aimantation, détermine la circu-
lation et l'orientation des courants particulaires préexistants.
Dans l'hélice en cuivre, au contraire, le courant de la pile, ne
rencontrant pas sur sa route ces courants particulaires, ne donne
qu'une aimantation relativement faible, provenant de l'action
uniquement produite par la série de courants circulaires égaux
et parallèles. Voici d'ailleurs une autre note de M. Trèves, por-
tant avec elle une lumière encore plus éclatante sur ces ques-
tions délicates. On sait que tout courant rectiligne indéfini tend
à diriger parallèlement à lui-même, un courant rectangulaire ou
circulaire, mobile. Si donc, on prend un aimant droit ou en fer
à cheval et si l'on y fait passer un courant énergique, d'une
extrémité à l'autre, tous les courants d'Ampère, s'ils existent
réellement, seront plus ou moins déviés de leur direction nor-
male à l'axe et une notable partie de l'aimantation devra dispa-
raître instantanément.

C'est précisément ce que l'on constate sur une boussole placée
dans le prolongement du barreau, si l'on emploie un barreau de
fer doux légèrement aciéré à la surface, et ne possédant qu'une
faible aimantation relative. Quand le barreau est aimanté, les
courants d'Ampère sont plus ou moins normaux à l'axe. Lorsque
le courant de la pile passe d'une extrémité à l'autre, les courants
d'Ampère pivotent, deviennent des ellipses, et l'aimantation
s'affaiblit. Pour faire disparaître toute trace d'aimantation, on
conserve l'un des pôles de la pile en contact avec l'une des extré-
mités du barreau et on le frictionne avec l'autre pôle de la pile.
Au bout de quelques minutes, on détruit ainsi toute orienta-
tion des courants particuliers, et on rend le barreau à son état
naturel. Dans cet état, si on continue à le frictionner en le fai-
sant tourner sur lui-même, on voit le barreau reprendre succes-
sivement son aimantation, ainsi que le constate la boussole.
Chaque fraction polarise ou dépolarise, suivant le cas, les cou
rants d'Ampère et les rend en quelque sorte visibles à tous.

Dans sa troisième note, M. Trève fait observer que rien n'égale
la mobilité des courants d'Ampère, il est bon de redire l'énorme
disproportion qui existe entre la force nécessaire pour aimanter
un barreau d'acier et celle qu'il faut employer pour le désaiman-
ter. Il faudra cinq éléments Bunsen, par exemple, pour aiman-

ter à saturation un barreau d'acier. Pour dépolariser les cou-
rants d'Ampère, c'est-à-dire pour ramener le barreau à l'état
naturel, il suffit de faire passer dans la bobine qui l'enveloppe le
courant inverse d'un élément microscopique à eau légèrement
acidulée. Il suffit de frapper quelques coups sur l'extrémité d'un
barreau aimanté avec un corps même non-magnétique pour dé-
polariser les courants et lui faire perdre son aimantation. C'est
un nouveau procédé de désaimantation, il suffirait d'un choc sur
un électro-aimant plein ou tubulaire au moment où le courant
cesse, pour diminuer la durée de sa désaimantation dans des
proportions considérables, et remédier ainsi au magnétisme ré-
manent.

M. des Portes frappait un des aimants de téléphone suspendu

par un fil avec une substance non-magnétique, et on en recueil-
lait le bruit à l'autre téléphone. Ce résultat est la conséquence
du *mouvement vibratoire* des courants particulaires d'Ampère, de
ces courants dont l'existence n'est plus douteuse maintenant et
qui pivotent si aisément sur leur axe.

Les nouvelles expériences de M. Trève nous paraissent si belles et si décisives, que nous n'hésitons pas à caractériser ces travaux, en appelant ce savant le fils d'Ampère, dans le domaine scientifique.

A. Boillot.

CAUSERIE ÉLECTRIQUE

Aug 18 1879

La Lumière Electrique

Lorsqu'il y a quelques mois ce journal fut créé, dans un programme placé en tête du premier numéro, nous avons essayé de faire bien comprendre notre raison d'être et notre but. Nous y disions que dans la phase troublée que traverse en ce moment la science de l'électricité, nous pensions être utiles en offrant un centre d'études, un recueil de renseignements précis et scientifiquement contrôlés.

C'était dire que nous nous adressions aux personnes versées dans cette branche de la science, et que c'était surtout à ceux qui la connaissent et la travaillent que ce journal était destiné.

De ce côté, nous n'avons qu'à nous louer du résultat. La lacune que nous prétendions combler était sans doute bien réelle, et nous n'aurons pas été inutiles. Nous en avons pour preuve l'accueil que nous avons reçu, le nombre toujours croissant de nos abonnés, les témoignages qui nous parviennent, et dont nous remercions profondément nos lecteurs.

Mais en atteignant ce but, il devient tous les jours plus clair que nous en avons touché un autre; autour de nos abonnés techniques sont des personnes moins versées dans la science électrique, mais qui, néanmoins, s'y intéressent; elles nous ont fait l'honneur de chercher dans notre journal des renseignements propres à les tenir au courant.

D'autre part, le bruit qui s'élève aujourd'hui autour de ces importantes études éveille chez beaucoup de gens le désir d'en suivre le progrès sans être obligées à un travail d'instruction pour lequel le temps leur manque; elles ont demandé à notre publication le moyen de le faire.

Tout ce public n'a pas été sans éprouver parfois quelque difficulté à suivre nos travaux, dont l'allure un peu scientifique le gêne de temps en temps. On nous a plusieurs fois déjà témoigné le désir de trouver dans nos pages des articles où l'on éviterait l'emploi des termes techniques, et qui rendraient l'accès de la science plus aisé aux nombreuses personnes qu'elle attire.

Nous nous étions toujours efforcés d'atteindre, sans nous éloigner de la précision, la forme la plus claire; on paraît nous demander que nous poussions plus loin dans ce sens.

Il ne nous est pas permis d'hésiter devant un désir si bien d'accord du reste avec notre but, qui est, en facilitant les études, d'augmenter autant que cela nous sera possible le nombre de ceux qui aiment et cultivent la science électrique. Nous ne nous dissimulons point les difficultés. Exposer un fait scientifique à l'aide des termes et des procédés de la science, cela n'est pas toujours facile; cependant on doit y réussir, les moyens étant ceux qui conviennent au résultat cherché; mais l'exposer avec clarté et exactitude sans recourir à l'emploi de ces moyens, c'est un travail souvent plein de difficulté et de péril.

Nous l'essayerons néanmoins, puisque nos lecteurs le désirent. Dans chacun de nos numéros, on trouvera à l'avenir une Causerie électrique. Dans cet article, nous nous efforcerons de résumer et de rendre facile à suivre le mouvement de la science; soit que nous y donnions place à des faits non traités dans le journal, parce qu'ils sont connus des électriciens, soit que nous revenions sur les sujets traités ailleurs sous une forme plus sévère, afin de les présenter d'une façon plus accessible.

Il demeure bien entendu néanmoins que nous ne pouvons nous adresser à des personnes totalement étrangères à l'électricité; nous serons bien forcés de supposer quelques notions premières. Il faudra, par exemple, que notre lecteur nous comprenne lorsque nous parlerons d'une pile, d'un courant électrique; et ainsi de quelques termes absolument élémentaires; mais ces notions sont aujourd'hui si répandues qu'il est inutile d'insister sur ce point.

Ces articles, s'ils n'ont pas d'autre utilité, auront, au moins, nous l'espérons, pour résultat d'attirer l'attention quelquefois sur des sujets négligés et de montrer l'importance de découvertes qui seraient exposées à passer inaperçues.

Voyez, par exemple, le téléphone; à plusieurs reprises dans notre journal, d'importants articles ont signalé et décrit ses progrès; les autres publications scientifiques ont fréquemment occasion d'en parler, et néanmoins, il faut bien en convenir, cet appareil est, dans la masse, aussi peu connu que possible, et mal apprécié aussi bien comme découverte scientifique que comme importance pratique.

Beaucoup de personnes encore aujourd'hui confondent le téléphone électrique avec le téléphone à ficelle qui a tant amusé les enfants sur nos boulevards. Il a fallu pourtant une longue suite de travaux pour l'amener au point où il est. Pour ne signaler que les faits saillants,*Page, en 1837, reconnaît qu'une tige de fer autour de laquelle passe un courant produit des sons lorsque ce courant est soumis à des interruptions rapidement répétées, et prouve que le son correspond exactement au nombre des interruptions; que si, par exemple, le courant est interrompu 435 fois par seconde, la tige autour de laquelle il passe donnera la note *la* qui correspond à 435 vibrations complètes. Il ouvre ainsi la voie aux recherches sur les vibrations moléculaires dues à l'électricité; phénomènes si curieux, si pleins de conséquences intéressantes.

Vers 1855, Léon Scott construit le phonautographe, un appareil qui enregistre la parole; il emploie pour cela une plaque de métal mince devant laquelle on parle et qui vibre sympathiquement avec la voix.

Les deux organes essentiels du téléphone sont alors trouvés: la plaque vibrante qui reproduit le son et le transmet, la tige vibrante qui le reçoit et le reproduit. Leur réunion a formé, vers 1870, le téléphone de Reiss, qui permettait de transmettre électriquement les sons musicaux à l'aide du courant d'une pile interrompu par une plaque vibrante.

De là à la parole articulée il y avait loin encore: le pas est fait par Graham Bell, dont le nom restera attaché à cette admirable invention. Il montra que pour reproduire la parole, il fallait lancer dans un fil conducteur, non pas des courants électriques interrompus, mais un courant modulé par la voix, qui s'infléchît et s'élevât avec elle et exactement comme elle; un courant ondulatoire, suivant son expression. Parmi les moyens propres à obtenir ce résultat, il parvint à réaliser le plus simple, qui est de faire produire à la voix elle-même le courant électrique qui doit la transporter. Pour cela, reprenant la plaque vibrante de ses prédécesseurs, il la place devant un aimant; lorsque cette plaque remuée par le son s'éloigne ou se rapproche dans sa vibration, l'aimant en est troublé dans son magnétisme; ces variations peuvent être recueillies dans un fil qui l'entoure, sous forme de courants électriques; elles iront ainsi se reproduire à l'autre extrémité de ce conducteur, et animant une deuxième plaque vibrante d'un mouvement pareil à celui qu'a reçu la première, elles lui feront répéter les paroles que celle-ci a reçues.

Cela est si ingénieux et si simple à la fois, que bien des personnes à l'origine ne purent croire à ces merveilleux résultats. Ils sont certains cependant. Le téléphone de Gower, excellent perfectionnement de celui de Bell, les met aujourd'hui tout à fait en relief et les fait passer complètement dans la pratique.

N'est-il pas juste de dire qu'il y a là une découverte scientifique de premier ordre, et un appareil d'une extrême importance? On rencontre cependant beaucoup de personnes disposées à le traiter comme un jouet de médiocre valeur; c'est une idée absolument fausse et à laquelle il faut renoncer en toute hâte. C'est pourquoi il nous a paru utile d'y revenir.

Quand ce serait seulement pour les applications scientifiques, le téléphone resterait un instrument d'un grand intérêt. Il est l'organe essentiel du sonomètre que M. Hughes vient de construire et qui a été étudié dans le journal. Dans ce curieux appareil, M. Hughes envoie un bruit dans le téléphone, mais il l'envoie à la fois par deux courants de sens contraire, en sorte que s'ils sont exactement égaux, le bruit n'est pas entendu, les deux courants qui l'apportent se détruisant l'un par l'autre. L'appareil étant ainsi en équilibre, si l'un des deux courants est modifié en quoi que ce soit, le bruit sera entendu, les deux flux électriques cessant de se détruire. On peut, par exemple, approcher de chacun des deux courants un morceau de métal; si ces deux pièces ne sont pas de même nature, de même poids, de même structure, le bruit sera entendu et signalera la différence. On a pu trouver aussi un dix millième d'alliage, une différence inappréciable de densité; et M. Hughes a mis dans la main des expérimentateurs un des instruments de recherche les plus puissants et les plus délicats qu'on puisse imaginer.

La voie est à peine ouverte, et nous ne sommes qu'au commencement; les étonnantes expériences où M. Ader a montré qu'il n'est pas besoin d'un aimant ni d'une plaque pour reproduire la parole, qu'une tige de fer, une bobine de fil métallique peu serrée peuvent le faire, ont indiqué l'étendue immense que prendront ces recherches et leur extrême importance.

Elles resteront certainement un des grands faits scientifiques du siècle, et nous devions appeler sur ce point l'attention de tous nos lecteurs.

FRANK GÉRALDY.

Transparency of Metals.

With the aid of electricity films of several metals of such minute thickness as to allow the light to pass through them can be produced. An electric current is passed into a wire of one of the metals, that extends into a glass tube containing rarefied air or gases. The particles of metal that the electric current loosens from the wire are deposited on the sides of the tube and form a transparent film. The light that passed through gold was a very handsome green, silver produced blue, copper light green, platina bluish gray, zinc dark bluish gray, and iron brown.—*Chemiker Zeitung.*

Sc. Am. Sept 6 1879

General Science.

Electric Brevities.—Mr. Chandler Roberts has lately read an interesting paper before the Physical Society, upon his examination of the behavior of metals and their alloys with the aid of Prof. Hughes's induction balance. A complete induction balance has been installed at the Royal Mint, and Mr. Roberts is engaged in testing its capability of being employed in the assaying of the precious metals. He expresses himself well pleased with the results thus far obtained. As the paper is not suited for abridgement, we refer our readers for details to the *Telegraphic Journal* (August).——M. Lagriffe is reported to have devised a combination of telephone and phonograph of such arrangement that a telephone circuit transmitting speech shall impress it with sufficient force upon a phonograph of improved construction to repeat it if desired. The instrument is said to be experimentally successful, and it has been called the *telephonographe*.

Transformation of Sound into Light.—We glean from London *Nature* the following details of a new system of transforming sound into light, devised by M. Coulon, Conservator of the Industrial Museum of Rouen. Two Geissler tubes are put in quick rotation on an axis. The induction coil of the first is worked by an ordinary interrupter, and gives the deviation of a luminous cross. The interrupter of the second is replaced by a telephone. The figure presented by the second tube projects on the first one, which is colored by uranoxide glass, and exhibits the most rapid changes according to the height of the tone delivered in the telephone trumpet. The sensibility of the changes are said to be startling and most interesting.

Aug 30 1879

The Relations Existing between Arc Resistance and Current Strength, and between current strength and illuminating power, have been studied by Professors Houston and Thomson; according to whom, within a certain range of conditions, the relations in question may be formulated as follows: 1. In arcs of equal lengths, the resistances are inversely proportional to the current strengths. 2. The illuminating power of an arc is approximately proportional to the current traversing it. 3. In arcs of equal length, the total energy given out is proportional to the current strength. For the details of this investigation our readers are referred to the (August) *Journal of the Franklin Institute.*

Engineering & Mining Jour

THE RELATION OF HEAT TO CURRENT STRENGTH.

[16019.]—IT is generally stated in electrical text-books, that the heat developed in a wire, through which a current is passing, is directly proportional to the square of the current strength. "Sigma" in his letters supports this, and if I understand him rightly, says, that it is because the energy thrown into the circuit is proportional to the square of the electromotive force: to both of these statements I object, and give my reasons for doing so as plainly as I can; for if right, plain speaking will only further the cause of right, while if wrong, plain speaking will only cause the more speedy correction of the error. If there be two voltaic cells having the same electromotive force, and each working separately through equal resistances, it is obvious that equal amounts of zinc are dissolved in each cell, and equal amounts of energy are thrown into each circuit, and of course the amounts of heat developed in one Ohm of each circuit will also be equal; and it would naturally be supposed that if both cells were placed in one circuit equal to one of those before mentioned, that the amount of heat developed in one Ohm of the resistance, would be twice as great as in either of the separate circuits, but instead it is found to be four times as great, although the current strength is only doubled. Now, according to the laws of electrolytic decomposition, it is plain that twice the quantity of zinc is dissolved in each cell, or in all, four times the amount of zinc in the one circuit, and consequently four times the energy (heat): this confirms the law which I object to. Taking another case, a battery is working in a circuit of 50 Ohms, and produces a current having a strength C; if that resistance is reduced to 25 Ohms, the current strength is 2 C; the amounts of heat developed in one Ohm in each case are to one another as 1 to 4: this is because, although the total amount of energy (heat) thrown into the circuit is twice as great, the one Ohm has twice the fractional value; that is, instead of being 1-50th of circuit, it is now 1-25th, and consequently receives four times the heat: this is the second confirmation of the law.

But now if two cells A and B are taken, having their electromotive forces as 1 to 2, and both working through equal resistances, it is plain the current strengths are also as 1 to 2; but it can be also proved that the amounts of zinc dissolved in each cell are also as 1 to 2; then the amounts of energy (heat) are also as 1 to 2, and any given portion of the circuit of one, say one Ohm, is receiving twice as much as an equal portion one Ohm of the other; while according to the objectionable law, the amounts of heat should have been as the squares of 2 and 1, that is as 4 is to 1.—Q. E. D. This is the simplest form of its incorrectness, and is quite sufficient to condemn the law as being universal. Perhaps "Sigma" will look over this, and point out the faultiness of my reasoning if it be faulty.

A. Adams.

Eng Mechanic Aug 15 1879

ELECTRO-MOTIVE FORCE, RESISTANCE AND CURRENT.

[16050.]—I AM inclined to think, with Mr. Moberly, 16011, p. 522, that small results will follow from our discussion; small, at all events, compared with the "energy" involved, considering that it has now taken him some seven columns to deliver his criticism, and, there are "various points" reserved for further remarks; that my writings involved include a long chapter in my book, three articles, and a previous reply; considering further that each remark of mine is quite capable of calling forth a column of observations which would require three columns to reply to, I begin to feel that life is too short for so much of it to be spared upon an undertaking which would leave both of us much about where we began, and not prove deeply interesting or very instructive to many of our readers.

In fact, Mr. Moberly and I reproduce the instructive apologue of the two knights and the shield—with this difference, that I, at all events, am perfectly well aware that the subject of dispute has the two different sides. I say *the* subject in dispute, meaning the original one of the values of the electric units; most of the points raised in the letter under reply are either mistakes of Mr. Moberly as to scientific truths, or as to what I have said and meant. I will say something which may finish off the first. As I said when first replying, I had no opportunity of referring to my remarks under criticism. In fact the same observation which Mr. Moberly makes on the report of the B.A. committee applies to my description of the units. I gave the dimensional values of the various units at p. 149 of my book as the foundation of the system, showing what is the meaning of the units. But I was not writing for advanced electricians and people of high mathematical attainments; for them there are the works of Thomson and Tait, Clerk Maxwell, Cumming and others—works of high value, but hopelessly unintelligible to the people whose wishes I had in view (and with whom I sympathise inasmuch as it is extremely difficult to myself to get at their meaning, and then very imperfectly). My desire was to express the meaning, that is to say, the practical upshot, of what is buried in those pages of cabalistic-looking hieroglyphics. It happens that my work has in some sense succeeded beyond my expectations; it has gone among the class for whom I did not write it, and is scattering seeds of thought which I believe will produce considerable results; just the very results which Mr. Moberly has himself expressed in his last paragraph. But the shells in which those seeds of thoughts are enveloped are naturally offensive to the mathematical type of mind, and, of course, this gives rise to somewhat scornful criticism in some quarters, which I quite anticipated and am utterly indifferent to. But then it has also succeeded to my hopes, for I have received letters from all parts of the world, and from many leading electricians (foreign ones, of course, according to the old parable) expressing strong approval of the course I have taken. Returning, then, to the value of the units, I said, page 150, "From the foregoing (that is the $E = L^{\frac{1}{2}} T^{-1} M^{\frac{1}{2}}$ system) *it results* that the absolute unit is a single expression for all forms of energy; while the practical units in ordinary use have a known value, and may be converted into absolute units." I then gave the result I had arrived at as the physical meaning embodied in the system, in such manner as I had myself found useful. Mr. Moberly himself says that I have so worked it out as to "keep false theory (false, that is, from the technical mathematician's point of view) and true practice fairly well in agreement." Well, if my theory, or rather, my arrangement is in accord with practical needs, and simple of comprehension, that is what I aimed at; but I say, also, that it is true, because whatever the difference of expression, it is really based upon the absolute unit. But as my description is open to the doubt Mr. Moberly has raised, I will, while retaining my own simple system, point out, in the further edition which I shall have to prepare for some of these days, I suppose, more fully than I have done, the other aspects of the system.

I will now turn to a few of the other points of Mr. Moberly's letter. I do not feel at all disposed to enter into a dissertation upon abstract "force and energy," their distinctions and meanings; nor am I at all inclined to pass in silence the remark that "he admits the essential distinction between them": this would appear as though I had ever questioned that distinction. I think I may say that very few people have maintained that distinction more clearly than myself, or done much more to spread distinct ideas as to force and energy than myself. I will try presently to clear away some little indeterminateness which seems to exist thereon in Mr. Moberly's mind. But distinct as they are in science, it is hypercriticism to deny that there are many cases in which the terms are by no means very distinct; would it be wrong to speak of either the force or the energy of a blow? It is in definite science, and more especially in mathematical expressions and formulæ, that the distinction becomes clear and important. I do not think I ever miss the distinction where it has any real existence, but I noticed long ago a slip in my book p. 152, and will give here a correction I noted. "*Electromotive Force.*—Force and Energy are generic terms for the sources of all the actions we are acquainted with, and modern science regards force as the *cause* of motion, and energy as *motion* in some form, when active, as the tendency to motion when in the latent or *potential* form." It is clear to me that anyone who cannot see the importance of the distinction between *quantity* of force and *degree* of force, has not quite fully mastered the distinction of force and energy. Force involves an abstract conception of the nature of tension or pressure, velocity, as in rate of vibration, and such-like *conditions isolated from quantity or mass*; thus we can speak of *degree* of temperature, or *quantity* of heat. *Quantity of temperature* would be absurd; *degree* of heat would mean nothing but temperature. Now, temperature measures the *force* of heat, the velocity of vibration, &c., but it has nothing to do with mass. But quantity of heat involves *energy*, and necessitates the consideration of mass. Furthermore, the distinction is perfectly clear and general that *force* is independent of mass, and *energy* connected to mass. Whenever mass has to be taken into account in considering force, or where area has to be taken into account, as in Mr. M.'s illustration of area of piston, it is because we are dealing with not a real force, but with energy, which we are, for various reasons, useful and necessary, expressing in terms of force; this I have explained often enough, by means of the same illustration of steam-pressure.

Mr. M., referring to my "laudable desire to explain what such expressions as $L^{\frac{1}{2}}, M^{\frac{1}{2}} T^{-1}$ really mean," seems not to understand what I really mean, or he would not suggest that I ought to have "traced out the way in which the originators of the expressions arrived at them." How on earth could I do so and be what I specially desire—comprehensible? Why, the originators themselves have written volumes on the subject, and no one can make head or tail of what they mean, except the few who, possessing a special order of mind, have spent years in training their minds to the comprehension of the subject. When David went out to fight Goliath, and the king fitted him out with his own armour, David put it off again, and said he had not proved it; in fact, he was more comfortable in his shirtsleeves, and felt himself master of his own simple weapons. Well, Mr. Moberly will not catch me encumbering myself with the mathematical paraphernalia which I make no pretence of understanding. They are no doubt very valuable, like Saul's sword and armour, to those trained to their use; but I prefer the natural side of science. When I spoke of giving the meaning of the symbols, I meant the physical natural truth, as it appeared to me, which those symbols convey or ought to convey. I should really like to know how many of our readers, for instance, comprehend the reasoning of Mr. Moberly's symbols, and how many (of course I mean of those really interested in the subject) simply passed them as if they were a Hebrew quotation.

I shall not attempt to follow up the rest of the letter. We might write pages upon pages about the commensurability of the foot in length, area, and capacity, and be just where we are, each quite right in some points of view. The distinction and connection which I draw will still remain true. As to all the remarks in the third column, and the contrasts between some of my remarks and certain quotations from various writers, I fail to discover the meaning. The ideas attributed to me are often different from my own understanding of my words, and others seem to me misapprehensions of the authorities quoted. But they must just stand as they are. So far as they relate to my recent statement, that electro-motive force is really [illegible] expression based upon the square root of [illegible] involved in the circuit, I shall be quite ready to defend the proposition when it is definitely attacked upon the ground upon which I have placed it, the analogy betwen E M F and head of water. I refuse to defend it from all manner of general and side attacks which would necessitate ranging over the whole subjects of force and energy. In fact I shall really defend it by developing it from my own point when I have time and inclination. But a hint to Mr. M. He too agrees with me that electricity is energy charged upon material molecules.

Is it not a necessary sequence that the true expression for electrical agency must be in *terms of energy!* If for the purposes of mathematical analysis and formulæ we express electrical actions as the results of a force, *must not that force be an expression of the energy involved* in the electrical action? We all know that the energy expended in the circuit is in the ratio of the square of the EMF. Does it not follow naturally that the EMF is really the square root of the energy, the expenditure or supply of which is the true origin of the force? That view simply conveys the natural law that cause and effect are equal, or, to put it in symbols, $\sqrt{E} = F$ and $F^2 = E$, when E means energy, and F force. Why, some of these days I shall be told that I am enunciating as a new truth what everyone knew before (only they did not see what their knowledge covered). I trust Mr. M. will not treat this as he has my previous remark, that the units of force, LMT^{-2} and of energy, L^2MT^{-2}, are the same value: he says he agrees with me that "they are precisely the same value, all units are—but they are very different things all the same." I do not think all units are the same value, and I do not understand what he means; but these units are equal in value simply because one and the square of one are arithmetically the same value, and also because the natural law of equality of cause and effect requires that the unit force shall be simply an expression of the energy connected with it in its unit action or length.

Sigma

L'ACTION DE LA LUMIÈRE SUR LES PILES

La Correspondance Scientifique Aug 12 1878

M. Edm. Becquerel a déjà étudié avec soin et avec précision l'action de la lumière sur la force électro-mobile de certaines piles. M. H. Pellat, de son côté, vient d'entreprendre une série de recherches qui ne manquent pas d'intérêt, et que nous allons résumer en quelques lignes.

M. H. Pellat a préparé, comme étalon de force électo motrice, deux éléments Daniell. Les sulfates étaient contenus dans deux vases en verre concentriques et communiquaient par l'espace très étroit laissé entre le bouchon à l'émeri et le goulot du vase intérieur. Ces éléments, parfaitement transparents, ont été gardés pendant cinq mois; le zinc ne s'est pas altéré, mais le cuivre s'est recouvert d'une couche de vert de gris. Malgré cette altération, les éléments avaient conservé leur force électro-motrice primitive (1 volt. 15 pour l'un, 1 volt. 11 pour l'autre), quand la mesure était effectuée à l'ombre; mais l'exposition au soleil la *diminuait* d'une quantité qui allait jusqu'à 1/40 de sa valeur (0 volt. 029). La variation était très rapide et cessait dès qu'un écran interceptait les rayons solaires.

M. H. Pellat ne pense pas que ce phénomène soit dû à une élévation de température; l'immersion de la pile à 50° degré ne produisant pas d'effet bien sensible. En outre, un verre rouge, qui laissait passer la moitié de la radiation calorique solaire, produisait l'effet d'un écran opaque sur la pile. Par contre, une cuve contenant une solution étendue de bleu céleste, ne laissant passer que 1/7 de la radiation calorique, transmettait encore 1/5 des rayons efficaces.

On peut donc croire que ce sont les rayons les plus réfrangibles qui agissent.

Un élément Daniell, dont le cuivre est bien net, se montre tout à fait insensible à la lumière; mais il n'en est pas de même pour un Daniell dont le cuivre est altéré par oxydation ou par formation d'un sel à sa surface.

En concentrant, à l'aide d'une lentille, les rayons solaires sur les différentes parties de la pile, M. H. Pellat s'est assuré que le contact cuivre altéré et sulfate de cuivre est seul sensible à la lumière. L'action lumineuse rend le cuivre *moins positif.*

On obtient encore un élément Daniell sensible en prenant pour l'électrode positive un fil de cuivre oxydé dans la flamme d'un bec de Bunsen; mais, dans ce cas, l'élément *augmente* de force électro-motrice par l'action de la lumière. En mettant un pareil fil dans une solution de sulfate de cuivre et en complétant la pile par un fil de cuivre non oxydé, on constate effectivement que l'insolation rend le cuivre oxydé *plus positif.*

Tel est le résumé des instructives expériences de M. H. Pellat, expériences exécutées au laboratoire de recherches physiques de la Sorbonne. Nous sommes heureux d'en avoir fait connaître les résultats à nos lecteurs. Nous ajouterons que toutes ces mesures ont été effectuées par M. H. Pellat, en compensant la force électro-motrice de l'élément par une force variable à volonté par degrés continus et constamment connue, et que l'égalité était constatée au moyen de l'électromètre de M. Lippmann.

E. Venelle.

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traine tous les vents de notre hémisphère. » Les faits sont plus complexes, et d'ailleurs, s'il en était ainsi, le maximum barométrique des Açores disparaîtrait de l'Atlantique pendant l'hiver : or on sait aujourd'hui qu'il existe toute l'année.

Thury

THE INTERNAL CURRENT IN A VOLTAIC CELL.

*On a Galvanometer for Demonstrating the Internal Current transmitted through the Liquid within a Voltaic Cell.**

By CONRAD W. COOKE, C.E., M. Inst., T.E.

It is of course well known that when the external circuit of a voltaic cell is closed a current of electricity is transmitted through that circuit, and at the same time a current of equal strength is transmitted through the liquid within the cell from one plate to the other. These two are in reality but portions of the same current, and are for convenience known as the external or internal currents respectively, to distinguish that portion of the main current which flows through the external conductor from that portion which is transmitted from plate to plate within the cell. The former of these is detected by its electro-magnetic and electro-chemical effects, producing deflections in galvanometers and electroscopes and sounds in telephonic instruments, and is utilised in all the applications of voltaic electricity.

As far as the author has been able to find out, there has not hitherto been any satisfactory means in the hands of the demonstrator of physics by which the existence of the internal current within a single cell can be made apparent. Faraday, in the course of his early researches, made the following experiment: he suspended a magnetic needle by a silk thread and lowered it into the liquid between the plates of one cell of a voltaic battery, so that its length should lie in a plane perpendicular to those of the plates, and he observed that when the needle was just below the surface of the liquid it was deflected the moment that the external current was closed. On lowering it still deeper (the current being maintained complete) its deflection gradually diminished as the depth of immersion was increased, until it reached a position about half the depth of the liquid, when it returned to zero, and after passing this depth it was again deflected, but this time in the opposite direction, its amount of deflection in either case increasing as its distance from the neutral or central point was increased. The cause of this phenomenon is obvious from the following considerations: If a wire carrying an electric current be held above and parallel to a magnetic needle, the latter, obeying Ampère's law, will be deflected with an angular displacement dependent upon the strength of the current and its distance from the needle; and if the same wire be held below the needle, the latter will be similarly deflected, but in the opposite direction. Now the flow of electricity through the liquid in a voltaic cell may, for the purpose of this explanation, be looked upon as made up of an infinite number of currents transmitted in a horizontal direction from one plate to the other; and when a magnetic needle is immersed just below the surface of the liquid, all these currents are flowing in one direction below it, and a corresponding deflection takes place; when, however, it is lowered deeper into the solution a certain number of currents are flowing below it tending to deflect it in one direction, and a certain number are flowing above it tending to deflect in the opposite direction; and its permanent deflection is due to the electro-magnetic effects of the difference between the two. When these become equal, as they are when the needle is at the middle of its depth, their effects on the needle are balanced and neutralised, and no deflection takes place, and when that point is passed the currents above the needle are in excess of those below it, and a corresponding deflection in an opposite direction is given to the needle. This is an interesting experiment, but is very difficult to repeat on account of the feeble and unconcentrated nature of the electric currents above and below the needle, and the resistance offered to its motion by the liquid in which it is immersed.

Professor Hughes, by placing in the current of a battery an apparatus, such as a clock microphone, or a key by which an intermittent or undulatory character may be given to its current, and holding one side of a rectangular coil of wire in circuit with a Bell telephone over one of the cells of his three-cell battery, induced a secondary intermittent or undulatory current in the coil by that portion of the primary circuit transmitted through the cell, and a corresponding ticking was heard in the telephone.

In both these experiments, however, the effects observed must be attributed rather to the external current of the other cells than to the internal current of the cell under experiment; and the author is unaware that any successful attempt has hitherto been made to construct an instrument which shall utilise the whole of the internal current of a single voltaic cell for the production of electro-magnetic effects. While engaged in some experiments a few years ago it occurred to the author that if a voltaic cell were divided into two portions, having the zinc element in one portion and the positive element in the other, and the solution contained in the one portion were connected to that in the other by a tube filled with the same liquid, the tube being coiled round a magnetic needle, a deflection of the latter, due to the current within the cell being forced by the convolutions of the tube to circulate around the needle, would be produced when the two elements were connected together, and the apparatus shown on the diagram was constructed. This will be seen to consist of two glass tubes closed at their lower ends with perforated corks through which the ends of the coiled tube are inserted. Within the rectangular coil of the tube was suspended a magnetic needle, and the whole having been filled with diluted sulphuric acid, a plate of zinc was placed in one tube and a stick of carbon in the other. On making connexion between them by means of a wire, a slight deflection took place, but owing to the feebleness of the current, the directive action of the earth's magnetism and the friction of the pivot, the instrument was not sensitive enough to be satisfactory, and the author therefore designed the instrument which is exhibited on the table, which consists of two glass test-tubes united together by a small tube about 2 ft. long, and convoluted into two circular coils after the manner of a Thomson's reflecting galvanometer. Within the coils is suspended an astatic system of magnetic needles of which the upper carries a light mirror by which its deflections may be made apparent by the movement of a spot of light on a screen. It may therefore in this respect be looked upon as a Thomson's reflecting galvanometer, coiled with liquid instead of with metallic wires. The elements are placed one in each of the little cells, and may be connected by a key; or, by placing a reflecting galvanometer in the external circuit, both currents may be simultaneously indicated on the screen and their independence or identity be demonstrated. The first instrument constructed by the author was made by connecting the two cells by means of a tube of india-rubber coiled round two cardboard cylinders, but through the kindness and unrivalled skill of his friend Mr. Gimingham, whose name is now inseparably connected with the splendid researches of Mr. Crookes, he was able to produce the instrument on the table, in which the tubes and coils are of glass, all in one piece, and it is a very beautiful specimen of accuracy of glass blowing. Below the base of the instrument is a fine slightly magnetised sewing needle, which can be rotated on a vertical axis through a small angle by means of a little lever, and by which the instrument may be adjusted to zero.

The author has been induced to bring the instrument before Section A of the British Association in the hope that it may be useful, not only for science teaching, but for aiding investigations connected with the physical action of the voltaic battery.

* Paper read before Section A of the British Association at Sheffield.

ELECTRICAL SCIENCE AT THE BRITISH ASSOCIATION.

Some New Instruments, recently constructed for the Continuation of Researches on Specific Inductive Capacity.

By J. E. H. GORDON, Asst. Sec. Brit. Assoc.

In this paper the author illustrated his observations by the exhibition of a miniature five-plate induction balance, similar in principle to the large balance shown at the Dublin meeting of the Association, but intended for the examination of crystals and other precious substances, which cannot be obtained in sufficiently large quantities for the balance; also a gauge for measuring the thickness of the dielectric plates to 1-10,000 inch, and a new form of quadrant electrometer for use with the small induction balance was shown. The capacity of the smaller plates of the little induction balance was so minute, that, when they were attached to the quadrants of the electrometer of ordinary construction (Elliott pattern), disturbances in them produced hardly any effect on the needle, on account of the much greater capacity of the quadrants of the electrometer. In order to construct an electrometer, whose quadrants should have very small capacity, and which should yet be very sensitive, Mr. Gordon had arranged the quadrants as pieces of a flat disc, only one inch in diameter, with the edges bent round them, so that the needle was acted on by both the upper and lower surfaces and the outside edge.

Mr. Gordon also exhibited a new rapid commutator, which was invented by Professor Cornu, of the Ecole Polytechnique, Paris. It could be used with either the large or small induction balance on the one hand, and with a Holtz machine or battery of 500 or more cells on the other. It reverses the electrification of the plates of the balance eighteen times per second, and between each reversal, short circuits, and puts to earth both poles of the induction balance, and both poles of the battery. By altering two screws it can be arranged to short circuit, and put to earth the poles of the induction balance only and to insulate the battery poles.

Secular Changes in the Specific Inductive Capacity of Glass.

By J. E. H. GORDON, Asst. Sec. Brit. Assoc.

The object of this paper was to describe the result of certain experiments made by the author by a method which has already been described before this section. The conclusion arrived at was that in the course of a year and a half an actual change had taken place in the glasses, which was shown by a considerable real increase in their specific inductive capacities. To complete our knowledge of this new phenomenon, however, it was considered that a series of monthly observations was required extending over a period of several years. These experiments had some importance as regards Professor Clerk Maxwell's electro-magnetic theory of light. Mr. Gordon had recently suggested that it was quite possible that the relations between electric induction and light exists—namely, that they are disturbances of the same ether, but that there is some unknown disturbing cause affecting the electric induction. Possibly a clue to the nature of this disturbing cause might be found in the fact that the specific inductive capacities were affected by some of the changes which chemists assert are constantly occurring in glasses, but that these changes do not affect the refractive indices.

Electricity as a Motive Power.

By Prof. W. E. AYRTON.

Discourse delivered August 23rd, 1879, to the Working Men of England.

We hear on all sides new complaints regarding the stagnation of trade, the competition of foreign labour, and the difficulty found in disposing of English products to other countries. Various are the remedies suggested: on the one hand we are told that protection is the cure, because our trade is now almost entirely an import one, kept up by the export of English gold, and not, as it should be, by an exchange of English commodities for foreign ones. Consequently, there are some people who say that the only way to induce other nations to lower their prohibitive import duties, so as to stop this one-sided traffic, is to cause their own goods, now freely exported to Great Britain, to hang on their own hands, and that this can be done by the English temporarily also adopting protection. On the other hand we are assured that emigration is the panacea, and that it is the strikes which ruin the country.

But while the one side is maintaining, and the other side stoutly denying, that commercial depression can be cured by legislation, we are apt, far too apt, to forget that there exists a means by which, without lessening the wage of the workman, or the profit of the master, the cost of production can be diminished, prices lowered, and the failing trade of England resuscitated.

For is it only by burning coals that we can hammer our steel, turn our grindstones, work our lathes, and propel our trains? Coal is no doubt an extremely useful servant, but it is one that here in Yorkshire costs you five shillings a ton when you want to get power out of it, about twelve shillings a ton when used for melting metals and making gas, and about ten shillings a ton when you want it to warm your houses; therefore, as Mr. Bainbridge has been so kind as to ascertain for us that roughly in Sheffield alone about 500,000 tons are used annually for the first purpose; 750,000 tons for the second; 150,000 tons for the third; and 250,000 for the last of these objects, you see there is altogether an annual consumption in this town of about one million six hundred thousand tons, costing you therefore about £790,000 every year.

It is worth while, then, considering whether this consumption of coal can, even in a small degree, be replaced by any other source of power and heat.

For example, at Ottawa, in Canada, where exist perhaps the largest wood-cutting works in the world, the logs of wood come down from the mountains, are collected in the river, lifted and placed in position on the benches, sawn into planks, and stacked; but not a pound of coal is burnt. For merely by taking advantage of the fall of water which exists at the place, a man has merely to turn on a particular water tap to perform any particular operation.

For a stock of water on a hill is, to the people in the valley, what a coal mine is to a Sheffield manufacturer. As the water runs down the hill it can turn wheels, it can work machines just as can coal as it burns in the furnace of a steam engine. You all know the water wheels round Sheffield employed to work the grindstones and the tilting hammers. The high quality of the anvils coming from your Mousehole Forge, where water power is, or was, exclusively used, would be alone sufficient to keep water power permanently before you.

On Goat Island, between the Falls of Niagara, there is a paper works, the machinery of which is worked by the Falls. But what an infinitesimal portion of the energy of these Falls is used by that single paper mill. For, in addition to the gradual slope of the river, on account of which the water acquires considerable velocity, a hundred million tons of water come tumbling down every hour, through a vertical height of 150 feet. Now the power this represents is, of course, the same as would be required by perfect pumps to pump it back again. To raise a hundred million tons of water per hour, through 150 feet, requires the expenditure of nearly seventeen million horse-power; and this could only be produced, with even good steam engines having much above the average efficiency, burning, say 3 lbs. of coal per hour per horse-power, by an annual expenditure of about two hundred million tons of coal, which is about equal to the total consumption of coal throughout the whole world. And if it be remembered that there exist in the world other waterfalls besides Niagara, that we have also innumerable rapidly flowing rivers, the important fact well known to scientific men, but one which it is difficult to induce the world at large to grasp, stares us in the face—that we obtain, in a laborious way from the depths of the earth, the power we employ, and we let run to waste, every hour of our lives, many, many times as much as we use.

But it is not every manufactory that is situated directly over a stream, or even near a stream; and even when that is the case, as in Sheffield, you find streams are sometimes fickle, the tilting cannot be regulated with the same nicety as with a steam hammer—the natural order of things is reversed; water gives way to fire.

But were it possible, without water courses or cumbrous mechanism, to transport direct the energy of the mountain torrent, then machines in the very heart of a town could be worked as economically as those close to cataracts.

Again, even in a perfectly flat country, where waterfalls are unknown, the question of economic transmission of energy has no less interest. For you know that large steam engines can be worked much more economically than small ones. If, for example, I have a steam engine of many hundred horse-power, it can be worked by an expenditure of about two, or two-and-a-half, pounds of coal per horse power per hour, or, at the present price in Sheffield for steam coal, five shillings per ton, the best steam engines, if they be very large, can be worked at considerably less than one farthing

per hour. But if a man has a small grindstone requiring, say one horse-power to work it, and if he uses a small steam engine for this purpose, then instead of costing him less than twopence per day of eight hours' work, he will probably have to pay a shilling a day, in addition to the expense and trouble of getting up the steam; so that if he only uses the small steam engine occasionally, it will be hardly worth while going to the expense of having one at all. If, however, he could have transmitted to him, just at the time he might require it, a small amount of energy at, say, one halfpenny per hour per horse-power, which would be three or four times the actual cost of production of the horse-power with a very large steam engine, and if he could turn off the power like gas when he did not want it, so that one single hour's work with a one horse power grindstone cost really only one halfpenny, how many of the smaller workmen of Sheffield would be glad to avail themselves of such a facility.

But you will say in our large factories, in our huge cotton spinning mills in Manchester for example, we do use very big steam engines, and therefore this transmission of energy cannot produce any great gain there. Undoubtedly, these steam engines are fairly efficient, because they are so large; but what about the enormous mass of shafting used to connect this single engine with all the stories of the factory and with all the machines in each story? Why, the waste of power in friction in this shafting is so great that, in spite of the extreme inefficiency of small engines, it has been proposed as an economical measure, to replace the one large steam engine by many small ones, each driving two or three machines direct.

It might, at first sight, appear that the water already brought to our houses for drinking and for cleansing purposes, might be also used there for working small turbines or waterwheels, and I have heard this suggested as a possible means of utilising a natural source of power. But this is one of those delusions into which over sanguine people are liable to fall. For there are very few towns where the working pressure of water in the streets is more than able to raise it to a height of 100 feet.

Now 1 cubic foot of water weighs 62½ lbs.
therefore 1 ,, ,, ,, ,, descending 1 ft. per minute
does approximately 1 foot pound of work per second.
That is—5⅓ cubic feet of water per minute } for every 100
Or— 330 ,, ,, ,, ,, ,, hour } feet head
produce approximately 1 horse-power.

Some allowance must, however, be made, for the fact that our best turbines have at the most only an efficiency of 0·8, that is waste 20 per cent. of the power. We may, therefore, say that practically about

450 cubic feet of water per hour } for every 100 feet
Or—2,700 gallons ,, ,, ,, ,, } head
produce 1 horse-power.

But even in places like Sheffield, where the supply of water is large, the minimum cost in the town, when more than seventy millions of gallons are used annually, is not less than 6d. per 1,000 gallons. Consequently, with water at a pressure of 100 feet, it would cost about one shilling and fourpence per horse-power per hour.

In Sheffield, where the working pressure of the water in the lower parts of the town is also unusually high, being not less than 130 lbs. per square inch, or 300 feet head, it would be possible to produce work by small turbines at about fivepence per horse-power per hour, but this of course cannot be compared with less than one farthing per horse-power per hour, the cost of working very large, good, steam engines.

In our poverty and depression, our old servant, coal, is beginning to desert us, and to demand a higher price than we can give. Water, a yet older handmaid, refuses to work at all in our houses, except for extravagant payment. Where is it that we must turn for help? Where can we find the carrier that will, at a small cost, transport our motive power over long distances?

It is to electricity we must look for an answer to this question. It is to that fleet, subtle, messenger to whom we trust the carrying of our news that we must trust the carrying of our motive power.

To explain better what I mean:—When I turn the handle of this machine, my muscular energy is turned into electricity. This electricity is conveyed by the two wires before you to the small motor at the other side of the Hall, where it is converted back again into work. I put in work then here and I get it out again at a distance, without any shafting, straps, or pipes connecting the two places.

In exactly the same way, but on a much larger scale, Mr. Wilson will be so kind as to polish a knife with motive power supplied by Messrs. Walker and Hall, of Howard Street, and conveyed here electrically, by wires suspended to the spire of St. Paul's church, and crossing the streets as you see them in this diagram.

This other diagram shows you exactly how the machines in Howard Street, and these on this platform are electrically connected together.

Now these machines that are employed for this purpose depend on two important discoveries, the first, supposed to have been made by Romanosi, in 1802, who found that an electric current could produce mechanical motion; the second discovery, made by Faraday, in 1831, who, after the most patient investigation, was at length able to prove conclusively the result that he had long felt in his own mind must certainly be true, viz., that a magnet must somehow be able to produce an electric current. The first of these discoveries may be illustrated by the following simple experiment. Here we have a vertical copper wire, through which we can send an electric current either upwards or downwards. Behind the wire there is a magnet, suspended on a horizontal axis, so that it can turn in a vertical plane. The magnet is so arranged, that usually it stands upright; but if I send a current upwards, you observe the marked end turns to your left, while if I reverse the direction of the current, the marked end turns to your right, the magnet in both cases placing itself at right angles to the wire. Now, why does the magnet move when the current flows along the wire? Because the wire with the current in it produces in the space surrounding it the same effect that would be caused by the presence of a large magnet. For if I hold this other magnet in this position, perpendicular to the suspended magnet, you see the latter one turns with its marked end towards your left hand, as it did when the current ascended; and when I reverse the position of the big magnet, the smaller one puts itself in the same position as it did when the current descended. From this you would anticipate that since an electric current can act like a permanent steel magnet, in deflecting a suspended magnet, and since a steel magnet can make this piece of soft wire into a magnet by being put near it, that an electric current will also make a piece of iron into a magnet, a result first proved experimentally by Arago. When the electric current passes through this coil of wire, wound round this iron bar, the bar acquires the power to hold up masses of nails, but the moment the current ceases the iron, as you see, loses almost, but not *quite*, instantaneously, all its magnetic properties, and the nails fall to the ground. But since, by electricity, I am able to produce sufficient pulling force to hold up bits

of iron, or, at will, cause this force to cease to act, then I must be able to do just as Newcomen did, when he made his so-called atmospheric engine.

For if we cause the attraction of this electro-magnet to pull a piece of iron, or armature as it is called, against the tension of a spring, and if, just when the iron is almost touching the electro-magnet, we interrupt the current, the spring will be able to pull the iron back again, and thus by repeating the action over and over again you see we can get an oscillating motion similar to that obtained in a single acting engine. And any oscillating motion you know can be turned into a rotatory motion by means of a crank and fly-wheel to make the crank pass the dead points. Now, the first man to make an oscillating electro-motor of this kind was a learned monk of Padua Salvator del Negro, in the year 1831. But an oscillating motion has many disadvantages, of which perhaps the most important in an electric engine is that the moving armature at the end of its stroke will be at a distance from the electro-magnet. Now the electro-magnetic attraction diminishes very rapidly as the distance increases, so that when the armature begins to approach the electro-magnet there will be very little force pulling it.

The Russian philosopher Jacobi explained this in 1834, and devised a rotatory engine in which the moving parts were not merely pieces of iron, but electro-magnets like the fixed ones. When the pole of one electro-magnet was approaching that of another due to the rotation of the apparatus, the currents were so arranged that there was attraction, but the moment the moving pole passed the fixed pole the electric current flowing round the former was reversed, so that there was attraction. An instrument such as Jacobi used may be seen working on the table, and like Jacobi's was originally intended to propel a boat. Here again I have a complete model boat driven by an electro-magnetic engine, with galvanic battery in the boat. A third electro-motor is working a Howe's sewing machine, while a fourth is a small engine running round on a pair of metal rails. This last would no doubt pass with the world as a mere toy, but the practical philosopher sees foreshadowed in it his dream of the future, just as Stephenson, in his "Puffing Billy," no doubt foresaw the express locomotive engine of the present day.

But after some time Jacobi abandoned his electro-motor, as the fuel cost far too much. Why then trouble you with considerations regarding electro-motors? Because we have since learnt why the old form was such an expensive producer of power, and what is the proper duty in which electro-motors should be employed.

Now, it was this very question:—Can an electric engine be made to work more economically than a steam engine that first attracted Joule of Manchester, in 1843, to commence that all-important investigation, which lasted for six years, the determination of the mechanical equivalent of heat.

Formerly, electric currents were almost entirely produced only by galvanic batteries, such as I have in my hand, in which zinc is burnt just as in the furnace of a steam engine coke is burnt. The amount of heat that could be got from burning a pound of zinc could be ascertained in the same way as the amount of heat produced by the burning of a pound of coal, but the fact that the latter was about seven times the former was of little value in the science of electro-motors, until Joule had proved that a certain quantity of heat is always equivalent to exactly the same quantity of work, no matter how the heat be produced; in fact, until Joule had arrived at that famous result which, although you know it well, will still bear repeating, that result which made the "Conservation of Energy" a law and not merely a speculation.

A quantity of water on a height, a heated body, a moving mass, two separated quantities of opposite kinds of electricity, an electric current, two chemicals which would combine if brought together, particles of attracting matter at a distance asunder, two planets in space, are examples of energy—each of the systems can be made to do work.

Now, experience shows that all these energies are convertible into heat, and that a certain quantity of each kind of energy is mechanically *exactly* equivalent to a certain quantity of any other. If a body, or if a system of bodies, possesses different kinds of energy, then as long as no energy leaves the system, or enters it from without, this sum is *perfectly constant*, no matter how one of these forms of energy may change into another form. Energy is in fact as indestructible as matter, and this law has one of its proofs in the long unsuccessful search for a perpetual motion.

Since, therefore, a pound of ordinary coal burning gives out seven times as much heat as the burning of a pound of zinc, we may say at once, that a steam engine would give seven times as much work as an electric engine for equal weights consumed, if in both cases all the heat could be turned into work; or, since zinc is about 24 times as dear as coal, that a steam engine would be about 150 times as economical as an electro-motor, worked by a battery.

But so far we have only considered the law of "Conservation of Energy." There is, however, another, and no less important, principle called the "Dissipation of Energy;" and this law tells us that although the energy of a system cannot by itself increase or diminish, yet our power to convert one form of energy into another is continually growing less, our stock of available energy is gradually failing. Our mountain lakes, our vast store of coal is practically useless until either the water is set in motion rolling down the hillside, or until the particles of the coal are set in rapid vibration as it slowly burns; energy of position, energy of chemical affinity, are of no use to the manufacturer until turned into kinetic energy or energy of motion. But from friction of various kinds, whenever energy exists in the kinetic form, some portion of it is being continually converted into heat. Whenever man or nature utilises energy it must be first turned into some kinetic form, and whatever be the aim of the special machinery employed some of this energy passes into heat. We cannot make even a clock go without regular winding up, although the only useful work done by the clock is to turn its hands at regular speeds; the earth's energy of rotation is now, like the moon's in past ages, gradually growing less, and is being converted into heat on account of tidal retardation; the earth, moon and sun, and all the planets are losing their energies of motion and relative positions, to be all ultimately turned into heat.

But at any rate it will be said there will still remain the heat, and since heat can be converted back into other forms of energy, we shall be none the worse off. But it must not be forgotten that whenever heat is produced some passes off by conduction through even our best non-conducting substances, and by radiation into space from even our best non-radiating surfaces; and this conducted and radiated heat, although it may impart some trifling warmth to unseen worlds, is for the greater part entirely lost to our universe. And even were it not so, even had we perfectly non-conducting coatings, and perfectly non-radiating surfaces,—had we, in fact, the most perfect heat engine that our study of the science of heat would lead us to believe theoretically possible, one with no friction, no loss of heat by conduction through the sides of our cylinders, and no radiation from their sur-

faces—still our power to convert heat into other forms of energy would be very limited. For if there are two bodies one hotter than the other we can employ an engine, like a steam engine, to convert part of the heat in the hotter one into some other form of energy; but the amount of heat converted, with even this ideal perfect engine, will, with such temperatures as are met with in practice, only be a fraction of what necessarily passes through the engine from the hot body to the cold, and warms up the latter; and as our whole power of conversion of heat into work depends on the difference of temperature, we lose it altogether when we have brought all parts of a system to the same temperature, no matter how high this temperature may be.

It is not, therefore, sufficient to say that the burning of a pound of coal produces seven times as much heat as the burning of a pound of zinc; but we must consider what fraction of the heat thus produced is converted into useful work in a heat and in an electric engine respectively.

As already mentioned, our most perfect steam engines can be made to produce one horse-power with the consumption of 2lbs. of coal per hour. Now, the burning of 2lbs. of coal will produce enough energy to raise 18,528,000 pounds one foot, or will produce 18,528,000 foot pounds of work. Now, one horse-power is equivalent to 1,980,000 foot pounds of work per hour, therefore, as regards the total energy in coal, even our best steam engines only utilize $\frac{1}{9}$ of it and waste $\frac{8}{9}$. But, as already mentioned, even a perfect engine cannot, with the ordinary temperature available, utilise the whole of the heat of the fuel. In fact, theory tells us that the efficiency of a perfect heat-engine, or the ratio of the work done on the maximum work obtainable from the consumption of the fuel, is equal to the ratio of number of degrees of temperature through which the steam is cooled in doing work to the highest temperature of our steam, when we take as our zero of temperature a point 460° below the ordinary zero of the Fahrenheit scale.

Now, in our best steam engines, the steam, when it begins to push the piston by expanding, has a temperature of about 300° F. and at the end of the stroke a temperature of 100° F. so that the efficiency of a perfect ideal engine working between these temperatures, is only about $\frac{1}{4}$, not so very much greater than that of best practical engines.

No great advance can be made then in a heat engine, except by making the temperature of the working substance, steam, gas, or whatever it may be, much higher. If, for example, we could raise the temperature of the working substance as high as, say, 3,000° F., the temperature of combustion, and could make it leave the engine without artificial cooling at the ordinary temperature of the air, which is, say, 60° F. then a perfect heat engine, under these conditions, would only waste about $\frac{1}{7}$ of the total energy; consequently assuming that we could, at these high temperatures, make a practical engine as good relatively to an ideal perfect engine, as we can at lower temperatures, then a practical engine would only waste $\frac{1}{6}$ of the total energy, or would have an efficiency of about 0·84.

But, with our present knowledge, to work with steam or gas at a temperature of 3000° F. is almost as ideal as an engine with no friction, and with no loss of heat by conduction and radiation. We are, therefore, led to the conviction that as it is solely by working with steam at very high temperatures, that the efficiency of steam engines can be seriously increased, it may be well to consider whether it is not possible to economically replace the steam engine with some other form of motor.

In order to estimate the efficiency of electric engines, we must consider the discovery made by Faraday, to which I have referred. We know that motion can produce electricity with the ordinary glass electrical machine, and that the electricity so produced can in its turn set up motion, as in the pith ball telegraph worked by Sir Francis Ronalds. We know that difference of temperature can produce an electric current, and the electric current can in its turn produce heat, or difference of temperature. Consequently Faraday felt sure that, since an electric current can, as you have seen, produce a magnet, a magnet must, in some way, be able to create an electric current. But his attempts were baffled time after time; failure, failure only was the result, yet buoyed up with hope, still persevering with that dogged earnestness which is the characteristic of an Englishman, he at length arrived at this all important discovery—to produce a current with a magnet it is no use placing the magnet this way or that way relatively to the coil, but you must have *motion* of the one relatively to the other. And this coil of wire before you is the very one made by Faraday's own hands, and which he used in investigating this problem. The results obtained with it were insignificant in magnitude, but they form the foundation of all the electric lighting of the present day and of the future electric transmission of power.

To enable you to better understand the discovery of "magneto-electric induction," I have here a coil of wire in which a magnet is suspended, and free to move in a vertical plane. Attached to the magnet is a pointer to enable you to detect any motion of the magnet. Those of you who are near will see the pointer itself, while those who are at the other end of the room will see it projected on to the screen as a huge vertical black bar. The exact construction of this instrument is also shown in the large diagram.

Now, we know from our previous experiments that this arrangement will detect whether an electric current is flowing through the wire and also which way it is flowing; in fact the instrument is in principle exactly the same as the one I previously used, only, as the wire goes many times round the magnet in this second instrument, it will detect a much weaker current. To the two ends of the wire forming the current-detector are attached the two ends of the wire forming this coil. The pointer of the detector is now vertical, indicating that no current is passing; but if I rapidly move this magnet towards the coil, the pointer deflects to the left, and then comes back again to the zero position, indicating that an instantaneous electric current was set up in one direction. Now, if I rapidly remove the magnet I have in my hand, you observe the pointer makes a swing towards the right, indicating an instantaneous electric current in the opposite direction. To be quite sure that the deflections you saw produced in the suspended magnet are the results of electric currents, and are not produced by the direct attraction of the large magnet, I hold in my hand, on the suspended magnet, I make a break in the circuit of the wire so that electric currents cannot now flow; and you observe that the motions of the big magnet produce no effect whatever on the little one at this distance.

Now, we have seen that an electric current can do work, and the principle of the conservation of energy tells us that work cannot come out of nothing, therefore, my hand, in moving the magnet, must do as much work as is performed by the current. As this current is weak it would be a little difficult to measure, in a simple way, the work done by my hand; but if we take a machine for producing strong magneto-electric currents, a machine called the "magneto," or "dynamo-electric machine," then as long as the wire is incomplete so that no current can flow, you see it is quite easy for me to turn the handle, but the moment a small

piece of wire is inserted so that a current is induced, my hand is arrested—I can hardly turn the handle—I have to do work, hard work, in order to continue the motion of the machine, and that work has its equivalent in the electric current that flows, and in the heat which you see the current is producing in the piece of wire we inserted, and which has now become white hot.

But, perhaps you may say, although this is very interesting in connection with the mechanical production of electric currents, what has it to do with the comparison of steam engines with electro-motors, the object of which is not to produce currents, but work? The answer is, because every electro-motor, every instrument that is worked by an electric current, is also a magneto-electric machine, that is, can produce electric currents, and, in addition, always is producing electric currents when it is itself set in motion by one. For taking this simple form of electro-motor—where an iron armature is attracted by an electro magnet—this attraction arises from the fact that as soon as the current is started, the iron armature is first converted by induction into a magnet before it is attracted; consequently when it moves up to the electro magnet, we have the case of a magnet approaching a complete coil of wire, the result of which you now know is the production of an electric current. Now, this electric current must be in the opposite direction to the original current producing the motion, for otherwise the original current would be increased by the induced currents, therefore the armature would be pulled with more force, and the total work done by the original currents would be increased without any equivalent consumption of energy elsewhere. This induced current therefore, like all currents induced by the motion of magnets, relatively to coils of wire, *tends to stop the motion*, and must be taken into account, in calculating the efficiency of an electro-motor; in fact not only must be taken into account, but experiment shows us that it is this tendency of the electro-motor to send a back current that makes it an electro-motor at all.

This reverse current may be thus shown experimentally. I have here a battery sending a current through a Froment's electro-motor, which, as you see, can work either this pump, or this pile-driver. Now, the strength of the current, as measured by this galvanometer, is 40° when I hold the electro-motor at rest, so that it can do no work, and 30° when I allow the motor to move rapidly as you now see it doing.

When an electro-motor is worked by a *given* galvanic battery, then calculations lead us to the result that if we wish to produce the work *most economically* we must, by diminishing the load on the motor, allow its speed to increase until the reverse current it produces is only a little smaller than that sent by the battery; in fact, until the current circulating through the arrangement is very small, in which case the efficiency of the engine, or the ratio of the work it produces in a given time to the maximum work it could produce from the same consumption of material is nearly unity. If, on the other hand, we desire a *given* battery to cause the motor to do work *most quickly*, independently of the consumption of material, then calculation tells us that we ought to put such a load on the motor that its speed will send a reverse current equal to something like a half of the strength of the current the battery could send through the motor when at rest. In this case the efficiency is about $\frac{1}{2}$, or half the energy is wasted in heat.

The difference between these two considerations of maximum values must carefully be borne in mind, especially as it is usually the second—or how to obtain work *most quickly*—that has generally been taken into account, whereas, this evening, it is the other one—or how to transmit work *most economically*—that will specially engage our attention.

Now, let us consider that we work our motor in the most efficient way—that is very fast with a small load, and let us consider that by so doing the efficiency is so little short of unity that we may regard it as one, then since an electro-motor worked by a battery in which zinc is burnt is 150 times as dear as a steam engine for equal efficiencies, the best electro-motor worked by such a battery will be 33 times as dear as our best steam engines having an efficiency of $\frac{2}{9}$. We may, therefore, throw on one side at once all idea of electro-motors worked by ordinary batteries, even although the electro-motors be perfect. Now, this result is most important, since it shows not that an electro-motor as a machine is inefficient, but it tells us that attempting to drive it with a galvanic battery is the hopelessly inefficient part of the arrangement.

But if we turn to the question of using electro-motors for the transference of power, then there is no difficulty about burning zinc, and the high efficiency of such motors is all important.

For in the case of natural sources of power, such as waterfalls, we have merely to consider what amount of energy will be produced at the distant factory; will it be sufficient to repay the expense of putting up wires from the source to the factory, together with the cost of the two dynamo-electric machines, or will it be cheaper to put up and use a small steam engine having probably an efficiency of only $\frac{1}{12}$?

When the distance between the source and the motor is considerable, the cost of putting up the leading wires becomes important, and the question therefore arises, can two or more people use the same leading wires without increasing the thickness, or must the thickness of the wire be so much increased as to make the construction of two sets of leads as economical?

To this question I must beg your most careful attention, since the answer to it, which I hope I may b able to put it in the power of all of you to give, will decide whether the electric transmission of energy is a mere dreamer's fancy, or is likely to have a real commercial future.

In order to decide this let us consider what proportion of the power is lost in transmitting it by electricity and what is lost when water is used as the carryng, agency. For convenience we will take the second question first.

Let w pounds of water flow per second out of a reservoir, along a pipe into a town, then if there was no friction whatever in the pipe, if the pipe were perfectly smooth so that the water could slip past the surface quite easily, then the work the water could do in the town would be

$$w\,H \text{ foot pounds;}$$

but experience shows that in reality this amount of work, when the pipe is straight, is diminished by at least

$$w\frac{4\,f\,l\,v^2}{d \times 64{\cdot}4}$$

where f is a number depending on the smoothness or roughness of the pipe, l the length, and d the diameter of the pipe in feet, and v the velocity of the water in feet per second with which the water flows through the pipe. The work, therefore, that the water can do in the town is only the difference between these two last quantities, or

$$w\left\{H - \frac{4\,f\,l\,v^2}{d \times 64{\cdot}4}\right\}$$

and the loss goes to slightly heat the pipe and the water. This loss will, in reality, be even greater than

112

what I have mentioned, as there is a certain amount of friction where the water enters the pipe at the reservoir, and additional friction at every bend of the pipe.

Now w pounds of water per second flowing, may be enough to work one man's machine, but suppose we want to increase the work done, we must, if we cannot alter the reservoir, diminish the water pressure in the town, to allow the velocity of the water and the quantity flowing per second to become greater. Suppose we double v then w will also be doubled. Double the energy will, therefore, be taken out of the reservoir, but the power furnished in the town will not be twice as great as before, since it would only be twice as great if we could both double the current and keep the pressure in the town constant; the loss, too, of power in the pipe will now be eight times as great as before, so that if we go on supplying a town in this way with motive power, the loss of energy will soon become ruinous.

But there is another way in which theoretically we can increase the power conveyed to the town, and that is by increasing the pressure at the reservoir, as well as the pressure at the town. Suppose, for example, that we double the pressure at the reservoir and increase the pressure at the town sufficiently to keep the difference the same as before, then the velocity of flow and therefore the quantity discharged will remain just the same. The waste, therefore, will not be increased, the power absorbed at the reservoir is double what it was before, while the power given out at the town is more than double what it was before, since the pressure in the town will have to be more than doubled to keep the current constant.

Such an arrangement, as far as we have gone at present, would then be a good one, since if we can much increase the pressure at the reservoir, and use at the town turbines, or water engines, working at a high pressure, we shall be able to transport any amount of power with exceedingly little loss.

Is this then the solution of the problem to transfer power economically by water? Theoretically, yes; practically, no. For when we talk of increasing the pressure at the reservoir, how are we to do it?

We must use some kind of force pump, worked either by a steam engine, having a combined efficiency of perhaps $\frac{1}{10}$ at the most, or by a considerable quantity of the water at a low pressure working a turbine which drives the force pump. Now, the combined efficiency of the pump and turbine will not be more than $\frac{1}{4}$. Taking this latter as being the larger and that assuming at the town itself we have some sort of water-motor, having an efficiency of even as much as 0·8, then the combined efficiency of the whole arrangement cannot be more than 0·32.

(*To be continued.*)

ELECTROMOTIVE FORCE, RESISTANCE AND CURRENT.

[1022.]—I am sorry to be obliged to take up so much space on this subject, but "Sigma's" replies are so unsatisfactory that I feel it to be necessary to do so. He persists in mixing up two things: the physical meaning of certain phenomena of electricity, and the mathematical processes employed in defining and measuring them. His "hard thinking," referred to by "Eclecticus," is well known to readers of this paper, and I have the greatest respect for his interpretations of electrical phenomena, so far as they are consistent with the mathematical theory. But, when the two clash, "Sigma" must pardon me if I insist that he is bound to show where the mathematical theory is wrong, or, if he cannot do that, then to conform his interpretation to it. Now, there are three principal points upon which "Sigma's" interpretations conflict with mathematical principles. The first is the distinction between force and energy, which, he says, consists in this: that force is independent of mass, while energy is dependent thereon. Avoiding semi-metaphysical discussions as to the intrinsic nature of force and energy, about which the wisest of us know very little, I merely ask "Sigma" whether his distinction is consistent with the fact that we measure force by the mass moved and by the acceleration produced therein? May I also, in passing, suggest to him that the distinction between the two, whatever it consist in, is lost sight of not only in the passage on page 152 of his book, for which he has noted a correction, but also in the list which follows it, and in all the earlier part of Chapter VIII. Considering that "Sigma" was writing in a scientific periodical, and on a scientific subject, his remark that, though distinct in definite science, "it is hypercriticism to deny that there are many cases in which the terms are by no means very distinct," is somewhat superfluous. I know perfectly well that the terms force and energy are popularly used as synonymous, but that does not make such use of them any the less wrong.

The second point on which "Sigma's" interpretation and the mathematical theory are at variance is the derivation of the Volt, Ohm, and Veber. In his book these are described as respectively 100,000, 10,000,000, and ·01 "absolute units"—a very vague description, which may be either right or wrong, according to what absolute units are meant. But in his recent articles he explained that he meant thereby the absolute unit of force, and when called upon to defend this description, he points to the table of dimensions of the various electric units given in his book, as showing what the units mean. Quite true, only the Volt, Ohm, and Veber are not mentioned there. All other authorities agree in stating that they are multiples of the absolute units of electromotive force, resistance, and current respectively; and these three units being measured in different ways, as shown by their dimensions, they are necessarily incommensurable with each other, and it follows that the Volt, Ohm, and Veber are also incommensurable (using that word in the usual sense). Now, "Sigma's" result is directly opposed to this, and I positively deny that any subject can have two aspects which contradict each other; one of the two *must* be wrong; but as "Sigma" chooses neither to defend his view nor to correct it, I must leave it to our readers to say which is wrong. But "Sigma" does not appear to realise that unless two things are measured in the same way, they cannot be of the same kind, nor can they bear any ratio whatever to each other. For when in my first letter I affirmed this of force and energy, giving as the reason that the dimensions of their units are different, "Sigma" asked whether this was so, and if so, why? I omitted accidentally to give the answer in my last letter, and will do so now. Will "Sigma" consider for a moment what would be the effect in our measurements of force and energy if we simply altered the value of one of the fundamental units which enter into the measurement of both? Take 10in. as the unit of length, instead of one metre, then the nominal value of what was unit force (LMT^{-2}), will now be 1-10th, but the nominal value of what was unit energy (L^2MT^{-2}) will now be 1-100th. Similarly with the units of electromotive force ($L^{\frac{3}{2}}M^{\frac{1}{2}}T^{-2}$) and energy, if we take 100 grammes as the unit of mass instead of one gramme; then the nominal value of what was unit E.M.F. will now be 10, whereas the value of what was unit energy becomes 1-100th. A simple change, therefore, in one of the fundamental units common to both, changes what (according to "Sigma") are equalities into differences of value in the one case of ten, in the other of 1,000-fold. "Now, two things which are really equal to one another must necessarily be expressed by the same numerical quantity *whatever* system of units be adopted." This is a quotation from Prof. Tait's lecture on force, published in his "Recent Advances in Physical Science," and he goes on to say, with reference to a common error of confounding momentum with force that, "whatever be the system of units you employ, if you increase in any proportion the unit of time, the measure of a momentum is increased in that proportion simply, while that of a force is increased in the duplicate ratio. *The two things are therefore of quite dissimilar nature, and cannot lawfully be equated to one another under any circumstances whatever.*" Now, *mutato nomine*, this applies equally to force, electromotive force and energy, and is almost word for word what I said in my first letter, though I had not then read Prof. Tait's lecture. The argument appears to me absolutely conclusive, and "Sigma" must be capable of wriggling out of his skin if he can wriggle out of this!

The third point will take more time. The object of my quotations, as "Sigma" might have seen, was to show that authoritative definitions contradict his doctrine that energy varies as the square of force. Whether this was meant to apply to ordinary mechanical force or to E. M. F. only, matters not; both are equally wrong. If it were as he said, the term electromotive force would be an abuse of the word force, for, whatever be its kind, "force" is by its very nature a cause to which the effect produced must, *ceteris paribus*, be simply proportional, whereas here the cause would not be the E. M. F. simply, but its square. "Sigma's" words "cause and effect are equal, or, to put it in symbols, $NE = F$ and $F^2 = E$, where E means energy and F force," can bear no other meaning, unless indeed that effect varies as the square of the cause, which would not only be contradictory but ridiculous. "Sigma" appears to have forgotten for the moment what he himself has said on p. 210 of his book: "the real fact is that it (the energy of a current) varies not as the square but in the direct ratio of the current, that is of the number of molecular actions in a given time, but that it also varies in the *direct ratio* of the force under which these actions occur; it is because these two necessarily vary in the same degree, one being dependent on the other, that the combined effect can be truly represented as due to the square of either one of them." Wherefore "Sigma" witnesses against himself when he says in his last letter, p. 669, "We all know that the energy expended in the circuit is in the ratio of the square of the E. M. F. Does it not follow naturally that the E. M. F. is really the square root of the energy?" He has himself shown that it is not so. Besides, if we consider that we may have any number of circuits expending the same amount of energy, but with very different values of the E. M. F. and current, it becomes self-evident that the E. M. F. cannot be an expression for the square root of the energy; otherwise we should have as many square roots as circuits! All this is the result of taking the current, or quantity transferred per second, as a fundamental phenomenon of electricity, instead of the quantity pure and simple, an error which leads to all sorts of laboured explanations why doubling E. M. F. without altering resistance does not double, but quadruples the electric energy. The plain fact is *that it does nothing of the kind*. What it *does* quadruple is *the energy set free per unit of time*, or, in other words, the rate of doing work; for in whatever degree the current is increased by an increase of E. M. F. a decrease of resistance, in that same degree is the time taken in the transfer of a given electric quantity decreased; so that electric energy is simply proportional to the electric quantity transferred and to the E. M. F. causing the transfer, as expressed by the formula $W = EQ$. And as these two things, E and Q, bear no sort of ratio to each other, it is clear that the energy is not really proportional to the square of either taken alone. E and C are proportional to each other simply on account of the nature of electric resistance, which is defined (B. A. Report, p. 69) as the quality of a conductor, in virtue of which it prevents the performance of more than a certain amount of work in a given time by a given electromotive force. It is not defined, be it remarked, either as a mechanical resistance, or by the amount of energy it dissipates; on the contrary, it is expressly stated (same page) that "Electrical resistance must not be looked on as analogous to a simple mechanical resistance, but rather to a coefficient by which the speed of the current must be multiplied to obtain the whole mechanical resistance. Thus, if the electrical resistance of a conductor be called R, the work W is not equal to CRt but $C \times CR \times t$, or $W = C^2Rt$, where C may be looked on as analogous to a quantity moving at a certain speed, and CR as analogous to the mechanical resistance which it meets with in its progress, and which increases in direct proportion to the quantity conveyed in the unit of time." Electrical resistance is, therefore, a perfectly definite property of matter, though its difference from what is usually meant by resistance has been clearly recognised long before "Sigma" claimed that difference as a heresy and paradox of his (letter 15718, p. 313). It is not, perhaps, surprising, if "Sigma" holds electromotive force to be a mere expression, having no actual existence, that he should seek to define it in terms of something which does actually exist, but I think he has not succeeded in doing so yet; and, moreover, the ground upon which he arrives at the above opinion seems to me more than doubtful. According to his first article (p. 101), this opinion is based on the assumption that E.M.F., though constantly acting on the circuit, has no accelerating action similar to that of gravity. I take this to refer to the absence of any increase in the current owing to a continued action of E.M.F. If so, "Sigma" is expecting what is not likely to take place. For E.M.F. (at least from one source) is only the affinity existing between any two molecules, and can continue to act only for the time the act of combination takes; when that is effected the force must necessarily cease to act, and as what we measure is the number of molecular changes, and not the actual molecular motion, we have no reason to expect any sort of acceleration. Doubtless, could we follow the motion of any molecule, we should find its velocity distinctly greater when the E.M.F. ceases than when it began to act.

I come now finally to the analogy "Sigma" finds between E.M.F. and the square root of head of water. Now, in order to explain and support an incorrect view of E.M.F., he appears to have invented a wholly imaginary mechanico-motive force, which, he says, "is seen to mean the same thing as the square root of head of water. If so, then head of water must be another of those remarkable things that have an indefinite number of square roots. For, according to "Sigma's" definition of mechanico-motive force, the current of water is to be considered equal to the product of

113

mechanico-motive force and conducting capacity; wherefore the same current will be produced whatever the value of those factors, provided they vary inversely as each other. But as "Sigma" also states that "head of water as a well-known fact in hydraulics, generates velocity, that is to say, current or flow of water, in the ratio of the square root of the head," it follows that, given a certain head of water, its square root, the so-called mechanico-motive force may be of any value we like. Truly an accommodating property! "Sigma" must pardon me for refusing to go further into the matter until such an inconsistency as this is removed. But the object of this surprising theory is gone if my preceding arguments have any truth in them; and, in fact, I cannot see why "Sigma" could not rest satisfied with the analogy, pointed out on p. 201 of his book, between the conditions of the closed circuit of a battery and a set of hydraulic machinery—an analogy as clearly shown as could be wished. Here the analogy of E.M.F. is the pressure of steam. I find also in the B.A. reports, p. 68, a clear analogy shown to exist between E.M.F. and head of water (that is to say, pressure), and not any imaginary square root thereof, and this also is perfectly satisfactory.

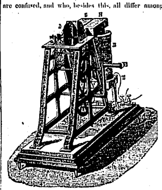
H. G. Moberly.

114

Finding the Mechanical Equivalent of Heat by Electro-Magnetism.

Oct Manufacturer & Builder

The strongest proof of the correctness of a numerical result is, undoubtedly, that the same figures are constantly arrived at when totally different means and principles are employed in the solution of a problem. Thus, in the case of the celebrated problem of the quadrature of the circle, the relation for the length of diameter and circumference of 1 to 3.14159265, etc., is obtained whether we use the elaborate method of approximations by calculating the periphery of polygons of many sides inscribed and circumscribed to the circle, or by calculating their surfaces; or if we apply trigonometry and calculate the arcs of given sines; or, again, if we apply the infinite series found by Leibnitz and others, or the continuous fractions expressing this relation; or, finally, the differential calculus—absolutely the same result is arrived at in each case, which is the best refutation to those circle squarers who either do not understand mathematics, or whose mathematical ideas are confused, and who, besides this, all differ among



Foucault's Electro-Magnetic Brake.

themselves, each obtaining a totally different number—the result of false reasoning.

The number of 772 foot-pounds for the equivalent of one unit of heat—first approximately obtained by Benjamin Thompson, and later more correctly by Joule and others—is in the same condition of absolute certainty. It means that 772 foot-pounds of force applied, and apparently destroyed by resistance, will reappear as one unit of heat—that is, will heat one pound of water one degree Fah. Thompson tried to obtain this relation by using horse-power in the boring of cannon and measuring the quantity and temperature of the water he could heat by the friction produced. Joule in England used paddle-wheels immersed in water, oil, mercury, and other liquids, and put in rotary motion by means of a weight; the descent of the weight produced a corresponding ascent of temperature in the liquid agitated, and the heat measured and compared with the weight and its descent.

Mayer in Germany compressed air, and observing the heat generated by this compression, compared it with the power applied. The results of these observations, when carefully corrected for disturbing influences, (for which we have not space here to give in detail), produced results identical with the above mentioned figures.

Passing over other methods employed with the same purpose in view, such as friction between solids, which is one of the most common impediments to motion, and which always produces an amount of heat equivalent to the motion destroyed, we will only describe one of the most remarkable of this class, consisting in the application of resistance to mot[illegible] by magnetic attraction, without any fri[illegible]ct, but by a purely magnetic action throu[illegible]rvening space.

Arago first observed that when a copper disk is rapidly rotated under a compass needle, it acts on it at a distance and causes it to rotate also; while Faraday discovered that when a small piece of copper is suspended by a fine thread and made to whirl around, it will be arrested if a strong magnet is held near it, and when it is made to revolve by force the resistance of the magnetic action will cause it to become warm.

Foucault modified this experiment in such a way as to be able to compare the heat thus developed with the power applied. His apparatus is illustrated in the adjoined engraving, which is a representation of the form in possession of the Stevens Institute of Technology in Hoboken, N. J. It consists of a powerful electro-magnet B, of which the poles are turned upward, and provided with a soft iron armature that expands at both sides of a copper disk D, ¼ of an inch thick and 3 inches in diameter, and embraces nearly one-half of it, being as close to it as is practical without contact. To the disk a very rapid rotation may be given by means of the handle M and intervening gearing. When the electro-magnets are not charged, it is quite easy to make the disk turn with a velocity of from 150 to 200 revolutions per second; and when left to itself the motion will continue for some little time by the momentum of the moving parts; but if the current of a voltaic battery is caused to pass through the coils surrounding the electro-magnet, the motion will not only be instantly stopped, but a strong resistance will be felt when the handle is turned. When three Bunsen elements are used and the motion forcibly continued, the apparent destruction of the efforts will reappear as heat, and the temperature of the disk can be easily raised some 100°, while, by increasing the battery current sufficiently, the resistance may be made too great for a man to overcome.

A comparison between the heat thus obtained with the power applied, will, when reduced to units and descending weights, give the same result of 772 foot-pounds as equivalent to a unit of heat. Joule used a tube with water, having a thermometer inside, and rotated it forcibly between the armatures of the poles of a magnet, properly shaped to receive the tube. He found the same figures in a more direct manner than was possible with the disk.

The explanation of all this is that the magnetism develops induced circulating electric currents in any conducting mass moving under its attractive influence, and these currents develop heat, as is the case with all electric currents, while the amount of this heat depends on the strength of the currents and the resistance they undergo.

unless indeed that effect varies as the square of the

115

CORRESPONDANCE

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Dans notre article relatif aux employés de télégraphe, nous avons mis le nom de Vesoul avec l'intention de savoir si des démarches seraient faites afin de découvrir l'auteur de la correspondance. Mais nous devons déclarer que la lettre nous est arrivée d'un point du territoire fort éloigné de celui que nous avons désigné. Les recherches, pour remonter à l'origine de cette lettre, seraient donc tout à fait infructueuses.

—

Les essais de la lumière Werdermann, faits à la demande du journal *l'Électricité*, ont eu lieu à plusieurs reprises la semaine dernière à l'usine de l'Alliance.

Nous avons reçu depuis lors plusieurs lettres conçues en des termes analogues, des abonnés qui avaient réclamé des lettres d'invitation.

Nous nous contenterons de reproduire celle qui nous a été remise la première.

Monsieur le directeur du journal *l'Electricité*,

Je vous remercie beaucoup, monsieur, pour la faveur que vous m'avez donnée de voir hier soir ce nouveau système de production de lumière tant simplifiée.

Le résultat actuel me paraît être déjà supérieur comme éclairage et plus économique que le système Jablochkoff.

Nous devons espérer la voir installer bientôt et entrer en compétence aux yeux du public parisien avec succès.

Recevez, etc...

F. GIRARD,
80, rue des Batignolles.

Theory (.) L'Electricité

La substitution de « potentiel » pour « tension »
La tension des pointes

Monsieur,

Permettez-moi de répondre à la lettre de M. du Moncel qui a paru dans votre dernier numéro. Il est vrai que dans ma lettre je débute en attaquant l'expression *tension d'un courant*, et qu'ensuite je défends le terme *tension*, pour lequel quelques mathématiciens ont voulu substituer le mot *potentiel*. Mais il n'est pas besoin de beaucoup de mots pour faire voir à M. du Moncel qu'il n'y a ici aucune contradiction. (Je dois observer en passant que l'expression *potentiel d'un courant* serait aussi dénuée de signification que celle qui a donné lieu à mon objection.) On pourrait, sans défaut de logique, protester contre l'expression *volume d'une surface*, et en même temps approuver le mot *volume* dans son application légitime. Un point, une surface, une charge statique peut avoir une tension; mais un *courant* — le résultat d'une différence de tension — ne peut aucunement lui-même avoir cet attribut. En effet, personne n'a jamais pu donner une définition de la tension d'un courant. Est-ce la tension d'un point quelconque dans le courant? Non, car ce point peut avoir une tension $+x$, ou $-x$, ou 0, et le courant reste constant. Est-ce la tension d'un des pôles de la source lorsque l'autre pôle est en communication avec la terre? Non, car alors un même courant pourrait avoir une infinité de tensions, puisque l'on peut obtenir le même courant avec toutes les sources et avec n'importe quelle tension au pôle en question. Est-ce la différence des tensions développées dans un circuit? Non, pour la même raison, et parce que cette différence constitue la force électro-motrice, et on ne dira pas que celle-ci s'appelle aussi *tension du courant*. Est-ce la différence des tensions mesurées aux extrémités d'une résistance constante? Non, car ceci constitue l'*intensité* d'un courant, ou la quantité d'électricité qui passe dans le circuit par seconde de temps.

Je remercie votre savant collaborateur — les opinions auquel, ici comme ailleurs, commandent toujours la plus grande considération — de sa déclaration que, selon lui, le potentiel et la tension ne sont pas deux propriétés différentes du fluide électrique. Or, pour exprimer une seule propriété, on n'a pas besoin, du moins dans la pratique, de deux termes, et il est clair que le mot *tension* jouit d'un droit de priorité qui devrait résister à toute innovation, pourvu qu'on ait soin de lui donner une définition exacte. Je ne veux pas parler d'une définition rationnelle ou physique, car la valeur de ce terme *tension* qui nous a été imposé par des mathématiciens est elle-même purement artificielle et ne représente que la *racine carrée* de la force électrique qui existe dans la nature. Mais si, faute de mieux, nous acceptons ce terme, pour éviter d'autres complications artificielles, nous devons lui donner les définitions suivantes :

1. La tension est la propriété de l'électricité qui se mesure par l'indication dite *électrométrique*. La tension peut être positive ou négative selon le signe de la charge de l'électromètre.

2. Posons :

$$E = \pm T - (\mp T_1)$$

Ici les deux tensions peuvent être (a) positives, (b) négatives, ou (c) l'une positive et l'autre négative; ce qui s'exprime par les deux signes qui précèdent T et T_1. Dans le cas (c),

$$E = +T - (-T_1) = T + T_1$$

Donc l'équation générale, dans les cas (a), (b), ou (c), pour l'une des tensions *maxima* dans tout circuit, conductive ou inductive, sera :

$$\pm T = E + (\mp T_1)$$

Et l'équation pour l'autre tension sera :

$$\mp T_1 = \pm T - E.$$

3. Posons $E = Q\,R$.

Soient r et r_1 deux résistances *inductives* en série dans un circuit (disons deux condensateurs ayant les capacités $c = \frac{1}{r}$ et $c_1 = \frac{1}{r_1}$). Alors $R = r + r_1$. Et, si nous supposons le circuit isolé, et que le pôle positif de la source soit en communication avec le condensateur ayant la capacité c, les tensions aux deux pôles seront :

$$+T = Q\,r = \frac{Q}{c}, \text{ et } -T = Q\,r_1 = \frac{Q}{c_1}$$

J'arrive maintenant à une question qui m'a été posée par M. du Moncel, et qui a une très-grande importance théorique. Dans le cas d'un conducteur taillé en pointe et électrisé statiquement, il y a écoulement de l'électricité sur la pointe, sous la forme d'aigrette ou d'effluve silencieuse. « Or, « en vertu de quelle force cet écoulement aurait-il lieu, si ce « n'est par suite d'un excès de tension que le fluide possède « en ce point? » — Je réponds que l'écoulement a lieu en vertu de la *tension;* mais que néanmoins cette tension est absolument la même pour tous les points du conducteur. N'en déplaise aux calculs du mathématicien Poisson, s'il y avait différence de tensions d'un point à un autre dans le conducteur, un courant en résulterait qui aurait l'effet d'égaliser instantanément les tensions. Du reste, l'indication électrométrique est absolument la même quand l'électromètre est mis en communication avec la pointe ou avec toute autre partie du conducteur. Mais pourquoi alors y a-t-il écoulement par la pointe? Tout simplement, parce que la résistance conductive, ainsi que la résistance inductive, est très-faible à cet endroit du circuit. La loi est identiquement la même pour ces deux résistances (R et *R*); c'est-à-dire que la même cause qui produirait une variation de R amènerait une même variation de *R*. Or, l'accumulation ou la densité électrique, à un point quelconque du conducteur, sera $\frac{E}{R}$, si nous appelons *R* la résistance (inductive) qui s'oppose à l'accumulation de l'électricité sur ce point; et la perte électrique, par conduction, du même point à travers le diélectrique, sera $\frac{E}{R}$. Donc, si la densité électrique sur un point est très-grande, nous savons que la résistance conductive à ce point sera très-faible, et qu'il y aura perte d'électricité sur ce point. Et, puisque nous savons que la densité électrique sur les pointes est comparativement énorme, et que cette densité résulte de la faible résistance inductive qui s'oppose à l'accumulation, il n'y a pas lieu de s'étonner s'il y a écoulement d'électricité par les pointes, car la résistance conductive doit être également faible.

Mais, d'ailleurs, il est facile de prouver, par les lois élémentaires de conduction, que la résistance qui s'oppose au passage de l'électricité par une pointe, doit être compara-

114

116 JN

Les subtilités de la science électrique en Allemagne

L'Electricité

Le numéro de juillet des *Annales de Poggendorf* contient un mémoire de M. Helmnotz sur *les couches limites de l'électricité*, qui occupe une cinquantaine de pages en tête de la livraison.

Ce travail a déjà paru par extrait dans le journal mensuel de l'Académie de Berlin, mais il était évidemment indispensable que les physiciens d'outre-Rhin pussent juger de l'ensemble d'un si remarquable document.

Dans une espèce d'introduction que nous demanderons à nos lecteurs la permission de ne point reproduire, il explique qu'il ne se contente pas, comme ses prédécesseurs, d'étudier les effets à distance de l'électricité, mais qu'il se préoccupe de déterminer l'épaisseur de la couche électrisée.

Appelant D la distance d'une plaque de cuivre, *e* la densité de l'électricité positive répartie à la surface, l'auteur pense que le produit *e* D est une quantité constante qu'il nomme le moment de la couche électrisée.

C'est en partant de cette considération que M. Helmnotz cherche à faire, à l'aide du potentiel, ce que nous nommerons l'anatomie idéale de la couche électrisée.

Dans cette partie de son travail, l'auteur s'appuie sur des recherches de Clausius et de sir William Thompson, démontrant que les molécules des gaz se bombardent l'une l'autre avec une vitesse de 50.000 centimètres par seconde, que le nombre des collisions entre ces deux molécules invisibles est de cinq cent-millionièmes de seconde, de sorte que le chemin moyen parcouru dans cet incessant bombardement est de la cent-millième partie d'un millimètre.

L'auteur suppose encore que par des raisons d'une clarté éblouissante, le nombre des molécules du gaz ne peut excéder 25 millions dans un globe dont le diamètre est précisément un cent-millième de millimètre. Il en tire la conclusion que le volume réel des molécules bombardantes ne peut être moindre que un cinq cent-millionième de centimètre et que par conséquent un centimètre cube d'air à la dureté ordinaire ne doit pas renfermer plus de six mille millions de molécules.

Combien nous regrettons que le défaut d'espace nous empêche d'entrer dans le développement de principes aussi utiles, pour le moins aussi féconds pour l'électricité que le Bathyblus du grand docteur Hœckell l'a été pour l'histoire naturelle.

Dans les autres parties de son œuvre, M. Helmnotz applique ces beaux principes aux mouvements des liquides à travers des cloisons poreuses quand il s'agit aussi bien de piles que de décharges de bouteilles de Leyde.

Malheureusement, l'auteur ayant oublié de conclure, nous ne nous chargerons point de nous acquitter, pour son compte, de cette formalité.

—

Laplace s'était préoccupé dans sa *Mécanique céleste* des altérations lentes que la résistance du fluide éthéré pouvait produire sur les mouvements de la Terre et de la Lune.

Ce prophète de l'astronomie officielle ayant établi, à la fin du troisième volume de son Code des *Lois du Ciel*, que cette cause perturbatrice produit sur le mouvement de la Terre un effet cent fois moindre que sur le mouvement de la Lune, il semblait que les physiciens dussent laisser l'éther en repos.

Mais sir William Thompson s'est avisé, il y a déjà pas mal de temps, de peser par le calcul la masse du fluide éthéré qui doit remplir un pouce cube anglais.

En employant des procédés aussi simples, aussi clairs, aussi précis que ceux de M. Helmnotz, sir William est arrivé à la formule

$$\frac{83\,g}{V^3 n^2}$$

expression dans laquelle g indique l'intensité de la gravitation, n la vitesse d'oscillation des particules d'éther et V la vitesse de propagation de la lumière.

La vitesse de la lumière peut être considérée comme connue par des expériences directes telles que le retard des éclipses des satellites de Jupiter. Quant à la vitesse d'oscillation des molécules d'éther, l'auteur du siphon enregistreur n'a pu concevoir un mécanisme susceptible de le mettre en évidence.

Mais un grand analyste ne s'arrête pas pour si peu de choses, et il a bravement annoncé que cette vitesse devait être de 1/50 de pied anglais.

En faisant cette hypothèse gratuite, sir William est arrivé à exprimer en livres anglaises le poids de la quantité d'éther contenue dans un pied cube anglais. En multipliant par 30 et réduisant en kilos, nous trouvons que pour avoir six kilos d'éther, il faudrait ramasser celui qui se trouve dans

2 700.000.000.000.000.000 mètres cubes.

Comme les mêmes auteurs, toujours avec l'appui des grands penseurs, tels que le célèbre Zölner de Leipzig, ont établi que la lumière et l'électricité sont une même chose, et que l'éther est le factotum de la physique, nous ne saurions exagérer l'importance de si surprenants résultats.

Aussi les lecteurs de l'*Electricité* n'apprendront-ils point sans quelque désappointement que M. P. Glam trouve que sir William s'est trompé.

Ce qui les consolera peut-être, c'est que ce savant rédacteur des *Annales de Poggendorf* a démontré que la matière éthérée est beaucoup moins rare dans le monde que sir William l'a imaginé.

En effet, il établit toujours par des raisonnements irréfragables que la descente du milieu éthéré est *sept mille quatre cent seize fois* plus grande que sir William ne l'a établi.

Que diront les héritiers de Laplace en voyant qu'on augmente à ce point la densité du milieu dans lequel les astres doivent éternellement tourner sans se fatiguer?

Ce n'est point à nous qu'il appartient de nous en inquiéter.

unless indeed that effect varies as the square of the

117

Eng Mechanic & World of Science

Dec 1879

DIAMAGNETISM.

[1....]—I am surprised to find so good a correspondent as "J. B." teaching the scholastic nonsense involved in diamagnetism.

Given a pair of scales, with 8oz. in one pan and 7oz. in the other, and the first weight will descend, but with 9oz. in the other pan it will ascend. Now, we do not say that this weight herein evinces "antithetic" properties,—that while descending it is the analogue of a magnetic, that while ascending it has an opposite quality, corresponding to a diamagnetic; yet this is precisely what Tyndall has contended for in diamagnetism, and which Faraday resisted almost to a quarrel.

Given a field of gravitating force and two balloons, one filled with carbonic acid gas, the other with hydrogen. The former would descend in air, while the latter would ascend, and for reasons too plain to require specification.

Given a field of magnetic force from one pole, let us imagine two small soap-bubbles filled with oxygen and hydrogen gases. The former would be attracted and the latter repelled, because the former is a better conductor of polar force than air, while air is a better conductor than hydrogen. The lines of force would be *alike* in both cases, but stronger in one case and weaker in the other. Faraday has beautifully shown how the lines of force behave in such cases, accumulating or condensing in the one case, and weakening or opening out in the other.

Given with iron solution a liquid field of force between two magnetic poles, let us suspend from their centres two small tubes of iron solution, one stronger than the medium (*a*), the other weaker (*b*). In air, of course, both would be magnetics, and point axially between the poles; but in the fluid (*a*) would be a magnetic, and (*b*) a so-called diamagnetic. If we imagine both placed alike in the axial position, the lines of force would condense in (*a*), and therefore involve stable equilibrium in that position; but the lines in (*b*) would open out, or become weaker, relative to the corresponding condensation in the better conducting medium, and therefore involve *unstable* equilibrium; so that when free to move, as from a centre, it would be displaced towards a transverse equilibrio; or, to use the expressive words of Faraday (although he never grasped the full meaning), "Magnetics tend to place themselves in the lines of strongest force, while diamagnetics tend to occupy the lines of weakest force."

Now, I would ask "J. B.," in regard to these tubes, while placed in the axial position and not free to move, can he imagine that the polarities, apart from quantity or strength, are normal in (*a*) and inverted or "*antithetical*" in (*b*)?

We know that (*b*) is a magnetic substance *per se*, and to suppose that at one moment it can react with a normal or opposite polarity, in relation to the inducing poles; and that at another moment it can react with an opposite, opposite polarity (the reverse of the former) is an outrageous hypothesis, as inimical to common-sense as it is incompatible with all observed facts.

I have tried to speak plainly and strongly; because, when error becomes fashionable and is taught in all the manuals, it is very difficult to dislodge it, and the more so when such vague and scholastic arguments are put forth in its support, and metaphysical mathematics have been largely subsidised.

But while the schools, manuals, and third-rate teachers will go on, some new facts have transpired which justify the prediction that from such good men as Tyndall we shall have but little more of diamagnetic disquisition.

What we have seen to subsist with gravitating weights and balloons, as with magnetic good and bad conductors of polar force, is now similarly proved for electrical action; and taking a battery field of force, or rather of action, as between the — and + plates, it is now found that we may insert, by a middle suspension, small bars of different substances, when better conductors of the electrolytic action, take an axial position, while worse conductors are deflected into the lines of weakest force, or, in other words, they tend to a transverse equilibrio.

We have long recognised good and bad conductors for sound, light, heat, and electricity; let us be equally fair in admitting the same for magnetism or polar force, and out of confusion and complexity comes order and simplicity.

Eclecticus.

THE NATURE OF ELECTRICITY[1]

ON surveying the wide sea upon which the numerous and varied practical applications of electricity are launched for the subject of this evening's address, I have been puzzled to steer a course that shall avoid the dazzling shoals of theory on the one hand, and the dry hard rocks of practice on the other.

[1] Abstract of the Inaugural address to the Society of Telegraph Engineers, by Mr. William Henry Preece (President), delivered January 28, 1880. Revised by the Author.

Hypothesis is a veritable Scylla that captivates the imagination and often sends the visionary to destruction, while practice alone is a hard-hearted Charybdis that lures the matter-of-fact practical man to folly and expense. Practice must be tempered with theory to utilize advantageously the great forces of nature, and theory itself must be based on practice, or on facts, to be comprehensive and acceptable. Hence success is the off-spring of the marriage of practice and theory, and, therefore, as the two are so intimately connected, I have determined to steer a middle course to-night to survey the progress of each in our profession, and to show their mutual relationship.

What is theory? It is an explanation of the hidden cause of certain effects that are evident to the senses. It is an effort of the imagination to account for operations that are in themselves invisible and insensible, but which result in facts that are observable and known. Thus the movements of all those bright bodies by which

> "the floor of heaven
> Is thick inlaid with patines of bright gold,"

are explained by the theory of gravity. Their appearance, vagaries, and beauties are accounted for by the undulatory theory of light. The warmth that the monarch of them all shed upon this earth countless ages ago, and that is now restored to us in our household fires, is explicable on the molecular theory of heat. The constitution of matter and its various states of solid, liquid, and gas, are completely explained by the atomic theory of Democritus and Dalton, and the modern kinetic theory of gases.

It is impossible for a practical man who has devoted more than a quarter of a century to the application of electricity to useful purposes, to avoid devoting much contemplation to the nature of the agent which he has to make use of. Is there a member of this society who has not striven to peer into the region of the unknown, who has not speculated on the power he uses, or who has not formed some conception in his mind of the nature of electricity? Yet it is remarkable that the answer to the question, What is electricity? cannot even now be given with authority. Faraday, our great apostle, whose researches should be every electrician's bible, declined to venture an answer, nor did he ever directly formulate his ideas on the subject, though his publications indicate pretty clearly and with no uncertain sound what they were. Clerk-Maxwell, who, while he overthrew all existing theories, failed to supply their place before he was so untimely removed from us. Sir William Thomson, in his published papers, always carefully eschews the consideration of any physical theory of electricity. The French electricians simply use the one-fluid theory as a convenience of language, while the Germans, as a rule, employ the two-fluid theory merely for mathematical purposes. Hence there is no recognised theory of electricity. Some maintain with Du Fay or with Franklin, that it is a form of matter—a substance; others, following Faraday and Grove, consider it a form of force—a motion—like heat and light. It must be either one or the other. There is no other category in which to class it. If it is not a form of matter it must be a form of force. The question I propose to discuss is, therefore, Is electricity a form of matter, or is it a form of force?

In discussing such a vexed question it is necessary to be very precise in language to avoid any misconception of my meaning, therefore I will define both matter and force in the sense in which I use those terms. *Matter* is that which can be perceived by the senses, or can be acted upon by force. It is characterised by weight, inertia, and elasticity. *Force* is that which produces, or tends to produce, the motion of matter. It may be pressure, tension, attraction, repulsion, or anything capable of causing alteration in the natural state of rest or of existing motion of matter.

Matter is found in either the solid, liquid, gaseous, or ultra-gaseous state, and it occupies space. It consists of molecules and atoms. The *atom* is the smallest indivisible part of an element, and a group of atoms of the same or of different elements forms the *molecule*, which has a definite magnitude and is unalterable in form for each substance. The *mass* of a substance is the aggregate of the molecules of which it is composed. There is no generation or destruction of atoms. The indestructibility of matter is a fixed law in nature. The size of the molecule is approximately known. Sir William Thomson says:—"If we conceive a sphere of water as large as a pea to be magnified to the size of the earth, each molecule being magnified to the same extent, the magnified structure would be coarser-grained than a heap of small lead shot, but less coarse-grained than a heap of cricket balls." Fifty million molecules ranged in single file would occupy an inch. They are highly elastic, and unless interfered with would move with constant velocity in straight lines. When they can move about freely without interfering with each other's proceedings, we have the ultra-gaseous state of Crookes, a state found only in very high vacua and under certain adventitious circumstances. When they collide and impinge on each other according to the law of the impact of elastic bodies, interfering with each other's path, we have *gases* as we know them; when their mean free path is so reduced as to bring them within the sphere of mutual attraction, without too narrowly restricting their play, we have *liquids*; when the attraction becomes cohesion and the motion of the molecule is confined to its own sphere, we have *solids*. The number of molecules in a given volume of gas is known, and their velocity calculated. In hydrogen the velocity at 0° Cent. is 6,097 feet per second, the number being 10^{21} per cubic inch. The mean free path of a molecule in air at ordinary pressures is the ten-thousandth part of a millimetre. Besides their constant motion in straight lines the molecules may be set in vibration, rotation, or any other kind of relative motion whatever.

This is the atomic theory of matter born in the brain of Democritus, "the laughing philosopher," 2,300 years ago; preached by Epicurus in Athens, and taught by Lucretius in Rome before the Christian era; lying dormant for eighteen centuries, until it was formulated by Dalton in the last century, and removed from the region of pure speculation by Joule, Clausius, Clerk-Maxwell, and Crookes during our days.

The definition of force shows us that whatever changes or tends to change the motion of matter (or of the molecules of which it is composed), by altering either its direction or its magnitude, is a form of force. Thus gravity is a form of force, for it attracts all matter to the centre of the earth, and it is measured by the rate per second at which a body acquires a velocity in this direction when falling freely at a given spot. Heat is a form of force, for it throws the molecules of matter into violent vibration, or it increases the velocity of their motion in straight lines, which thus becomes the measure of its heat or its *temperature*. Light is a form of force, for it is produced by the undulation of the molecules of matter, and it is transmitted by the undulations of that medium called Ether, which fills all space.

When we take a given free mass and impress upon it a given force, we throw that mass into motion; for instance, when we fire a loaded cannon, we have imparted to the ball "*energy*," and in virtue of the motion of the ball, this energy is called "*kinetic*." Again, if we lift the ball to a certain height above the earth's surface—say to the top of a tower—and let it remain there, we have again imparted to it "energy," but this time it is called "*potential*," for it is dormant or resting. In each case the energy possessed by the ball is the exact equivalent of the work done upon it, that is, of the force impressed and the distance through which it has acted. The motion of the ball is readily transferred to the motion of the individual molecules of the ball. When, in the first case adduced, the ball strikes the side of a ship or a target, its kinetic energy is thus converted into light and heat, which is molecular motion; or, in the second case, when it is allowed to fall, its potential energy is converted into kinetic energy, which again, on coming in contact with the ground, is converted into molecular motion or heat. Energy is always either potential or kinetic, and one of the most remarkable generalisations of modern days is the grand principle of the conservation of energy, which implies that the total energy of the universe is a quantity which can neither be increased nor diminished, though it may be transformed into any of the forms of which energy is susceptible. Energy is therefore as indestructible as matter. All the recent advances in the science of heat have been due to the discovery of this principle, and its application to electricity has gone far to remove that science from the hypothetical state in which it has existed so long.

My purpose is to contend that electricity is not a form of matter but a form of force, and that all its effects are evident to us in one or other of the several forms of energy characterised by the motions of molecules or of mass.

It is interesting to trace the historical growth of theories. The uncultivated human intellect cannot soar above its own limited sphere of childish observation. Whatever is mysterious and incomprehensible in nature is attributed to that which is equally mysterious and incomprehensible. Life has ever been of this character, and heat, magnetism, electricity, and many

unless indeed that effect varies as the square of the

Some recent very remarkable researches of M. Planté with his rheostatic machine[1] have shown that fine wires conveying powerful currents are wrinkled up into well-defined regular nodes, that ... accompanied by a peculiar crackling, and that the ... giving clear indication of the vibratory ... He gives as the result of his inquiry that electrical transmission is the result of a series of very rapid vibration of the more or less elastic matter which it traverses, and he points out certain analogies between electric motion and sonorous vibrations. This view is supported by the researches of Professors Ayrton and Perry[2] on the viscosity of dielectrics.

Prof. Challis, of Cambridge, has extended this view so far as to embrace magnetism, electricity, light, heat, and gravity in one category of physical force, and to assert that they all result from motions and pressures of a uniform elastic fluid medium pervading all space not occupied by atoms. His views, however, have not received much attention, for they are not based on the foundation of any new facts, and they are utterly subversive of many cherished principles deeply rooted in the scientific mind. It is to be observed, however, that he regards electricity as a form of force.

Mr. Crookes, in his recent beautiful experimental researches into molecular physics in high vacua, has still more conclusively proved the connection that exists between electrical action and molecular motion. In fact, his experiments are so brilliant, his expositions so lucid, that one can fancy one sees with the eye of the body that peculiar play of the molecules which can be evident only to the eye of the mind. Not only has Mr. Crookes established as a physical fact the kinetic theory of gases and the molecular constitution of matter, but he has indicated the existence of a fourth state of matter where the molecules fly about without mutual let or hindrance. He has also led us to doubt the truth of the generally received opinion that an electric current flows from the positive to the negative electrode. It would appear from his investigations that the reverse is the case. Be that as it may, he has added one story to the structure of the molecular theory of electricity.

The criterion of a good theory is, however, its power of prediction. A false theory has never led to prevision. Neither the corpuscular theory of light, nor the fluid theories of heat and electricity, ever led to the prediction of something of which eyes had not seen nor ears heard. The triumphs of prediction in astronomy, sound, light, and heat are innumerable. Faraday predicted the effect of induction in lowering the velocity of currents of electricity and the action of magnetism on a ray of light. Sir William Thomson predicted that a current in passing from a hot to a cold part of a copper bar would heat the point of contact, while in an iron bar it cools it. Peltier predicted the cooling effect of currents on the junctions of thermoelectric pairs.

But the true identity of these physical effects is conclusively shown by their quantitative character and by their adhesion to the law of the conservation of energy. Take the case of the electric light: the consumption of coal in a furnace generates steam, the steam works an engine, the engine rotates a coil of wire in a magnetic field, the motion of the coil in this field induces currents of electricity in the wire, these currents of electricity produce an arc, and thereby heat and light. The energy of the coal is transformed into heat and light through the intermediate agency of electricity. Is it possible to conceive that this intermediate agency is anything but a form of energy? Take the case of the Bell telephone: the energy of the voice produces the energy of sonorous vibration in the air, the vibrations of the air cause the vibrations of the iron disk, the vibrations of the disk vary the magnetism of the magnetic field, this produces currents of electricity in a small coil in this field which vary the magnetism of the distant magnet, which in its turn throws its disk armature into vibration, and thereby repeats at the distant station the sonorous vibrations of the air, and thus reproduces the energy of the voice. A tuning fork comes to rest sooner in front of a telephone than when it is allowed to vibrate freely in air. Here we have the energy of the fork passing through the several stages indicated above, and ultimately coming out in its original form. The energy of sonorous vibrations at the distant station is that lost by the vibrating tuning fork.

Is it possible to assume that in this cycle of changes energy has been transformed into matter and matter again formed into energy? It is impossible and absurd. Clerk-Maxwell said—

"When the appearance of one thing is strictly connected with the disappearance of another, so that the amount which exists of the one thing depends on and can be calculated from the amount of the other which has disappeared, we conclude that the one has been formed at the expense of the other, and that they are both forms of the same thing."

Would it be possible to light the streets of New York by the energy of the falling water at Niagara, as has been suggested by our Past President, Dr. Siemens, if the cycle of changes from the one spot to the other were not all different forms of this same energy? Would it be possible to plough a field a mile away from the source of motive power of the transmitting medium if the electric currents were not forms of the same power? Electricity in its effects is and must be a form of energy.

The final stage into which any physical theory grows is that in which every action can be expressed in mathematical language, where every phenomenon is calculated upon an absolute physical basis, and where we can foretell exactly what will occur under any possible emergency. This is the present condition of the science of electricity. We can calculate exactly how much steam power is required to generate a given current to produce a given light. We can tell precisely what dimensions of cable are necessary to give a certain number of words per minute on the other side of the globe. If a fault develop itself in a long cable through the gastronomic propensities of a thoughtless young teredo, we can calculate to within a few fathoms the locality of his edacious depredation.

Clerk-Maxwell,[1] in his classical work on electricity, has used a somewhat curious argument to show that electricity is not, like heat, a form of energy. He says that energy is produced by the multiplication of "electricity" and "potential," and that it is impossible that electricity and energy should be quantities of the same category, for electricity is only one of the factors of energy, the other factor being "potential." But this does not militate in any way against the force of the argument, for in nature we can no more do so than we can separate heat and temperature. Energy usually appears as the product of two factors, and it is the equivalent of the work done. Thus, *Potential energy* is the product of mass and gravitation acting through a distance. *Kinetic energy* is the product of mass and the half-square of velocity. The energy of fluids is the product of volume and pressure. The energy of heat is made up of heat and temperature, and the energy of electricity is the product of electricity and potential. Hence it is that electricity, *per se*, may be said to be a form of force, while all its effects as known to us are forms of energy. Force alone cannot produce energy; it must be force and something else. Force is the power of producing energy, and it must have something on which to produce it. Hence matter is always present; and thus, though heat, light, and electricity are forms of motion, they are in reality properties of matter from which they are inseparable. They are evident to us through the play of the molecules of matter, and thus are properly called molecular forces.

Earth currents have been a favourite subject of inquiry of mine for many years. I have always entertained the idea that they are directly due to the action of the sun. Some disturbance in the sun causes, by induction, a variation in the distribution of the lines of potential on the earth's surface, and produces the conditions required for these currents. I have many facts to support this hypothesis, but I want more to confirm it. Profs. Ayrton and Perry have developed a theory of terrestrial magnetism based on the assumption that the earth is a highly electrified sphere, which not only coincides well with facts, but which tends greatly to support my views. I want observers to record the times of daily maxima and minima. I want them especially to note during those periods of unusual disturbance the direction of the circuits which are *not* affected, for they would give the direction of the lines of equi-potential. This not only offers a useful field of observation, but its failure or success will illustrate the modern method of scientific research, when the brain suggests to the hand and the eye what they have to do, and what they have to look for.

Mr. Preece then went on to speak of the educational work of the Society and to notice some of the recent practical applications of electricity, and in speaking of the telephone stated that litigation has commenced between the Post-Office and the telephone companies not to restrict or in any way to interfere with the use of the telephone, but to prevent the establishment of a

[1] *Comptes Rendus*, lxxxix., pp. 76-80, 1879.
[2] *Proc.* Roy. Soc. pp. 7-8, 1878.

[1] Vol. I., p. 30.

Electrical Generators.

Scientific American Jan 17 1880

To the Editor of the Scientific American:

It would seem that the authors of books and chapters on electricity are largely culpable for the numerous discussions which have appeared of late in the SCIENTIFIC AMERICAN on electrical generators. The problem to find the maximum current with a given lot of battery cells and external resistance is well known; also the answer to it, viz., internal resistance equal external resistance. But the other problem, viz., to find, with given external resistance, the number and arrangement of cells, for procuring a given current with a minimum consumption of zinc, seems to be far less common in books, and perhaps generally, though the result may often be of far greater importance.

To illustrate, suppose that in some electro-plating establishment a plating bath is so run as to offer about constapt resistance to current; and suppose a certain standard constant current is preferred. If these conditions can be realized by one arrangement requiring $25 greater outlay in first cost for increasing the number of cells, whereby a saving of $50 a year for zinc is realized; a party, expecting to run for years, would be quite likely to adopt the greater first cost.

What is true in consumption of zinc in batteries will be true, in some measure at least, in dynamo-electric machines, because the zinc consumed in one case represents energy, and so do the foot pounds consumed in the other. Hence, for simplicity, batteries are here considered instead of machines.

That for a given external resistance a given current strength may be maintained by different arrangements of cells in rows, the total number of cells varying as required, is evident from considerations of Ohm's law. For instance, if 100 cells in 5 rows satisfies a certain current and resistance, the same effect may be secured with 10 rows of batteries, though 40 or 60 cells may be necessary. It may happen, however, that a large percentage of zinc will be saved with the 60 cells and 10 rows.

The energy of a current is stated, on good authority, to be proportional to the zinc consumed in a well conditioned battery; also, it is proportional to the electro-motive force multiplied by the current strength. These facts applied so as to bring about the relation between the zinc consumed in different cases will show that *for the same external resistance the weight of zinc consumed in a battery arranged for maximum current; divided by the weight of zinc consumed in a battery by like cells in greater number for an equal current, is simply equal to the number of cells in one row of the first battery, divided by the number of cells in one row of the second battery.*

Also for the relation of numbers of cells, it will be found that the ratio of the number of cells in one row, 1st battery and 2d, added to the ratio of number of rows, 1st battery and 2d, is equal to 2; also, the maximum value of this 1st ratio can never be greater than 2.

An example will serve to fix the ideas: Let the cells of battery considered be all alike, with equal electro-motive forces, and the internal resistance of each equal 1 ohm; let the external resistance equal 4 ohms. If the number of cells be 144, arranged in 24 rows of 6 each, we have the maximum current for the cells of resistance named. Again, if 192 like cells be arranged in 12 rows of 16 each, we will have the same current strength, though the total internal resistance of the 2d will be only a third of the 1st.

According to the rule above, the consumption of zinc in the 1st battery will be 50 per cent greater than in the 2d.

Hence it appears that the best arrangement of a battery of several cells for maximum of current is one thing, while the best number and arrangement for securing a given current with a minimum of zinc is quite another. The quantity of zinc diminishes with internal resistance.

From the fact that zinc consumption in a battery stands for about the same thing as foot pound consumption in the dynamo-electric machine, it would seem that for the minimum of power the internal resistance of the machine should be reduced to as small a fraction of the whole as possible, the size of the machine and conditions of working being, of course, consistent with the given current required.

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their holdings.

ON THE ELECTROMOTIVE FORCES WHICH APPEAR IN FREE JETS OF WATER.—Elster considers his investigations proved, if an electromotive force is to arise in a free jet of water, it is necessary that the water particles be in contact with a solid body. That the evolution of electricity takes place only where the particles of the liquid undergo friction, so that only a relatively small portion of the water-jet contributes any thing to the development of electricity. That when the velocity of a jet issuing constantly from the same orifice is varied, the electromotive forces are proportional to the *vires vivæ* of the liquid particles—a relation the reason of which is found in the law of the conservation of energy. And, lastly, that the electromotive force is dependent on the nature of the body which is in contact with the liquid. From these results the author draws the following conclusions:—The motion of a fluid does not by itself produce any electromotive force. Consequently the inference deduced by Edlund from his unitary theory of electricity has not been confirmed. Capillary electric currents are conditioned solely by the friction of the particles of the fluid in motion—in nonhumectant fluids by their friction against the particles of the solid wall, in humectant fluids by friction on the particles of a layer of the same fluid condensed upon the surface of the solid body, which behaves towards the less dense layer like a heterogeneous substance. The capillary-electric currents discovered by Quincke are identical with the friction-currents, first observer by Zöllner, which make their appearance in the rubber of an electrical machine.

ON A NEW ACTION OF THE MAGNET ON ELECTRIC CURRENTS.

Electrician March 13 1880

By E. H. HALL, Fellow of the Johns Hopkins University.

Sometime during the last University year, while I was reading "Maxwell's Electricity and Magnetism" in connection with Prof. Rowland's lectures, my attention was particularly attracted by the following passage in Vol. II., p. 144.

"It must be carefully remembered that the mechanical force which urges a conductor carrying a current across the lines of magnetic force, acts, not on the electric current, but on the conductor which carries it. If the conductor be a rotating disc or a fluid it will move in obedience to this force, and this motion may or may not be accompanied with a change of position of the electric current which it carries. But if the current itself be free to choose any path through a fixed solid conductor or a network of wires, then, when a constant magnetic force is made to act on a system, the path of the current through the conductors is not permanently altered, but after certain transient phenomena, called induction currents, have subsided, the distribution of the current will be found to be the same as if no magnetic force were in action. The only force which acts on electric currents is electromotive force, which must be distinguished from the mechanical force which is the subject of this chapter."

This statement seemed to me to be contrary to the most natural supposition in the case considered, taking into account the fact that a wire not bearing a current is in general not affected by a magnet, and that a wire bearing a current is affected exactly in proportion to the strength of the current, while the size and in general the material of the wire are matters of indifference. Moreover, in explaining the phenomena of statical electricity it is customary to say that charged bodies are attracted toward each other, or the contrary, solely by the attraction or repulsion of the charges for each other.

Soon after reading the above statement in Maxwell I read an article by Prof. Edlund, entitled, "Unipolar Induction" (*Phil. Mag.*, Oct., 1878, or *Annales de Chemie et de Physique*, Jan., 1879), in which the author evidently assumes that a magnet acts upon a current in a fixed conductor just as it acts upon the conductor itself when free to move.

Finding these two authorities at variance, I brought the question to Prof. Rowland. He told me he doubted the truth of Maxwell's statement, and had some time before made a hasty experiment for the purpose of detecting if possible some action of the magnet on the current itself, though without success. Being very busy with other matters, however, he had no immediate intention of carrying the investigation further.

I now began to give the matter more attention and hit upon a method that seemed to promise a solution of the problem. I laid my plan before Professor Rowland, and asked whether he had any objection to my making the experiment. He approved of my method in the main, though suggesting some very important changes in the proposed form and arrangement of the apparatus. The experiment proposed was suggested by the following reflection:—If the current of electricity in a fixed conductor is itself attracted by a magnet the current should be drawn to one side of the wire, and, therefore, the resistance experienced should be increased.

To test this theory, a flat spiral of German silver wire was enclosed between two thin discs of hard rubber, and the whole placed between the poles of an electro-magnet in such a position that the lines of magnetic force would pass through the spiral at right angles to the current of electricity.

The wire of the spiral was about $\frac{1}{2}$ millim. in diameter, and the resistance of the spiral was about two ohms.

The magnet was worked by a battery of twenty Bunsen cells, joined four in series and five abreast. The strength of the magnetic field, in which the coil was placed, was probably fifteen, or twenty thousand times H, the horizontal intensity of the earth's magnetism.

Making the spiral one arm of a Wheatstone bridge, and using a low resistance Thomson galvanometer, so delicately adjusted as to betray a change of about one part in a million in the resistance of the spiral I made, from October 7th to October 11th inclusive, thirteen series of observations, each of forty readings. A reading would first be made with the magnet active in a certain direction, then a reading with the magnet inactive, then one with the magnet active in the direction opposite to the first, then with the magnet inactive, and so on till the series of forty readings was completed.

Some of the series seemed to show a slight increase of resistance due to the action of the magnet, some a slight decrease, the greatest change indicated by any complete series being a decrease of about one part in a hundred and fifty thousand. Nearly all the other series indicated a very much smaller change, the average change shown by the thirteen series being a decrease of about one part in five millions.

Apparently, then, the magnet's action caused no change in the resistance of the coil.

But though conclusive, apparently, in respect to any change of resistance, the above experiments are not sufficient to prove that a magnet cannot affect an electric current. If electricity is assumed to be an incompressible fluid, as some suspect it to be, we may conceive that the current of electricity flowing in a wire cannot be forced into one side of the wire or made to flow in any but a symmetrical manner. The magnet may *tend* to deflect the current without being able to do so. It is evident that in this case there would exist a state of stress in the conductor, the electricity pressing, as it were, toward one side of the wire.

Reasoning thus, I thought it necessary, in order to make a thorough investigation of the matter, to test for a difference of potential between points on opposite sides of the conductor.

This could be done by repeating the experiment formerly made by Prof. Rowland, and which was the following:—

A disc or strip of metal, forming part of an electric circuit, was placed between the poles of an electro-magnet, the disc cutting across the lines of force. The two poles of a sensitive galvanometer were then placed in connection with different parts of the disc, through which an electric current was passing, until two nearly equipotential points were formed. The magnetic current was then turned on and the galvanometer was observed, in order to detect any indication of a change in the relative potential of the two poles.

Owing probably to the fact that the metal disc used had considerable thickness, the experiment at that time failed to give any positive result. Professor Rowland now advised me, in repeating this experiment, to use gold leaf mounted on a plate of glass as my metal strip. I did so, and, experimenting as indicated above, succeeded, on the 28th of October, in obtaining, as the effect of the magnet's action, a decided deflection of the galvanometer needle.

This deflection was much too large to be attributed to the direct action of the magnet on the galvanometer needle, or to any similar cause. It was, moreover, a permanent deflection, and therefore not to be accounted for by induction. The effect was reversed when the magnet was reversed. It was not reversed by transferring the poles of the galvanometer from one end of the strip to the other. In short, the phenomena observed were just such as we should expect to see if the electric current were pressed, but not moved, toward one side of the conductor.

In regard to the direction of this pressure or tendency as dependent on the direction of the current in the gold leaf and the direction of the lines of magnetic force, the following statement may be made:—If we regard an electric current as a single stream flowing from the positive to the negative pole, *i.e.*, from the carbon pole of the battery through the circuit to the zinc pole, in this case the phenomena observed indicate that two *currents* parallel and in the same direction tend to repel each other. If, on the other hand, we regard the electric current as a stream flowing from the negative to the positive pole, in this case the phenomena observed indicate that two *currents* parallel and in the same direction tend to attract each other.

It is, of course, perfectly well known that two *conductors* bearing currents parallel and in the same direction are drawn toward each other. Whether this fact, taken in connection with what has been said above, has any bearing upon the question of the absolute direction of the electric current it is perhaps too early to decide.

In order to make some rough quantitative experiments a new plate was prepared, consisting of a strip of gold leaf about 2 cm. wide and 9 cm. long, mounted on plate glass. Good contact was ensured by pressing firmly down on each end of the strip of gold leaf a thick piece of brass polished on the under side. To these pieces of brass the wires from a single Bunsen cell were soldered. The portion of the gold leaf strip not covered by the pieces of brass was about $5\frac{1}{2}$ cm. in length, and had a resistance of about 2 ohms. The poles of a high-resistance Thomson galvanometer were placed in connection with points opposite each other on the edges of the strip of gold leaf, and midway between the pieces of brass. The glass plate bearing the gold leaf was fastened, as the first one had been, by a soft cement to the flat end of one pole of the magnet, the other pole of the magnet being brought to within about 6 mm. of the strip of gold leaf.

The apparatus being arranged as above described, on the 12th of November a series of observations was made for the purpose of determining the variations of the observed effect with known variations of the magnetic force, and the strength of current through the gold leaf.

The experiments were hastily and roughly made, but are sufficiently accurate, it is thought, to determine the law of variation above mentioned, as well as the order of magnitude of the current through the Thomson galvanometer compared with the current through the gold leaf and the intensity of the magnetic field.

The results obtained are as follow:—

122

Current through gold leaf strip. C.	Strength of magnetic field. M.	Current through Thomson galvanometer. c.	$\frac{C+M}{c}$
·0616	11420H	·00000000232	·303000000000
·0249	11240	085	·329
·0389	11060	135	·319
·0598	7670	147	·312
·0595	5700	104	·326

H is the horizontal intensity of the earth's magnetism = ·19 approximately.

Though the greatest difference in the last column above amounts to about 8 per cent. of the mean quotient, yet it seems to conclude that, with a given form and arrangement of apparatus, the action on the Thomson galvanometer is proportional to the product of the magnetic force by the current through the gold leaf. This is not the same as saying that the effect on the Thomson galvanometer is, under all circumstances, proportional to the current which is passing between the poles of the magnet. If a strip of copper, of the same length and breadth as the gold leaf, but ¼ mm. in thickness, is substituted for the latter, the galvanometer fails to detect any current arising from the action of the magnet except an induction current at the moment of making or breaking the magnet circuit. It has been stated above that, in the experiments thus far tried, the current apparently tends to move, without actually moving, toward the side of the conductor. I have in mind a form of apparatus which will, I think, allow the current to follow this tendency, and move across the lines of magnetic force. If this experiment succeeds, one or two others immediately suggest themselves.

To make a more complete and accurate study of the phenomenon described in the preceding pages, availing myself of the advice and assistance of Prof. Rowland, will probably occupy me for some months to come.

It is, perhaps, allowable to speak of the action of the magnet as setting up in a strip of gold leaf a new electromotive force at right angles to the primary electromotive force.

This new electromotive force cannot, under ordinary conditions, manifest itself, the circuit in which it might work being incomplete. When the circuit is completed by means of the Thomson galvanometer, a current flows.

The actual current through this galvanometer depends, of course, upon the resistance of the galvanometer and its connections, as well as upon the distance between the two points of the gold leaf at which the ends of the wires from the galvanometer are applied. We cannot, therefore, take the ratio of C and c above as the ratio of the primary and the transverse electromotive forces just mentioned.

If we represent by E' the difference of potential of two points a centimetre apart on the transverse diameter of the strip of gold leaf, and by E the difference of potential of two points a centimetre apart on the longitudinal diameter of the same, a rough and hasty calculation for the experiments already made shows the ratio $\frac{E}{E'}$ to have varied from about 3,000 to about 6,500. The transverse electromotive force E' seems to be, under ordinary circumstances, proportional to Mv, where M is the intensity of the magnetic field, and v is the *velocity* of the electricity in the gold leaf. Writing for v the equivalent expression $\frac{C}{s}$, where C is the primary current through a strip of the gold leaf 1 cm. wide, and s is the area of section of the same, we have $E' \propto \frac{MC}{s}$.

—*American Journal of Mathematics.*

DETERMINATION OF CHEMICAL AFFINITY IN TERMS OF ELECTROMOTIVE FORCE.

TO THE EDITOR OF THE ELECTRICIAN.

Electrician Jan 17 1880

SIR: It is stated, p. 180, in *The Electrician* of the 6th inst., that Dr. C. W. Wright read before the Physical Society an "important paper" on this subject. It is also stated that he gave a history of the subject, but not having, as yet, seen the paper, I do not know whether what I am about to say found its place in that history. At all events, I feel it is only due to myself to call the attention of Dr. Wright and others to the fact that this matter was fully worked out by myself in a series of articles which appeared in that widely circulated scientific paper, the *English Mechanic*, in 1871, and which formed the chapter on "Electromotive Force" in my book "Electricity; Its Theory, Sources, and Applications," published in 1875, and itself pretty widely circulated, seeing that 1,700 copies have passed into the hands of the public.

I believe I may claim as my own the definite idea of the actual identity of chemical affinity and electromotive force, and the possibility of definitely expressing the former in the easily ascertained terms of the latter, and I gave the means of doing this and the means of converting one into the other either from experimentally measured electromotive forces, or from experimentally measured chemical forces (such as the heat of combustion). General ideas had been previously expressed by many as to these relations, such as between the forces of batteries and the oxidations, &c., effected therein; but I showed the definite connection, and proposed a unit of conversion, the equi-volt, which in some of its possible forms, would be a perfect unit for all forces and forms of energy. I feel some interest in this, and so claim my rights in the matter, because I have felt that it effectually settles the whole dispute as to the chemical and contact theories, and puts the latter in the famous condition of Humpty Dumpty, beyond the repairing powers of all the mathematicians, and all their cabalistic formulæ.

Dr. Wright has experimented with the decomposition of water (so called), and brings out the force as 1·5038 volts. I gave it, in the places mentioned and p. 222 of my book, as 1·464. Dr. Wright considers that, from his determination, certain corrections require to be made in Joule's equivalent, and compares the values arrived at by different experimental processes. I should suggest that no experimental results, when dependent upon many varying conditions, all subject to error, can be compared in value with those arrived at from sound theoretical considerations. The actual equivalent is attainable from the ratio of the heats of constant volume and pressure of gases, and from the transmission of sound in different densities of air, more correctly than from any experiments specially devised for the purpose. As to the difference between my value for water and that of Dr. Wright, it seems very doubtful if either is really correct. My own was avowedly an approximation based upon the measurement by Favre of the heat of combustion of hydrogen, and subject to other probable corrections; but it appears to me that Dr. Wright's value is too high; that his determination of the electromotive force includes that absorbed in the resistance of his voltameter as well as that represented in the work of decomposition.

While in the act of reclamation, I may also remark that in the No. of February 28th there is recorded a paper sent to the Society of Telegraphic Engineers, on the 25th, by Mr. J. B. Stearns, on some defects in differential galvanometers and the possible remedies. Every one of those matters is mentioned p. 135 of my book. But that is nothing.

J. T. SPRAGUE.

unless indeed this direct varies as the square of the

123

this point in his description in the *Bot. Mag.*, and it was for the further investigation of the case that I raised a plant in my garden.

The flowers grow on long peduncles, which generally have a horizontal position, projecting some five or six inches from the mass of the foliage. When the calyx opens, the filaments as well as the style are irregularly twisted; but in about two or three days all become straight. The style hangs obliquely downwards; the filaments all bend sideways, the bend being inside the tube of the corolla, a little over the hairs at their base. There is often a distance of 15 centimetres between the anthers of either side. About 5 or 6 o'clock p.m. the anthers burst, and soon after the style rises and assumes a central position, so that there is a distance of about 10 centimetres between the stigmata and any of the anthers. *Only then* is nectar being secreted by the glandular disk round the base of the ovary, but so copiously that by means of a small pipette I obtained from each flower a mean quantity of 0·14 cubic centimetres. This nectar is completely transparent, very sweet, and slightly mucilaginous. It contained a kind of gum which is precipitated by absolute alcohol. *The nectar appears therefore when the anthers have done their work;* even an hour before their rupture no trace of it is to be found. The nectar-cavity in the tube of the corolla is completely shut up by the numerous spreading hairs at the base of the filaments, so that an outflow is impossible. The grains of pollen are very large (0·2 millim. in diameter) and of the same structure as in *Cobæa scandens*. They are covered by a glutinous layer, and are heavier than water.

Several weeks passed at first before I witnessed the manner of fertilisation. The stigmata were every morning carefully examined, but no pollen could be discovered on them. The filaments twisted back again and got somewhat frizzled, after one single night's expansion. About noon the corolla drops off, separating from close to the glandular ring, and then slipping down over the style, which, by this time, is again in a relaxed hanging position. There is always some nectar in the tube of the corolla after its separation, but none remains in the calyx round the ovary, nor does its secretion continue.

These facts show clearly that the fertilisation must take place in the same night after the bursting of the anthers, and it was but natural to suppose that it was effected by nocturnal moths. It would appear, furthermore, that *the nectar is not of any direct advantage to the plant*, as Mr. G. Bonnier emphatically affirms (*Annales des Sci. Nat. Bot.*, sér. vi. vol. viii. p. 206), because of its being produced and lost in all flowers, fertilised or not, in the same way.

As soon as the number of flowers increased (on some evenings twenty to twenty-five had their anthers opened), I found every morning most of them with pollen on the stigmata, and keeping a close watch, I discovered that the plant was visited by several large Sphingidæ belonging to the genera *Chaerocampa*, *Diludia*, and *Amphonyx*. I observed altogether four visits of an Amphonyx, three of a Chaerocampa, and one of a Diludia. All of them proceeded in the same manner. Holding the body close over the style, they dipped their spiral tongues into the tube of the corolla, beating all the while the anthers so violently with the tips of the fore-wings that they dangled about with great velocity in every direction. The grains of pollen being covered by a sticky substance, many of them adhered to the wings. I have caught an Amphonyx which, after having visited six flowers consecutively, had the tips of the fore-wings almost yellow with pollen. When leaving a flower for another one, some of this pollen is even lost on the foliage, but by the time the insect takes its central position before the flower the stigmata are likewise touched by the wings, and thus some pollen is left on them. Some flowers remain without being fertilised, especially in places where the moths cannot reach them easily. All flowers fertilised in this manner set fruit very soon; but no flower gave a fruit without having its stigmata pollenised by crossing.

Self-fertilisation is therefore excluded, and this is further proved by the following experiments:—Twelve flowers were artificially fertilised by their own pollen and afterwards protected by muslin bags; only in one case was a fruit obtained; but I am not quite sure whether there did not come some foreign pollen on the stigmata of this flower. Cross-fertilisation was likewise tried in twelve flowers, nine being experimented on in the same evening after the opening of the anthers, and three the next morning. All the former are now with fruit; the latter remained sterile. This fact shows how very short is the period of possible fertilisation.

Flowers visited by nocturnal moths are as a rule either large and of white colour, or have a strong smell; but in our *Cobæa* the former is certainly not the case, and my olfactory nerves at least cannot discover any smell. But it is well known that insects, especially Lepidoptera, are in this respect of a really wonderful keenness, which enables them to track a scent absolutely imperceptible to man.

As I shall have a considerable crop of Cobæa-seeds, I can offer some to any botanists who should wish to grow the plant.

A. ERNST

Caracas, April 4

P.S.—As soon as the corolla has fallen off, the peduncle withdraws slowly amongst the dense foliage, where the fruit develops, protected from all kinds of injury.

EXPERIMENTAL RESEARCHES IN ELECTRICITY[1]

Part III.—*Tube-Potential; Potential at a Constant Distance and Various Pressures; Nature and Phenomena of the Electric Arc.*

MESSRS. De La Rue and Müller, in the third part of their researches on the electric discharge, commence by describing a series of experiments to determine the potential necessary to produce a discharge in a tube, exhausted gradually more and more while using a constant number of cells in all the experiments. In consequence of the life of the battery becoming so much exhausted by the method employed the experiments were confined to one gaseous medium, namely, hydrogen. Since the completion, however, of the measurements described in the paper the authors have found two other more convenient methods for determining the tube-potential, which do not exhaust the battery injuriously; these are described in an appendix. The tube, 162, employed was 33 inches long and 2 inches in diameter, the distance between the ring and straight wire terminals being 29·75 inches; the battery consisted of 11,000 cells. The discharge took place when the pressure was reduced to 35·5 mm., 46,710 M (millionths of an atmosphere), and the exhaustion was afterwards continued gradually until it fell to 0·0065 mm., 8·6 M. In commencing each set of experiments the deflection of a tangent-galvanometer was observed when the battery was short-circuited. By a table previously calculated the value of the deflection in ohms of resistance per cell could be read off; this, multiplied by 11,000, gave the total resistance of the battery; the tube was then connected with the terminals and the galvanometer again observed; this gave a less deflection and indicated a greater resistance, which, multiplied by 11,000, gave the total resistance of the tube and battery: by subtracting the resistance of the battery the resistance of the tube was ascertained. Calling the total resistance R, the tube resistance r, the tube-potential V, $V = \frac{r \times 11{,}000}{R}$. The tube-potential requisite to produce a discharge, with a pressure of 46,710 M, was found to be 10,250 cells; this gradually fell until

[1] "Experimental Researches on the Electric Discharge with the Chloride of Silver Battery," by Warren De La Rue, M.A., D.C.L., F.R.S., and Hugo W. Müller, Ph.D., F.R.S. (*Phil. Trans.*, vol. clxxi. p. 63).

124

centre of gravity had been lowered with each change: "And the conclusion, therefore, at which we have arrived is that, if she lurched and rolled very deeply when fitted as a ship of war, it may fairly be presumed that, but for the presence of the bilge keels, she would have lurched and rolled more deeply as a training ship, still more so on the second cruise, and most of all on her last cruise."

After giving the opinion of Mr. John, who had been requested by the Committee to make an independent series of investigations as to the vessel's stability, that "it was by no means improbable that she would capsize, if caught in a squall of wind unless skilfully handled," and stating that Mr. Barnaby appeared to share Mr. John's preference for a design with less beam and more ballast, the Committee complete this section of their report with the following remarkable paragraph:

"What we are required to say is, whether the Atalanta when she left England in November, 1879, was a stable ship; and the conclusion to which we have come, after a full consideration of all the facts of the case, is that she was on the whole a very stable ship except at large angles of heel; that she was more stable than when first commissioned as a training ship; and much more so than in her previous commissions as a man-of-war."

It is little to be wondered at that the press and the public generally have seized the words "except at large angles of heel" as giving a clue to the whole mischief. Herein to our minds lies an entire confirmation of the views put forward by Mr. John. With a ship carrying a huge spread of canvas, as the Atalanta did, for her size and weight, and lurching heavily and deeply, as is now beyond question, and thus reaching large angles of heel frequently, surely it was at these large angles that she should have been abundantly supplied with stability.

The Committee further say under the head of seaworthiness, that if the Atalanta had been thrown on her beam-ends she would have sunk; and that to have increased her ballast sufficiently to have given her a good righting moment when on her beam-ends, would have been attended with other elements of danger, such as excessive labouring, and a consequent tendency to carry away the masts, which would also endanger her safety. It has been remarked by some of our contemporaries, that it must have been difficult to know what to do with her. Mr. John, in his evidence, stated that he thought her "a type of vessel which it is very difficult to make easy at sea, and very easy to make unsafe." Few will now, we think, be disposed to question this description of her, but still fewer will think she was ever fit for a training ship, to cruise about with 300 young sailors on board. On the whole the impression left by the Committee's report is, that they in effect accepted the views laid before them by Mr. John, which is substantially contained in the following extract from his first day's published evidence:

"Under all these circumstances it appears to me that the Atalanta as equipped for sea on her last cruise, combined an apparent stiffness under her canvas at moderate angles of heel likely to be misleading when combined with a deficiency of stability at large angles for a vessel so heavily sparred in proportion to her displacement. This, combined with the facts recorded as to her deep rolling and lurching, renders it in my opinion by no means improbable that she was capsized in a squall of wind, which might easily have happened if the vessel was otherwise than very skilfully handled."

33

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CHEMICAL AFFINITY AND ELECTROMOTIVE FORCE.

An important paper giving the latest results of his exhaustive research to determine the value of chemical affinity in terms of electromotive force was read at a recent meeting of the Physical Society by Dr. C. R. Alder Wright, lecturer on chemistry and physics at St. Mary's Hospital. In the present article we propose to give the leading and most practical conclusions at which the author has arrived.

Dr. Wright began by considering the true value of the extant British Association unit of resistance, or ohm of electricians, and from a consideration of the values obtained by different experimenters such as Weber, Kohlrausch, and Rowland, he concludes that the true value of the ohm lies between 1 and 1.005 earth quadrants per second, and therefore that until fresh determinations are made, the existing British Association units may reasonably be taken as correct. It follows also that the electromotive force of a new-made Clark's standard element is 0.457 volts, without correction for error in the British Association unit. The qualification new-made is needful, for according to Dr. Wright's experience of these cells, their electromotive force diminishes with age. When carefully prepared they will keep constant for three or four months, but after that the electromotive force begins to decline by a slight percentage, say one or two per cent. in two years. This declension is accelerated or occasioned by air within the cell, and the directions given to seal the mouth of the cell with paraffine wax are hardly sufficient to keep out the air, for the wax cracks at the edges. A better plan is to hermetically seal the orifice of the cell.

By comparing in the same way the different values got for J, or Joule's mechanical equivalent of heat by Joule himself, H. F. Weber, Hirn, Violle, and Wright and Rennie, Dr. Wright finds that if the British Association unit is taken as exactly one earth quadrant per second, then J is 42×10^6 centimetre-gramme-second units, with a probable error of less than one per cent. too great or too small. Joule's values obtained from experiments on the friction of water in 1850 and 1878, namely, 41.57×10^6 and 41.54×10^6 respectively, are probably below the truth.

It is then shown by Dr. Wright that in an electrolytic cell the total work done is that performed in breaking up the electrolyte into the "nascent" products of electrolysis, together with that due to the resistance, R, of the fluid, which is indicated by the expression $C^2 R t$, where C is the strength of current passing, and t is the time it passes. So that by determining the total work by the formula $W = E Q$ (where E is the electromotive force or difference of potential between the electrodes, and Q is the quantity of electricity that passes, or in other words $C t$), and subtracting from it the work of overcoming the fluid resistance $C^2 R t$, there is left the work done in breaking up the compound into the "nascent" products of electrolysis, or $(E - C R) Q$. The quantity $E - C R$ is the counter electromotive force set up during electrolysis which is indicated by e in Ohm's formula:

$$C \frac{\Sigma(E) - e}{\Sigma(R)},$$

where $\Sigma(E)$ is the sum of the electromotive forces other than the counter electromotive force, and $\Sigma(R)$ is the sum of the resistances in circuit. Hence by electrical measurements the work done in breaking up an electrolyte into its "nascent" products is easily ascertainable; and it ordinarily exceeds the work done in breaking up the electrolyte into its final products.

After discussing the results of previous observers, Dr. Wright propounded the important theorem founded on his own measurements, that the first action of the current is to break up the electrolyte into "nascent" forms which would evolve heat in becoming transformed into the ordinary forms of the bodies produced by decomposition. However, the attractive action of the surfaces of the electrodes employed causes a variable fraction of the products to be evolved not in the nascent state, but in the ordinary condition or nearly so, if solid, and in the form of quasi-liquefied substances if normally gaseous (such as oxygen and hydrogen), thus necessitating a less expenditure of work than would otherwise be requisite to bring about decomposition. Similarly if the electrodes are oxidisable, or if substances which are chemically acted on by the nascent products should be dissolved in the fluid electrolysed or should adhere to the electrodes, or if other analogous physical or chemical changes take place, the energy thus gained is subtracted from that otherwise requisite to be expended to produce electrolysis. The "nascent" products here spoken of are perhaps the ultimate atoms which compose the ordinary molecules of a substance and which in clashing together again to form the molecule give out heat. This theorem indicates the value of e to be given by the series:

$$e = E_1 + \{(1 - n_1) H_1 - n_1 h_1 + (1 - n_2) H_2 + n_2 h_2 - \Sigma(H \quad \times J,$$

where E_1 is the electromotive force representing the work done in the breaking up of the electrolyte into the final products; n_1 and n_2 the fractions of the total ions at the positive and negative electrodes, which are not evolved in the nascent form; H_1 and H_2 the heats of transformation of the nascent ions into the final products; h_1 and h_2 the heats of condensation of the evolved gases (when the final products are gaseous) to the quasi-liquefied forms of these substances; and $\Sigma(H)$ the algebraic sum of the heat evolved by the action of the ions on the electrodes, &c., including the electromotive force due to the formation of liquids of different densities round the two electrodes respectively. It is further shown by Dr. Wright that this formula includes and accounts for a large number of observed facts in electrolysis.

For instance, the formula accounts for the decline of the polarisation of the electrodes of a voltameter as time elapses after the breaking of the circuit, and the nature of the curves expressing the rate of fall. It predicts that the rate will be greater in water containing dissolved air, than in water free from air, and greater, *cœteris paribus*, with smaller electrodes than with larger ones. These results are verified by experiment. It also indicates that the electromotive force of a Grove's gas battery composed of hydrogen and oxygen must lie between 0 and 1.50 volts, and must be subject to great variations under certain conditions, a result which is found to be the case. The phenomenon of so-called "condensation" of voltameters is in strict conformity with the formula, which also accounts for the observation that under certain conditions water may be electrolysed with a visible evolution of either oxygen or hydrogen, or both, by a battery of less electromotive force than 1.5 volts.

A more important practical deduction, however, is that the value of e increases with the strength of the current, though at a less rapid rate; and hence it follows that the electromotive force of a voltaic couple in which hydrogen escapes or a metal is deposited is not constant but diminishes as the generated current increases. This deduction may be experimentally verified on Daniell's, Grove's, and other cells. One result is that Ohm's method of determining the electromotive force of batteries and their internal resistance by means of two or more currents of different strength produced by the same battery, are more or less erroneous, for in these methods it is assumed that the electromotive force of the testing battery yielding the current, remains practically constant. In the case of a Daniell cell the variation of electromotive force with the strength of current given by the cell is sometimes as much as 10 per cent. It is not easy to see how the internal resistance of a battery can be measured without employing at least two currents of different strength. Indeed, if we remember rightly, Dr. O. J. Lodge has endeavoured to show that it is theoretically impossible; but we have Dr. Wright's assurance that it can be done by two methods based on polarisation, and employing only one strength of current. Probably Dr. Wright will publish them before long, and enable electricians to put them into use.

In the course of his laborious experiments Dr. Dr. Wright has made many determinations of the quantity of oxygen evolved by electrolysis in different periods of time by very minute currents, and they invariably show that the law of Faraday, to the effect that there is no conduction without electrolysis, is always observed.

NORTHERN IRON TRADE IN 1880.

In no recent year have there been the fluctuations in the iron trade of the north that have marked the course of the year 1880. These fluctuations have been chiefly in the value of iron—the extent of the trade as measured by the production having been increased with some steadiness, and this not in one branch alone but in most. When the year began, prices were rising rapidly under the stimulus of the demand from the United States, and though that demand collapsed by the middle of the year, and prices returned to their old level, yet the result, in an increased and increasing production of crude iron, and of several kinds of manufactured iron, has remained, so that at the close of the year the output is much larger than at its commencement, and is far above that of the average of recent years. At the beginning of 1880 the price of Cleveland pig iron was based on a standard of 50s. per ton; it rose rapidly to 63s. per ton in the month of March, and it receded as quickly to 39s. per ton by June, since which it has fluctuated a shilling or two up and down. There has been no such fluctuation in the extent of the output. At the beginning of the year there were 99 of the 105 blast furnaces in the Cleveland and Durham district in operation,—and that number has been steadily increased until there

Menlo Park Scrapbook, Cat. 1047

No. 33A. "Laws of Electricity and Magnetism"

This scrapbook covers the years 1879-1885 and contains clippings about electrical and magnetic laws and theories. There are 164 numbered pages.

Blank pages not filmed: 60-164.

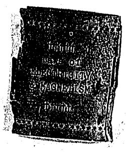
Missing pages: 16-35.

1047

Laws of Electricity & Magnetism

Theory

33



Electrician May 1 1880

ON THE DISRUPTIVE DISCHARGE OF ELECTRICITY.

BY ALEX. MACFARLANE, D.SC., AND P. M. PLAYFAIR, M.A.

During the months of November and December of this Session we have investigated certain questions suggested by the results already communicated to the Society.

Difference of Potential required to pass a spark between (1) two equal spherical balls at different distances, (2) a plate and ball at different distances, and (3) a plate and point at different distances.

A series of observations was taken for each of these, and on three successive days, without altering the arrangement of the apparatus or the charge of the electrometer. The couple of small Leyden jars were attached to the conductors of the Holtz machine, as we had previously found that it was impossible to observe the discharge between a plate and point with any degree of accuracy when the capacity was small.

Two balls, each of ¾ inch diameter.—The series of observations for the two balls is a more minute and extended investigation of a problem we took up and solved approximately before. We have observed more minutely the values of the readings at the smaller distances, and also noted the cause of the irregularity at the ends. We found that at 80 mm. small violet sparks began to pass before the principal white spark, and that the reading was then more ambiguous than for smaller distances. Escape from the conductor was first noticed at 120 mm.*

Plate and Ball.—We employed a tin plate 8 inches diameter, and one of the brass balls used in the previous experiment. The curve obtained is not very different from that for the two balls; it is somewhat more circular. Small sparks passing before the large one were observed to begin at a shorter distance than in the previous case. Another irregularity at the end was due to the passing of two large sparks. Finally, the electricity began to escape from the insulated wires.

Plate and Point.—The plate used was the tin plate of the previous experiment; the point was conical and of brass. From 1 to 5 mm. the discharge was in the form of a white spark; for higher distances nothing was visible excepting a glow at the point. The series was continued up to 200 mm., as there was no difficulty due to escape of the electricity into the air.

Discharge through a Solid Dielectric.—We obtained, by favour of Mr. Calderwood, of Addiewell Chemical Works, a quantity of a pure solid paraffin of low melting point. The plate electrodes were separated to a distance of ¼ inch inside a glass vessel, the liquefied paraffin poured in so as to cover the plates completely, and then allowed to solidify for twenty-four hours. When the plate electrodes were charged the first spark which passed was large, and illuminated the whole of the paraffin, but the succeeding discharges were much smaller, and of equal amount. The first spark produced a deflection 3·6 times as great as the succeeding sparks. When the plate of paraffin was examined afterwards it was found to be perforated in a zigzag manner, the hole being surrounded by char. We found that—

Electric Strengths.

Air	1
Paraffin when solid	5
Paraffin when liquid	2·5

Thus the electric strength of this substance when in the solid state is, to its electric strength when in the liquid state, as 2 to 1.

As an instance of how these experiments may be made directly useful, I may mention that we obtained two samples of liquid paraffin from Mr. Calderwood to compare their electric strength. We found the ratio to be 1·6. It is, however, extremely difficult to effect the comparison unless we have a considerable quantity of each specimen. It is best to have a dish of the above form, where we can have broad plates, the lower one slightly raised above the glass bottom, and the upper one well immersed in the liquid. The former of these conditions helps to prevent solid particles getting in between the plates, and the latter prevents the rising of the liquid up the stem, and consequent splashing about of liquid particles.

Discharge through Paraffin Vapour.—We put the discharging vessel, with a quantity of one of the pure liquid paraffins, inside the receiver of an air-pump, exhausted the air, and allowed the paraffin vapour to accumulate. When the barometer-gauge indicated 50 mm. pressure, the distance being ¼ inch, we took sparks through the vapour. The spark was of a broad section, green at either end, but of a deep violet between. When a quantity of air was let in white jagged sparks were observed in the midst of the coloured spark. From the readings obtained at 50 mm. pressure we infer that this paraffin vapour is 1·7 times as strong as air.—*Proceedings Royal Society of Edinburgh.*

Scientif. Amer. Aug. 20 1881. 1

A Large Electro-Magnet.

MM. Von Feilitzsch and W. Holtz have recently made, for the University of Greifswalde, an electro-magnet of enormous dimensions. The price of a bar of iron made in one single piece would have been too expensive, while, on the other hand, in a system formed of several pieces poles become developed at the contacts. The electro-magnet was, therefore, constructed of 28 plates of iron, 7 millimeters thick, bent into a horseshoe shape, and of a size such that their combination forms a cylinder 195 millimeters in diameter. These plates are varnished, in order to avoid the formation of extra currents; they are connected together by iron bands, and so arranged as to form a cylinder of uniform diameter. The total height is 125 centimeters, the distance between the poles 596 millimeters; the total weight 628 kilogrammes. The magnetizing helix is composed of 100 kilogrammes of plates of copper, forming 15 layers, insulated from one another by gutta percha.

Outside there are 175 kilogrammes of wire, 2 millimeters thick, forming 5 double layers of wire, and the extremities of the different parts of the circuit communicate with terminals fixed on insulated columns, which allow of any required connections being made. The poles are topped with two plates, 33 millimeters thick, which can be set at any required distance apart, and are capable of carrying various accessories. A movable plate, placed between the two branches, can be placed at any convenient height for the experiments. With this apparatus, excited by 50 small Grove cells, it was possible to melt in two minutes 40 grammes of Wood's metal by Foucault's experiment, and if the poles were set close, the resistance stopped the movement in spite of the tension of the driving band. It is very easy to show the rotation of the plane of polarization in heavy glass, when the latter is traversed by a ray of light, etc. In this apparatus, as has been pointed out, the bar of iron weighs 628 kilogrammes, and the wire 275 kilogrammes, while in the one constructed by Plücker, and which was the largest existing, the weights were only 84 and 35 kilogrammes respectively.—*Les Mondes.*

Electro-deposition of Bismuth.—A series of experiments with various solutions of this metal has recently been carried out in the laboratory of Mr. D. G. FitzGerald at Brixton. Sesquioxide of bismuth dissolved in a hot solution of the double tartrate of soda and potash (Rochelle salt) was found to give excellent results at a temperature of about 160° Fah. The anode should be considerably larger than the cathode or article to be plated, and the electromotive force should be between one and two volts. A perfectly adherent deposit of silvery lustre, but of a darker colour than silver, and not liable to tarnish, may readily be obtained on iron or steel, copper and brass. Mr L. A. Davies, who, as pupil-assistant in the above laboratory, carried out most of the experiments in question, has, since he resigned that position, written to a contemporary to state that a solution of the ammonio-citrate of bismuth, as well as the solution above-mentioned, possesses all the practical requisites for the successful deposition of this metal. Electrician

March 6 1880

English Mechanic
Dec 26 1879

GALVANIC CONDUCTION OF METALLIC ALLOYS.

According to Obach's observations, alloys of lead and tin, potassium and sodium, and sodium-amalgam, or alloys of proper metals, conduct the electric current like conductors of the first-class without being decomposed. Now, since, on the other hand, combinations of metals with non-metallic substances are mostly electrolysed, the question remained how combinations of metals with half-metallic elements, such as arsenic, antimony, bismuth, or tellurium would behave. In order to answer this question Herr Elsässer has recently (*Ann. der Physik*) tried the alloy of some metals with antimony and bismuth and by the following method:—

Into one end of a 15ctm. long tube of difficultly-fusible glass, about 1ctm. in internal diameter, a piece of gas-carbon was fixed as electrode. The tube was then fastened vertically and filled with the alloy to be examined. This having been brought into fusion, the other electrode, also of gas-carbon, was introduced into the upper end of the tube. The carbons were at first connected for a long time with the galvanometer, in order to observe any thermo-current that might arise, and then the current from a battery of six large Bunsen elements was so passed through the alloy that the heavier metal must be precipitated at the lower part of the tube. From time to time the electrodes were connected with the galvanometer in order to be able to observe a polarisation current. After the action of the battery-current had continued 4 to 6 hours, the alloy was cooled, the cooled bar taken out of the tube, and pieces about 1ctm. in length taken off the ends and analysed. Herr Elsässer had previously examined whether the alloys, in being fused without a current, remained homogeneous, having fused them in a vertical tube 4 to 5 hours, and determined the specific gravity at the ends. With exception of the antimony-lead alloys they were all available, these five, viz., antimony-zinc, antimony-copper, antimony-tin, antimony-silver, bismuth-lead, and on these the experiments were made.

The result was that none of these alloys was decomposed by the current—the composition at both electrodes was always the same. In the case of antimony-zinc, indeed, a polarisation-current was observed, which was possibly due (the author thinks) to the fact that the antimony-oxide produced at the surface of the alloy was again decomposed.

The selection of alloys for this research was limited to those above-mentioned because many metals give too difficultly-fusible alloys or one too easily oxidised. Arsenic, in place of antimony, gave alloys very difficult to fuse, and out of which the arsenic, in fusion, was volatilised.

"None of the alloys examined by Obach and Lyne," says Herr Elsässer, "were decomposed. Since antimony is, with the exception of arsenic and tellurium, the most electro-negative of all the half-metals, it can hardly be doubted that the alloys of the above-specified positive metals and of positive metals generally, with elements which are less negative than antimony, would also not be decomposed.

"Now, the transition from these compound conductors of the first-class to those of the second, the electrolytes, is evidently not a sudden one. There are between these two groups materials which, at a low temperature, conduct without decomposition, but at a higher, and partly before melting, are electrolysed—*e.g.*, copper and silver sulphide. The sulphides of lead, nickel, iron, bismuth, tin, and antimony behave similarly. These substances share with conductors of the second-class, the peculiarity that their conductivity increases with rising temperature, and so with increased mobility of their particles.

"The same peculiar behaviour characterises a large number of other compounds, which it has not hitherto been found possible to electrolyse, probably only because they are so difficult to liquefy. Such compounds are tin-oxide, iron-oxide, and chrome-oxide. These, therefore, probably belong to this same middle class of compounds which form the transition from the compound conductors of the first-class to electrolytes, while the electrolytes proper do not conduct without being decomposed. To the latter belong especially the haloid compounds of the metals, which are not decomposed in the solid state, because they are mostly insulators. As soon as they begin to conduct, that is, when they are fused, they are decomposed. Some oxygen compounds, also the oxides of lead, antimony, and bismuth and molybdic, vanadic and chromic acids behave thus.

"Lastly, there seems to be still a fourth class of compounds, which in general do not conduct, either with or without decomposition. Apart from this latter group, and considering the compounds which can form a positive element with other elements, ranked according to the position of these elements in the electro-chemical series, then passing in such a series from the positive to the negative side, we first meet with conductors of the first-class, then middle members, which at a lower temperature conduct metallically, at a higher electrolytically, and, lastly, at the negative end, only electrolytes.

"It would be useful for the characterisation of the elements if we could determine, for each of them, in which of its combinations the electrolytic conductivity begins. This is possible now for some of them. The compounds of copper and silver with sulphur permit of being decomposed at a comparatively low temperature, whereas their combinations with antimony and selenium are no longer decomposable. It is probable that their tellurium combinations also behave like conductors of the first class. Accordingly for silver and copper the electrolytic limit would seem to be at sulphur.

"The sulphur compounds of tin, lead, and zinc behave like conductors of the second class. Their antimony compounds are no longer decomposed—the electrolytic limit for these metals, therefore, lies between sulphur and antimony.

"The above-mentioned disturbing properties of many compounds, their difficult fusibility and spontaneous decomposition, unfortunately render it difficult and prevent the fixing of this limit for all elements."

THE THEORY OF THE TELEPHONE.

Electrician July 17 1880

An interesting communication bearing on the theory of the telephone has been made to the French Academy of Sciences by MM. Ader and Du Moncel.

Our readers will remember that in 1879 M. Ader constructed a telephone without a diaphragm, the sound being given out by a soft iron wire enclosed in a helix, through which the current passed. The action was explained by M. Du Moncel to longitudinal vibrations in the wire resulting from successive lengthenings and shortenings of the wire under the action of the magnetising helix, it being well known that an iron core is lengthened by magnetisation. M. Du Moncel employed this fact to support his molecular theory of the action of the Bell telephone. Since that time M. Boudet, of Paris, has, by means of his sensitive microphone, succeeded in revealing these changes of length. Moreover, M. Ader himself has investigated the subject very closely, and, besides measuring the effect in question, has arrived at the important principle that *all bars of a magnetic nature submitted to a mechanical action, be it compression, torsion, or tension, tend to recover their primitive molecular arrangement under the influence of the current which magnetises them.*

The apparatus employed by M. Ader in his experiments consists of a small straight electro-magnet, having its core formed of an iron wire 0·04 or 0·05 mètres long, and one extremity chamfered off. Upon this chamfer acts a long lever, which serves the double purpose of an indicator and exciter of the mechanical action. The lever terminates in an index which moves itself before a graduated scale (in front of which is a lens), and is connected to the magnetic core in a manner differing with the mechanical action to which the latter is submitted.

In the cases where compression and tension are produced, two distinct effects are seen. On allowing the current to flow for several instants continuously, the index is gently displaced, moving up the scale in the former case (compression) and down the scale in the latter case (tension), with a deflection proportional to the intensity of the battery and the time of closure of the current. This effect is evidently due to the dilatation of the core in each case under the influence of the heat developed by the current, for it is obtained with a core of copper. On closing the circuit momentarily the lever rises instantly in both cases, and instantly falls on the current being interrupted. At the same time a "dry" sound can be perceived at each make and break of the current when the ear is applied against the table supporting the apparatus. But the apparatus is so arranged that the displacements indicated in the two cases correspond to two mechanical effects diametrically opposite in character; that is to say, to a lengthening and shortening of the core. It can, therefore, only be due to a molecular action tending to annul the mechanical strain on the core in either case.

In the case of torsion, the index rises always at the moment of making the circuit and falls again at the moment of breaking it, and in a degree corresponding to the force of the mechanical action, as can be determined by a weight sliding on the torsion lever. In this case the thermal effect is not shown at all, since the indicating lever does not change its position by reason of the lengthening or shortening of the magnetic needle. The magnetisation in this case tends, as in the experiments of MM. Guillemin and Coulon, to untwist the wire.

The length by which the core is shortened by closing the circuit momentarily by the current, according to M. Ader's calculation, is less than one ten-millionth of a mètre, or one ten-thousandth of a millimètre. It is greater under the influence of torsion, and less under the influence of tension.

THE THEORY OF THE TELEPHONE.

Electrician July 31 1880

By experiments made at Toulon in 1878, M. Desportes demonstrated that sounds could be determined in a telephone under the influence of a shock produced in a bar magnet, enveloped by a magnetising coil connected to the telephone. This effect has been attributed to induced currents resulting from displacements of the bar inside the bobbin under the influence of the shock. Experiments made by M. Ader since that time have, however, shown that the phenomenon is more complicated, and, by combining several diverse experiments in order to elucidate the question, he has arrived at some interesting results, which have been recently submitted by him to the French Academy.

Firstly, he shows that if proper precautions are taken to avoid all displacement of the magnetic core inside the bobbin connected to the telephone, if, for example, one enrols the wire of the bobbin on the core itself, and stiffens the spires in shellac, no sound is obtained on striking the core with a non-magnetic body. On the other hand, the sounds may be perfectly well reproduced by striking the core with a mass of iron. It can also be reproduced if the ends of the coil thus embedded in shellac are loosely wound around the coil in two or three turns.

Again, if we place inside a small ordinary bobbin metallic cores composed of different metals, we find that only the magnetic metals, *deprived of persistent coercitive force*, provoke the telephonic sounds when struck. Thus, a wire of iron or nickel gives very characteristic effects, *whilst a wire of tempered steel, not magnetised*, produces none.

But what is most important is that these effects are the more energetic in proportion as the core is more divided in the interior of the bobbin, and the best results have been obtained when the magnetic wire was composed of ends of iron wire disposed end to end, and being only one millimetre or two millimetres long by one millimetre in diameter.

Under these conditions the telephone was made quite capable of reproducing speech very distinctly. To effect this, all that was necessary was to place under a telephone diaphragm (of about 10 centimetres diameter and $\frac{1}{20}$ millimetres thick, and furnished with a mouthpiece), a small bobbin of fine wire (No. 40) about five millimetres long, filled with the said fragments of iron wire, and to press with a suitable pressure, the external piece, which ought to be longer than the others, against the centre of the diaphragm. In speaking into the mouthpiece then, a series of vibrations are set up which, in producing a series of corresponding shocks, transmit speech in a satisfactory manner without the necessity of any battery.

The preceding apparatus permits further of proving an important fact which only complicates the question. It proves that *the displacement of the magnetic core in the heart of the bobbin does not suffice to reproduce the sounds.* It is necessary that there should be also a *shock*, and even several shocks. This may be demonstrated by soldering to the diaphragm of the apparatus a wire of iron thrust into the helix. Under these conditions the vibrations displace the iron wire, and in presence of the terrestrial magnet there ought to be developed currents capable of reproducing sounds; but none are forthcoming, and to obtain them it is necessary to place on the coil a second core of iron against which the first may produce shocks. In these circumstances the effects produced can be in some sort analysed by the following experiments:—

If we compress a core of iron furnished with a bobbin wound between two pieces of copper pressed between the jaws of a vice, and if the iron core is rivetted upon one of these pieces, we recognise, on suddenly raising under pressure the other piece of copper, that it produces a sound in the telephone, and this sound is doubtless due to the movement of the magnetic molecules which take their normal position of equilibrium. If we reproduce a similar mechanical action upon the core, but in a manner so as to draw instead of compressing it, we still observe a sound at the moment when the bar takes its normal conditions, and it is the same when torsion is exerted on the core. It may therefore be concluded that all mechanical action having for its consequence a disturbance of the molecular equilibrium of a magnetic core developes at the moment when this core suddenly recovers its condition of equilibrium an electric current capable of being felt on the telephone.

4

Electrician July 31 1880

Heat Theory of the Galvanic Current.—Clausius points out that Helmholtz's contact theory is inadequate, and he chose to elaborate the theory of the Dutch physicist, Buys-Ballot—that at the contact of two metals, the movement of heat itself causes potential differences. Thomson has given a theory of thermo-electric currents, which is complete, if we assume that the Peltier effect will show itself in one and the same metal at different temperatures. Tait has proved the well-known formula of Avenarius, and Edlund has proved the formula of Thomson—that the electromotive force of a thermo-element at the same difference of temperature is proportional to the absolute temperature. In the rational explanation of thermo-electric phenomena there are inconsistencies :—(1) Thomson's careful experiments still leave it doubtful whether we really find Peltier's effects showing itself in one metal; (2) bismuth is positive to antimony, and yet the current flows in the heated junction from bismuth to antimony; (3) Peclet has proved that with increased temperature the contact difference of zinc and gold is unchanged. (1). The author describes how, using weak currents, he gets the result which Thomson obtained using strong currents. (2). The author gives lists of metals placed according to experiments such as those of Volta and according to thermo-electric experiments. He finds by his own experiments the following contact differences with brass, given in percentages of a Daniell;—zinc 80, bismuth 16, antimony 12·5, silver 4, platinum I. 2·0, copper 1, platinum II. 4·0 gold 8. Platinum I. was chemically pure; platinum II. was the metal of commerce. This list, deduced from the author's careful experiments, he says, proves that the results of Volta, Seebeck and others are correct, in spite of the obvious carelessness of their methods. He goes on to show that, for instance, in a bismuth-copper junction, the electromotive force produced in the bismuth itself tending to give a strong current from cold to hot parts of the metal, is actually greater than the contact electromotive force of the two metals; and hence, since there is only a small effect of this kind produced in copper, these metals ought to be differently placed in a contact list and in a thermo-electric list. This is also the reason why we find the neutral points in thermo-electricity. The author gives an experiment bearing out the above explanation. (3) He repeats Peclet's experiment, and gets a result which is in accordance with theory. He, therefore, concludes that potential differences shown on heating are only modifications of those discovered by Volta; and as thermo-electric phenomena are explainable by the laws of thermodynamics he uses to explain Volta's contact differences, heat effects at the junctions. He deduces from this that not merely chains of metals, but chains of metals and liquids should owe their electric currents to heat effects at the junctions; so that we must not explain them by changes in chemical effects. He discusses the case of zinc in sulphate of zinc, where there is an electromotive force of contact, and yet in which there is no chemical action. He describes an experiment showing that the positive electrode in a decomposition cell becomes warmer than the negative. The author describes arrangements by means of which zinc plates were maintained at different temperatures in sulphate of zinc, and copper plates in sulphate of copper, and he finds that the ratio of the electromotive forces of these cells is 1·26. He also finds that the thermal currents between metals and fluids depend, as regard their direction, only on the fluids, and not on the nature of the metals. The author, after declaring that the question—Is the electromotive force of Daniell equal to the sum of—

$$Zn \mid Cu,\ Zn \mid Zn\,So_4,\ Cu \mid Cu\,So_4$$

has not hitherto been taken up, proceeds to describe his experiments proving that this is true. He finds—

$$Zn \mid Zn\,So_4, = 48 \text{ per cent. of a Daniell,}$$
$$Cu \mid Cu\,So_4 = 27{\cdot}4 \quad \text{,, \quad ,,}$$

He then proceeds to consider the well-known statement that the direction of the current in a cell depends on the nature of the chemical effects producible at the junctions, and he shows by the example of a single cell formed of lead and copper in water that the statement is not always true. Thus, according to Favre—

$$Pb\,O - H_2\,O = 27{,}675 - 34{,}462 = -6{,}787 \text{ heat units.}$$
$$Cu\,O - H_2\,O = 21{,}885 - 34{,}462 = -12{,}577 \quad \text{,,}$$

and yet this cell gives a pretty strong current, which, in the fluid, has the direction from lead to copper. The remainder of the paper is devoted to a theory of the voltameter, based on the following principle:—When a certain amount of polarisation is in existence, not the maximum amount, it is as if one of the platinum plates had a number of buttons of zinc partially covering its surface, so that the current from a voltaic cell when it enters the voltameter is in parallel circuit. In one path through the voltameter there is no opposing electromotive force, but by the other there is such an opposing electromotive force, and this latter becomes more and more important as time goes on. He deduces the result—

$$J = \frac{E - \frac{p}{n}}{R + r},$$

Where p is maximum polarisation, E the electromotive force of battery, r resistance of voltameter, R all other resistance of the circuit, J the current, and n a number which depends on the time decreasing from infinity to 1 with a rapidity determined by the current and the area of platinum plates. The author describes many experiments illustrating his theory—refers to Edlund's experiment showing that the heat effects produced in a voltameter are not merely those due to current resistance but also to polarisation—refers to the fact that Favre found the simple cell zinc, sulphate of zinc, platinum, to cool when it produced a current, and shows how other facts of the same kind are explainable on thermodynamic principles.—Abstract of a paper by M. Hoorweg in *Annalen der Physik und Chemie*.—*Jnl. Soc. Tel. Eng.*

5

6

THE MECHANICAL ACTION OF LIGHTNING.

Sc. Am. Sup. Aug 14/1880

WITHIN the last few days England has been visited by several thunderstorms of considerable severity, and deaths caused by lightning have taken place in three or four localities. Trees have been rent, animals slain, houses injured, and there is some reason to conclude that the summer of 1880 may become rather remarkable for the manifestations of electric disturbance taking place in Great Britain. Although it is well understood that thunderstorms are always to a certain extent dangerous; and although most buildings, public or private, of abnormal height, are provided with lightning conductors to protect them, very few persons know accurately what lightning is. That portion of the general public which is fairly well informed, holds that a flash of lightning is a discharge of electricity from a cloud to the earth. The country journalist regards it as "a discharge of the electric fluid." The ignorant peasant speaks of a thunderbolt, and believes that an invisible something concealed in a "flash of fire," comes from the sky and slays or rends. If we turn to text books for information we shall find very little. "Lightning," writes Professor Fleeming Jenken, "is an enormous electric spark passing between two clouds, or from a cloud to the earth." We shall see in a moment what it is that Professor Jenken calls a spark, and we shall be able to judge whether the conditions are such that an electric spark and lightning are one and the same thing. But before going further we must ask our readers who may care to peruse this article to think a little for themselves. It is not probable that they can thus find out what a flash of lightning is, and it is certain that we cannot tell them, but we at least show that it is possible to construct a theory concerning the phenomenon which is consistent throughout.

We may start by saying that lightning is unquestionably a form of electrical discharge, and it produces effects in all ways analogous to those produced by a discharge from a Leyden jar or other reservoir of high tension electricity. It has recently been urged that electricity is a mode of force. It is very difficult, though not impossible, to form a mental conception of a pure force, isolated and apart from matter; but be electricity what it may, it makes its presence known to our senses by its effect on matter; and there is, furthermore, reason to believe that matter which may be invisible or imponderable is first acted on before that kind of matter with which mankind is more or less familiar. Let a Leyden jar—one large enough to hold about two quarts of water will answer very well—be fully charged, and then discharged through a sheet of thick pasteboard. If matters are properly managed a hole may be punched in this way through a thickness of about a quarter of an inch. If this hole be examined it will be found that, although the edges may be singed, it has not been burned through, but punched through. The hole will be very like in its character to those made by a charge of No. 9 shot fired at a distance of twenty yards through a similar sheet of pasteboard. It is very difficult to conceive that such a hole has been made by the passage through the pasteboard of a pure force; all the evidence goes to show that something, that is to say, some form of matter, has gone through the cardboard and made the hole. If a piece of the pasteboard target, with one shot hole only on it, and the piece of card punched by the electric spark, were handed to a man who did not know anything of how the holes were made, he would say of both that something, either a shot or a rather blunt metal instrument, had been driven through the material and left the holes behind. There is, however, this to be noted, that in many cases the hole appears as though it had begun within the substance of the paper, and not at one side or both. It has been laid down that when an explanation of any phenomena or occurrence is available which satisfies all the conditions, it is unnecessary and illogical to offer theories based on any second hypothesis. The electrically punched hole is just such a hole as would be made by the passage of something material through the paper, and so far we have reason to believe that something material has passed through. Now, if we compare the effects of a Leyden jar spark with those produced by lightning, we find a strict similarity between them. The lightning is different from the Leyden jar spark not in kind but in magnitude. When stone is ground to powder, or a tree split, we are justified in asserting that matter in some form or other came in contact with the stone and powdered it. It is supposed that trees are split by the production of steam from their juices by the heat of the electric discharge; and when lightning strikes sand it often produces curious tubes of fused quartz called ligurites. But allowing for this, a sufficient number of cases occur in which the effect produced is certainly not due to heat. At first sight these statements will, perhaps, seem to a few of our readers as extremely heterodox. They will say that we have a theory of material thunderbolts, such as the ignorant peasants hold. Our reply is, that there may be thunderbolts and thunderbolts, but that the peasant, according to his lights, has spoken and reasoned wisely. He has assumed that a great hole cannot be dug in the earth unless something of which the soil can take cognizance has operated upon it. We cannot form any conception of a hole being dug in a field by a pure force. Nor can we imagine such a mundane thing as a block of granite reduced to powder save by the impact or influence of something very different from pure force. There may be forms of matter, however, susceptible to the operation of pure forces. We neither assert nor deny that such is the case, but it is more reasonable to suppose that when a stone is shattered or a hole pierced, or an excavation made, it is made by some form of moving matter than by anything else. Lest it should be said that in assuming that the electric spark is a manifestation of matter in motion we are standing alone, we shall support our opinions by the following quotation from Prof. Fleeming Jenken's "Electricity and Magnetism:" "The distribution of electricity over bodies which have points or angles is such that the electric density becomes very great on these points as it would on a very small sphere, even when the potential is not high. The result is a great repulsion of the electricity for itself, or rather a great repulsion between the neighboring parts of the matter charged with it. We then frequently see *the electrified matter passing off in the condition known as the electric spark.*" Again, in another place he writes: "The electricity has such a repulsion for itself that if it accumulates sufficiently the force becomes great enough to break down the pressure of the air, and *highly electrified particles of the conductor and of air fly off the point. Every electrical spark seen is an illustration of this convection. Lightning is one example.*" The italics are ours. We are apparently justified then in saying that the hole was punched in our card by a volley of missiles dispatched from the surface of the ball of the discharger, and that the mechanical effects of lightning are in like manner possibly due to a volley of missiles discharged from the clouds to the earth. It is more than probable that few of our readers, who are not trained electricians, have before heard or seen the statement, which we have just made. Its truth does not admit of direct demonstration, but it does admit of indirect demonstration.

We may now turn our attention to the nature of the missiles with which we have to do. Apparently there is nothing very alarming about them. A thunderbolt may be a very small thing indeed—let us try to give our readers an idea how small. It is not easy to say what the velocity of a flash of lightning may be; but we have to deal particularly with the fact that particles of matter have to be dispatched with a certain velocity like shot from a gun. Let us assume that this velocity is 50,000 miles per second; it is possibly very much more, but 50,000 miles will suffice. Let us suppose that we have one pound of matter moving at 50,000 miles, or 264,000,000 feet per second. The work stored up in our pound of matter will be found by the formula $\frac{Wv^2}{2g}$, and it amounts to 1,089,000,000 foot-pounds, or over 486,100 foot-tons. It is impossible to convey an adequate conception of the mighty force with which we are dealing. Let us suppose that we have a thunderbolt which weighs one ounce moving at 50,000 miles in a second. It would represent 30,000 foot-tons in round numbers, or a force great enough to lift a great ironclad bodily 3 feet. The one hundredth part of an ounce would have stored in it a capacity for doing work amounting to 300 foot tons. It would lift a rock weighing 3 tons 100 feet. A "thunderbolt" weighing as much as a grain of small shot would be competent to demolish a steeple or to rend an oak.

The mechanical action of lightning, then, may be due to the impact of very minute quantities of matter moving at a prodigious velocity. Their energy is due solely to their velocity, and the comparatively isolated range of the influence of lightning is no doubt attributable to the circumstance that the quantities of matter involved are exceedingly minute, and owe their power entirely to their speed. A cannon ball, moving at comparatively small velocity, may stun, and bruise, and batter, and spread destruction over a wide range; but not so the lightning flash. Just as a bullet, fired through a pane of glass, makes a hole in it, so is the action of lightning confined to beaten tracks and narrow strips of paths. We have, it will be noticed, made no attempt to explain why or how electricity imparts velocity to particles of matter. That no one knows. Nor have we said what form of matter our "thunderbolt" is composed of. Possibly molecules of oxygen or hydrogen from the water in the electrified clouds. Nor have we said anything concerning the charge of electricity which, no doubt, accompanies the matter put in motion, and which, by its inductive effects, may kill men or animals without touching them. Electricity is yet enveloped in a cloud of mystery, rifted here and there, but black as night elsewhere. We have endeavored to show that, according to the best authorities, the electric spark is due to matter cast off from conductors; and we have supplemented this by pointing out that the most insignificant quantity of matter, moving at a sufficiently high velocity, can contain enough energy to account for the mechanical effects produced by lightning. If our readers find inconsistencies in the theory, they must not blame us. The theory, as set forth here, is the legitimate deduction from observed phenomena and the writings of the best authorities on electrical science.—*The Engineer.*

7

Science, May. 1881.

THE CONSERVATION OF ELECTRICITY.

The following is from the preface to "Elementary Lessons in Electricity and Magnetism," by SILVANUS P. THOMPSON, now in the press.

"The theory of electricity adopted throughout is that electricity, whatever its nature, is *one*, not *two*. That this electricity, whatever it may prove to be, is not *matter*, and *energy*; that it resembles both matter and energy in one respect, however, in that it can neither be created nor destroyed. The doctrine of the *Conservation of Matter*, established a century ago by Lavoisier, teaches us that we can never destroy nor create matter, though we can alter its distribution and its forms and combinations in innumerable ways. The doctrine of the *Conservation of Energy* which has been built up by Helmholtz, Thomson, Joule, and Mayer during the last half century teaches us that we can neither create nor destroy energy, though we may change it from one form to another, causing it to appear as the energy of moving bodies, as the energy of heat, or as the static energy of a body which has been lifted against gravity or some other attracting force into a position whence it can run down, and where it has the potentiality of doing work. So, also, the doctrine of the *Conservation of Electricity*, which now is growing into shape, but here first enunciated under this name, teaches us that we can neither create nor destroy electricity, though we may alter its distribution—may make *more* to appear at one place and *less* at another—may change it from the condition of rest to that of motion, or may cause it to spin round in whirlpools or vortices which themselves can attract or repel other vortices. According to this view all our electrical machines and batteries are merely instruments for altering the distribution of electricity by moving some of it from one place to another, or for causing electricity when heaped up in one place to do work in returning to its former level distribution. Throughout these lessons the attempt has been made to state the facts of the science in language consonant with this view; but rather to lead the young student to this as the result of his study than to insist upon it dogmatically at the outset.'

THE ALTERNATING ELECTRIC DISCHARGE.

Electrician Aug 21 1880 10

The alternating discharge apparatus devised by M. Thenard is well adapted to show the shower of electric fire in different gases under various pressures, for the phosphorescent lights, invisible in full day, which illumine the gas placed in the annular space comprised between the two tubes of concentric gas, when analysed with care in the obscurity, always exhibit the character of a shower.

If the phenomenon is very difficult to observe in oxygen, it is, on the contrary, found by MM. Hauteville and Chappuis to be very easily recognised in fluoride of calcium.

When produced at atmospheric pressure in this substance, the spark has the appearance of a homogeneous luminous sheet. The annular space is filled with little luminous globules of a greenish yellow hue in darkness, and a tender rose colour in diffused light, the flame of a candle. In examining the tube by a magnifying glass during discharge, we are struck with the analogy which the phenomenon presents with that described by MM. de Mondesir and Schlesing in their beautiful experiments on "electric butterflies," where the burning of hydrogen in the air gives lights which move like swarms of flies.

The discharge in fluoride of silicon is easiest of all to study if the distances of the electrified surfaces attain several millimetres, because the luminous points, well separated, show that the successive discharges take place under the form of little luminous cylinders joined to small phosphorescent sheets with circular outlines; so that if the two cylinders are concentric, the central tube seems to be plastered on its exterior surface with regular luminous lines, equidistant, and terminated at the other tube, the whole recalling a mop with luminous tags. If the two cylinders are not concentric, the discharge only passes between the nearest walls, allowing the phenomenon to be studied on the edges. The space seems traversed by a shower of fire, as in the apparatus of M. du Moncel.

A diminution of pressure of the fluoride of silicon does not change the general characters of the discharge; but, in withdrawing the tubes of electrified glass, it can be readily proved that each luminous line is swollen at the ends. With low pressures the luminous drops, instead of designing themselves on a black background, seem hid in a violet mist. At the same time their contours loose their definition. A maximum of splendour is seen in the discharges which occur in the plane passing through the observer and the axis of the apparatus. The cylindrical lines, if dilated in rarefied gases, preserve, nevertheless, a lively splendour when the eye looks along them.

For pressures below ·005 mètres the general illumination masks the shower of fire almost completely—the drops seem to be deep in the mist.

Nitrogen is, after fluoride of silicion, the gas which gives the finest rain of fire. At ordinary pressure the globules—of a pale reddish blue—are very small and very close. The phenomenon takes more splendour of colour when we reduce the pressure of nitrogen to what supports the gas in air. We only obtain a luminous sheet of homogeneous appearance at pressures below 0·050 mètres.

Hydrogen exhibits also this form of discharge. At atmospheric pressure the phenomenon in colour is almost identical with what we observe in fluoride of silicon at low pressures.

The same appearances are observable with chlorine. The luminous drops are greenish, and much less brilliant than those of fluoride of silicon. This gas, under ordinary pressure, opposes a very great resistance to the passage of electricity. The electrified surfaces ought to be very near, for if they are at 0·002 mètres, for example, the luminous lines, without having the character of a spark, resemble it in luminous intensity. This mode of discharge is distinguished from the preceding by the small number of luminous lines and the brilliant *aigrettes* which appear on the surface of the walls of the tube, uniting amongst them the successive lines situated sometimes more than a centimetre from each other.

In oxygen the discharge is hardly visible, the gas becomes very slightly luminous, or rather phosphorescent. Nevertheless, in darkness, and by the aid of a magnifying glass, a granulation on the surface of the concentric tubes can be noticed, and, if the gas has not too feeble a tension, the distinct luminous globules can be detected.

The constitution of the milky white lights produced by the alternating discharge in carbonic acid recalls the lights observed in oxygen, but the analysis of them is easier.

These discharges are only silent, in all gases, at feeble pressures. They are silent also in hydrogen at atmospheric pressure. The rain of fire is accompanied in other gases by a rustling sound.

Discharge tubes, such as are constructed by M. Alvergniat, will show the rain of fire under its various aspects in different gases under different pressures.

jour : à quinze mois, il doit peser le double de ce qu'il pesait à cinq mois : soit 14 kilog. En général, un enfant qui s'accroît de moins de 20 grammes par jour doit être considéré comme mal nourri, comme malade ou sur le point de le devenir. Il va sans dire qu'il se présente presque toujours des exceptions à la règle.

Le savant praticien cite, entre autres exemples qui prouvent l'utilité des pesées, le cas suivant communiqué par M. Tarnier : Un enfant bien venant, de neuf à dix mois, allaité par une bonne nourrice, avait depuis sa naissance une croissance régulière. Sans cause appréciable, on vit d'abord le poids de l'enfant cesser d'augmenter, puis, après dix jours d'état stationnaire, on constata une diminution. On incrimina à tort la nourrice. Trois semaines après l'arrêt d'accroissement, il se déclara une méningite à marche rapide qui enleva l'enfant.

Nous ne pouvons suivre dans leur détail les prescriptions très-sages et très-prudentes qu'a résumées M. René Blache dans son travail. Il nous suffit de les avoir signalées aux intéressés, et d'avoir encore une fois insisté sur tout le parti que l'on peut tirer de l'emploi de la balance pour contrôler le développement normal de l'enfant.

H. de P.

LE TOPOPHONE

NOUVEL APPAREIL POUR PERCEVOIR LES SONS

Lorsqu'un navire à vapeur ou à voile navigue par un temps de brouillard intense, il est ordonné par les règlements maritimes de faire jouer le sifflet à vapeur ou sonner la cloche du bord, afin de prévenir les autres bâtiments et de les éloigner de la route suivie. Chaque année les journaux nous apprennent que tels ou tels bâtiments suivant la même route se sont abordés, et qu'un sinistre s'en est suivi. Qui n'a encore présent à l'esprit le terrible abordage du paquebot la *Ville du Havre* par un bâtiment à voile ? Mais il arrive souvent que le bruit des vagues, du vent, celui qui se produit sur le bâtiment, ne permet pas de juger exactement d'où vient le bruit de sifflet ou de cloche entendu. Dans ce cas, il peut y avoir rencontre fortuite tout comme si l'on avait négligé de se conformer aux règlements maritimes internationaux.

Le journal suisse : *le Monde de la Science et de l'Industrie*, nous fait connaître aujourd'hui un appareil très-curieux dû à M. Mayer, le *topophone*, destiné à se rendre compte de la direction en quelque sorte topographique d'où vient le son.

Le topophone de M. Mayer consiste en une tige horizontale de bois, disposée de manière à pouvoir se poser en équilibre sur le cou et les épaules, à la manière de ces leviers qui, dans certains pays, servent à porter les seaux d'eau. A chaque extrémité de cette tige-levier est un résonnateur ou appareil destiné à recueillir et à renforcer le son. Ce résonnateur est une caisse en métal dont une paroi est légèrement concave et percée à son centre d'une petite ouverture. A la paroi opposée, également terminée par une ouverture, est adapté un tube de caoutchouc qui vient se terminer à un cornet acoustique placé dans l'oreille. Les deux résonnateurs peuvent glisser sur les bras du levier afin de recevoir la position la plus favorable à la réception du son, et les deux tubes viennent se réunir sur la poitrine dans une même enveloppe, pour de là se bifurquer vers chaque oreille. Tout le système est maintenu en place par un ensemble de ceinture et de courroies.

Fig. 90. — L'officier porteur du topophone.

Lorsque l'officier porteur de cet appareil veut distinguer d'où vient le sifflet ou le son de la cloche que les guetteurs ont perçu, il se tourne dans plusieurs directions, et suivant qu'il se rapproche ou s'éloigne de celle d'où proviennent les sons, les résonnateurs les répètent avec une intensité plus ou moins grande. On comprend alors que l'officier-observateur étudiant à quel moment le son du résonnateur est plus intense, se rendra compte de la direction d'où provient le son avertisseur et fera route en conséquence. Deux navires pourvus de topophones pouvant se rendre un compte absolument exact de leur position, les accidents par abordages, les plus redoutables sur certaines routes maritimes, notamment celles de New-York, par les bancs de Terre-Neuve, deviendront beaucoup plus rares et peut-être même arriveront à ne plus se produire.

P. L.

EARTH CURRENTS.

Several communications have appeared in our daily contemporaries, referring to auroræ, seen by various observers on August 12th. In "Slip" will be found those inserted in *The Times*. Connected possibly with this phenomenon we have accounts of strong earth currents on and about this date. A most interesting statement describing the earth currents on various cable lines, has been sent to us by Mr. H. Saunders, electrician in chief to the Eastern Telegraph Company. The phenomena of earth currents are so universal, so important to science, and so little understood, that we hope some way will be found to accumulate facts, from which data laws may possibly be deduced. Mr. Saunders, speaking of the electrical and magnetic disturbances of the 12th and 13th August says:—

"The earth currents on those days were exceptionally strong and variable, causing great interruption to the traffic over all the English and Continental lines, so much so that the Director of Telegraphs in France gave notice in the papers of the cause of delay to telegrams.

"I have collected the following data as to what was observed on the Eastern Telegraph Company's system and the Eastern and South African Company.

"Between London and Porthcurno, and London and Marseilles, and London and Liverpool, there were very considerable disturbances all day of the 12th, the maximum effects being observed between 11 a.m. and 4 p.m.

"The English Government and the Submarine Company's systems were also affected.

"The system upon which we work most of our lines, which is purposely intended to block earth-current disturbances, prevents them being noticed except when very strong and variable, so that on the cables from Porthcurno to Lisbon and Vigo nothing very unusual was observed; but upon a cable from Lisbon to Vigo, which is undergoing repair, and upon which an instrument is kept in circuit, strong and variable currents were observed on the 12th and 13th, the maximum being between 11 a.m. and noon, the weather being unusually calm and the sky thickly overcast.

"At Gibraltar very strong currents were observed on the cable to Lisbon at 10:45 a.m. of the 11th. On the 12th there were strong currents both on the Lisbon and Villa Real cable, maximum at 11:46 a.m., and currents on both cables during the 13th, but not so strong. Little or no current was noticed on the cable between Gibraltar and Malta on either of the days.

"Malta observed nothing unusual on the cables connected with Gibraltar, Marseilles, and Alexandria, nor did Alexandria observe anything on any of the cables connecting Malta, Cyprus, and Candia. In the Levant there was considerable disturbance on most of the lines. The Otranto Zante cable was violently disturbed between 10 a.m. and 4 p.m. of the 12th, and the Zante-Candia line the whole of the day, rendering working very difficult.

"On the 13th the former section was free, but the latter still slightly disturbed. Candia did not have anything unusual either on the Syra or Alexandria cables. The currents were also very strong upon the cables connecting Syra with Tenedos, and Pera and Tenedos and Salonica, as also on the Turkish lines, both on the 12th and 13th. The currents were not observed on the cable at Cyprus connected with Alexandria, but were on the land lines on both days, strongest on the 13th, and on the Larnaca Limassol section. Nothing exceptional was observed on the cables between Suez, Aden, and Bombay. But, curiously, currents appeared upon the Eastern and South African cables between Zanzibar, Mozambique, Delagoa Bay, and Natal. It is all the more curious that, as a rule, these lines are very free from earth currents.

"This is, of course, a very imperfect record, owing to the fact that cables are dividend-earning machines in the first place, so that when there is trouble on the lines the whole of the efforts of the staff are devoted to getting the traffic through, leaving little time for scientific investigation.

"However, the salient points are sufficiently determined, viz.:—

"1st. The extent of the disturbance extending over Europe, as far as Constantinople, down to the extreme points of the southern coast at Gibraltar and Otranto, but not affecting Malta or Egypt, nor the Red Sea; but turning up again at Zanzibar and along the east coast of Africa.

"2nd. The remarkable coincidence as to the time of maximum effect at different places widely separated.

"These disturbances are generally accompanied by displays of the aurora borealis, and I see from a letter in *The Times* of the 14th that a vivid display was seen from Ilfracombe on the night of the 12th, extending over nearly 40° of the horizon beyond the Welsh coast. The aurora was visible at Suez on October 24th, 1870, and again on Feb. 4th, 1872, when there were great electrical disturbances over all the lines. During the last I measured earth currents equal to 170 Daniell cells upon the Suez and Aden cable. The aurora was preceded in each case by electrical disturbance on the line, and in the present case earth currents had been unusually strong for some days before, although during the actual time of the greatest disturbance on other lines the Suez-Aden section was clear."

ELECTRO-TELEDYNAMICS.

BY PAGET HIGGS, LL.D.

(CONTINUED FROM PAGE 148.)

For a first consideration of the subject, there will be more interest in approaching it from a point of view whence we can be accompanied by the practical engineer, for it is to him that promoters of the system of electro-teledynamics must bring the details in order that the system may have the full appreciation it merits.

The first question that arises usually in such discussions is—What size and kind of conductor will be used? before giving a direct answer to this question let us ascertain what current an ordinary telegraph line will carry. And for this purpose we may select, as a most convenient size, the ordinary line-wire of No. 6 American gauge (= ·162 inch diameter) corresponding very closely to No. 8 Birmingham wire gauge (= ·165 inch diameter), and to the French 4 mm. wire. Calculated in C.-G.-S. units from the specific resistance of iron as 9827, this wire would have 2·4 ohms for 1,000 feet or 12·65 ohms a mile; in practice, however, the resistance should be taken at 3 ohms for 1,000 feet.

There are two points to be determined—How rapidly the wire will become heated by a current? and how rapidly that heat will be emitted into the surrounding atmosphere? It is not at all advisable to push the heating to extreme limits, because this heat not only represents loss of work by loss of current in heating effect, but it decreases the capacity of the line by increasing the electrical resistance. Therefore, we must consider the temperature in the wire as to be not much above that of the surrounding atmosphere. It may seem unnecessary to dwell upon this point, but there appears to have been but little consideration given to it. Sir William Thomson even, in a hasty speech before the Institution of Civil Engineers, when this subject was under discussion in 1878, says: "The most practical way would be to put the wire in the shape of a copper tube. Having a copper tube, with a moderate amount of copper in its sectional area, and a current of water flowing through it, with occasional places to let it off and places to allow water to be admitted for the purpose of cooling, there would be, without any injury to the insulation, a power of carrying heat practically unlimited." One does not always have the good fortune to catch so great a philosopher tripping, but this statement has been so often quoted to me that I am compelled to point out that the heat carried away by the water is work carried away and lost (unless we use the water in our dwelling houses or in some equivalent way). Further, such a loss does not compensate in any equivalent gain; for, calcu-

12

lating the heating effect as work and as taking place in the circuit proportionally to the resistance of the various parts of the circuit, we cannot afford to lose heat (beyond a necessary quantity) in the inactive or line circuit.

It is requisite, then, to determine the emissive rate for the wire in question, and afterwards to ascertain the current that will generate only that quantity of heat the wire can emit under usual atmospheric conditions.

A thousand feet of the wire under consideration—and the consideration of a thousand feet will, for the same current, be the same as for a thousand miles—will have an emissive surface of 38,100 square centimetres. I have determined, by rough experimental means, although with sufficient accuracy for the purpose, the loss of heat from new and from old galvanised iron wire, and the results I have obtained differ, as far as I have carried my experiments, but little from those obtained for copper surfaces as described by Mr. D. M'Farlane in the *Proceedings* of the Royal Society for 1872 (p. 93). It may for all practical purposes be taken, for between 30° and 60°C. differences of temperature of the wire and the surrounding atmosphere, that ·0003 unit of heat is lost per second per square centimetre of surface for each degree of difference of temperature. The surface of the 1,000 feet of wire will, therefore, have an emission of 11·43 units of heat per degree of difference, and assuming the atmosphere at 64°F., or say 18°C., we may take conveniently a difference of 30°C., bringing our wire to a temperature of 48°C., or say 118°F. This will give us a rate of emission (including surface conduction) for heat of 343 units of heat a second; in other words, there is that quantity of heat emitted sufficient in one second to heat 343 grammes of water 1°C.

The specific heat of iron is, nearly enough for our purpose, 0·1—that is, an equal weight of iron would require one-tenth of the heat necessary to raise the same weight of water to a given temperature. As 343 units of heat (gramme-degrees) is represented by 11·43 grammes of water raised 30°C., the same quantity of heat would raise 114·3 grammes of iron to the same temperature.

But in the 1,000 feet of iron wire are 29,750 grammes of metal, therefore there are required 89,313 gramme-degrees to raise this wire to 30°C. above its normal or atmospheric temperature, and to maintain this temperature against the loss of heat by emission and surface conduction.

This wire has a resistance of 3 ohms, and we have to find what current in webers will produce on this resistance the required quantity of heat. We have the well-known simple equation $0·2406\ C^2 R = H$; and having H given as 89,313 and R as 3, we find $C = 353$ webers.

The conclusion has been arrived at, by a somewhat round-about process it is true, that a common telegraph wire of No. 8 B.W.G. will convey a current of 350 webers with perfect safety and without appreciable heating effect.

A NOTE ON EXNER'S PAPERS ON CONTACT ELECTRICITY.

BY PROFS. W. E. AYRTON AND J. PERRY.

Electrician Mar 20 1880

The authors' attention was drawn to Prof. Exner's papers about a year ago by Prof. Fleeming Jenkin, but on reading them it did not seem necessary to answer them. Finding now, however, that they have been translated and reprinted several times, and that they are calculated to mislead, it has been thought well to bring a criticism of them before the society. Starting from Thomson's (or Joule's) well-known theory that the heat of combustion, due to the chemical actions going on in a cell, represents the E.M.F., Exner states that the difference of potential between zinc and its oxide, which he calls 2 E, is measured by the heat due to oxidation of zinc. If, now, a non-oxidisable metal, say platinum, is brought into metallic connection with the zinc there is no difference of potential between the zinc and platinum, the platinum takes part of the charge of the zinc, and the difference of potential between the platinum and the oxide of zinc becomes E. And from this it follows that the difference of potential between two metals in contact in air is measured by half the difference of their heats of combustion in oxygen. To show that his reasoning is correct, Exner has made experiments on three contact differences of potential, which agree very remarkably with the theory. The authors first consider Exner's theory, and show that, even if they allowed the first assumption, the reasoning disregards what is known of the laws of electricity, for Exner does not assume a constant difference of potential between zinc and its oxide since this begins at 2 E and ends with E; neither does he assume a constant quantity of electricity in the oxide, for in that case his last difference of potential would depend altogether upon the condensing arrangements employed in the experiments. So that Exner has simply assumed what a casual reader might think he had proved, viz., the above statement as to half the difference of heats of combustion. But if the statement agrees with experiment, Messrs. Ayrton and Perry showed that it might be regarded as a most important empirical law. Now, Professor Hoorweg has shown in a paper in *Wiedemann's Annalen* that Exner's experimental results are in complete disagreement with those of Kohlrausch, Hankel, and Ayrton and Perry, and gives the following table:—

	Kohlrausch.	Hankel.	Exner.	Perry and Ayrton.
Zn | Pt	0·984	0·984	0·881	0·981
Cu | Pt	0·184	0·184	0·367	0·238
Fe | Pt	0·384	0·312	0·704	0·369

So that, although Exner gives as his reason for his making the above experiments, that the results of all experimenters since Kohlrausch's time are isolated and unreliable, it would seem that the consistency of these three series of determinations with each other, and their inconsistency with his new measurements are such as to make us reject his statement even as an empirical law. The authors then take up Exner's crucial experiment, to show that two plates of silver, one in an atmosphere of chlorine and the other in an atmosphere of oxygen, but in metallic connection with one another, show a difference of potential. They point out that if this experiment had been properly performed it would have corroborated the result arrived at by Mr. Brown of Belfast, which in no way contradicts the contact theory, since every adherent of the contact theory recognises a difference of potential between a metal and an oxide or chloride or any other salt of the metal, either in the wet or dry state. But Exner's experiment was carelessly performed, as instead of a metallic contact between a platinum wire used in the experiment and the silver plates there must have been a layer of chloride of silver between the metals.

In another of Exner's papers he states that the contact theory requires the E.M.F. of a Smee's cell to be at first 0·732 Daniell, and then to become less, and that the E.M.F. depends on the negative metal; whereas the chemical theory gives a much greater E.M.F. at the beginning if the liquid is oxygenated, and it can never become less than 0·732 D if zinc is prevented from being deposited on the negative metal. Many previous experimenters had proved that the latter statement is the true one, and its truth is shown by Exner's new experiments, which further show that whatever be the negative metal the E.M.F. must be the same. The authors point out that Exner's statement as to what the contact theory requires in a Smee cell is quite gratuitous, and indicates that he is not at all acquainted with the contact theory; they show that the sum of the contacts for a Smee cell published by them in the *Transactions* of the Royal Society, gives an E.M.F. greater than that of a Daniell. They quote also from Sir W. Thomson's well-known paper in the *Phil. Mag.* of 1851 as complete a statement of what goes on in a Smee cell; of its primary E.M.F. being as much as 2½ Daniell's; of its *working* E.M.F. being what Exner says it is; as if Exner and all his predecessors' experiments on Smee's cell had been perfectly well-known to Thomson thirty years ago. Thomson, however, did not know that the nature of the negative metal is indifferent. This appears to be the only new fact given us by Professor Exner, but unfortunately for him it has been disproved by the more careful experiments of Beetz, who gives the following results for various

13

THE TELEGRAPHIC JOURNAL AND ELECTRICAL REVIEW.

Vol. VIII.—No. 182.

33

THE BRITISH ASSOCIATION MEETING.

The address of Professor A. C. Ramsay, the President of the British Association, although a masterpiece of its kind, was hardly one to excite general attention, the scope of the subject (geology) being necessarily narrow. The address of Professor W. G. Adams, the President of the Mathematical and Physical Section, was of a different nature, and is one likely to prove of considerable interest to scientific men generally. Departing from our usual course, therefore, we do not propose to give Professor Ramsay's address, but to give that of Professor Adams' at length, as follows:—

It has been said by a former President of this Section of the British Association, that the President of a Section ought to occupy your time, not by speaking of himself or his own feelings, but by a review, "more or less extensive of those branches of science which form the proper business of this section." He may give a rapid sketch of the progress of mathematical science during the year, or he may select some one special subject, or he may take a middle course, neither so extensive as the first nor so limited as the second.

There are many branches of science which have always been regarded as properly belonging to our Section, and the range is already wide; but it is becoming more and more true every day that the sciences which are dealt with in other sections of the Association are becoming branches of physics, *i.e.*, are yielding results of vast importance when the methods and established principles of physics are applied to them. I wish to direct your attention to investigations which are being made in that fertile region for discovery, the "border land" between chemistry and physics, where we have to deal with the constitution of bodies, and where we are tempted to speculate on the existence of matter and on the nature of the forces by which the different parts of it are bound together, or become so transformed that all resemblance to their former state is lost. It is not long since the theory of exchanges became thoroughly recognised in the domain of radiant heat, and yet it is already recognised and accepted in the theory of chemical combination. Just as the molecules of a body which remains at a constant temperature are continuously giving up their heat motion to surrounding molecules, and getting back from them as much motion of the same kind in return, so in a chemical compound which does not appear to be undergoing change, the combining molecules are continuously giving up their chemical or combining motions, to surrounding molecules and receiving again from them as much combining motion in return. We may say that each molecule is, as far as we can see, constantly dancing in perfect time with a partner, and yet is continuously changing partners. When such an idea of chemical motion is accepted, we can the more easily understand that chemical combination means the alteration of chemical motion which arises from the introduction of a new element into the space already occupied, and the consequent change in the motion of the new compound as revealed to us in the spectroscope. We can also the more readily understand that in changing from the old to the new form or rate of motion, there may be a development of energy in the shape of heat motion which may escape or become dissipated where a means of escape presents itself. We know from the experiments of Joule and of M. Favre that as much heat is absorbed during the decomposition of an electrolyte as is given out again by the combination of the substances composing it.

We are making rapid strides towards the exact determination of those relations between the various modes of motion or forms of energy which were so ably shadowed forth, and their existence established long ago, by Sir William Grove in his Correlation of the Physical Forces, where, in stating the conclusion of his comparison of the mutual interchange of physical forces, he distinctly lays down the principles of energy in this statement, "Each force is definitely and equivalently convertible into any other; and where experiment does not give the full equivalent, it is because the initial force has been dissipated, not lost, by conversion into other unrecognised forces. The equivalent is the limit never practically reached."

The laws of Faraday, that (1) when a compound is electrolysed the mass of the substance decomposed is proportional to the quantity of electricity which has produced the change, and that (2) the same current decomposes equivalent quantities of different substances—*i.e.*, quantities of their elements in the ratio of their combining numbers, have given rise to several determinations of the relation between chemical affinity and electromotive force. In a paper lately communicated to the Physical Society, Dr. Wright has discussed these several determinations, and has given an account of a new determination by himself. The data at present extant show that when 1 gramme of hydrogen unites with 7·98 grammes of oxygen there are about 34,100 units of heat given out, making the latent heat of dissociation of *1 gramme of water equal to 3,797 units.* The results obtained are compared with the heat given out by the combustion of hydrogen and oxygen, and the value of the mechanical equivalent of heat is deduced from these determinations.

The value of this mechanical equivalent obtained by Dr. Wright, which depends on the value of Clark's standard cell, and, therefore, depends upon the value of the ohm, agrees fairly well with Joule's determination from the heat produced by an electric current in a wire, but is greater than Joule's value as obtained from his water-friction experiments. This may be accounted for by supposing an error in the value of the ohm or B.A. unit, making it too large by 1·5 or 2 per cent. Kohlrausch has also made comparisons of copies of the B.A. unit with standard coils, and comes to the conclusion that the B.A. unit is 1·96 per cent. too large. On the other hand, Professor Rowland, in America, has made a new determination, and finds that according to his calculations the B.A. unit is nearly 1 per cent. too small. These differences in the values obtained by different methods clearly point to the necessity for one or more new determinations of the unit, and I would venture to suggest that a determination should be made under the authority of this Association, by a committee appointed to carry out the work. And it is not sufficient that this determination should be made once for all, for there is reason to think that the resistance of standard coils alters with time, even when the material has been carefully selected. It has been found that coils of platinum silver which were correct copies of the standard ohm

14

WHAT IS ELECTRICITY?

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My letter to you of the 30th September was written with the object of getting Mr. Gordon to enter into a correspondence about the assertion in his book, "The cushions are connected with the ground so that the negative electricity produced on them can escape." His reply in your issue of the 16th October was virtually a refusal to enter into correspondence, but I am glad to find through his letter in your issue of 30th October that he has changed his mind, and has admitted that the passage in question is wrongly worded, and that he will amend it in the next edition of his book. This is just as it should be. An experimenter in, and writer on, science is looked upon as a false guide if he does not make the attainment of scientific truth the mainspring of his actions. Now that Mr. Gordon is following in the right course, it is interesting to trace his views as to what he does regard as being the truth. The change he proposes to make in the second edition of his book on the above quoted passage is to remove the word "escape," and substitute for it the word "disappear." This proposal proves that Mr. Gordon is mentally in a state of great darkness as to wherein the passage is wrong. The error lies in his assumption, according to Dufay's two-fluid theory and Faraday's two-force theory, that there is formed on the cushions negative electricity, which is either to "escape" or "disappear" by a connection being made with the ground. This is wrong, the cushions take electricity from the ground, then deliver it to the glass, and the glass transfers it to the prime conductor. It is one electric fluid which passes through the machine. It is amazing that Mr. Gordon does not see that the passage in question commits him to Dufay's two-fluid or Faraday's two-force theories. The passage in question is far from being the only one in his book which commits him to being an upholder of one or other of these duplex theories, which are both wrong.

Again, Mr. Gordon writes in his last letter to you, "Let us attach a wire from the rubbers to the knob of a positively charged Leyden jar. Then, when we work the machine, the positive charge will be diminished. We may either say that some of the positive electricity has been drawn up the wire, or that negative has flowed down it, and neutralised some of the positive. We have no means whatever of distinguishing which is the correct view." If Mr. Gordon had read with attention your reprint of my letter of 1839, he would have seen that there was pointed out therein the means of determining the direction of a current of electricity. I shall now describe it more minutely. Let Mr. Gordon insulate a friction electrical machine entirely by placing vulcanised india rubber or blocks of paraffin wax below the base of it, and clothe the handle of it entirely with vulcanised india rubber. This will conserve all the electricity collecting power of the machine. Let him now take a copper wire from the rubbers to the ground, or still better to the water-pipe of his house. Let him now cut this wire in two near the machine, and place a small brass ball on each end of the wire where cut. Let him now adjust the two balls so that the distance between them is such as lets the electricity pass easily from the one to the other when the machine is in motion. Let him now place between these two brass balls a flame of gas well insulated by passing through a glass tube, and let the flame be free from smoke. If the size of the flame is properly adjusted so that the current of electricity has full power over the flame, he will find that whenever he sets the machine in motion and keeps it moving steadily the flame will bend down in one direction, and will never fluctuate backwards and forwards as a pith ball would do, but, on the contrary, it will always bend down in one direction, and this direction indicates the direction in which the current of electricity is moving. A pith ball is deceitful because it takes on a coating or charge of electricity, and therefore dances backwards and forwards. The insulated gas flame cannot receive a coating or charge of electricity, and therefore it does not fluctuate in its movements. Mr. Gordon will find it utterly impossible to get the insulated gas flame to indicate that a current of electricity ever goes from the rubbers to the ground. The flame always indicates that the current of electricity goes from the ground to the rubbers.

This establishment of the fact that no negative electricity accumulates on the rubbers requiring to be allowed to "escape" or disappear, demolishes Dufay's theory of two fluids and Faraday's theory of two forces.

There are some other very important matters in Mr. Gordon's last letter, but at present I refrain from making comments on them, because it is best in controversy to exhaust one subject before going to another. Will Mr. Gordon try the experiment of the gas flame and let you know if he can get it to indicate that a current of electricity goes from the rubbers to the ground?—Yours, &c.,

JAMES JOHNSTONE.

Craiglockhart Hydropathic, near Edinburgh, Nov. 9, 1880.

1839? = Sept. 30?

15

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SOMMAIRE

33

DES FORCES ÉLECTRO-MOTRICES

DE CONTACT DANS LES ACTIONS VOLTAIQUES

On doit se rappeler la discussion fameuse qui s'éleva au commencement de ce siècle entre Galvani et Volta et qui eut pour dénouement la découverte de *la pile voltaïque*. On sait que Volta, ne voulant pas admettre que l'électricité dégagée dans l'expérience de Galvani fût d'origine animale (*le fluide galvanique*), montra que les mouvements de contraction de la grenouille devaient surtout être rapportés à ce que l'arc métallique qui réunissait les nerfs lombaires aux muscles de l'animal, dans cette expérience, était *composé de deux métaux différents*. De *ce contact* devait résulter, suivant lui, la création d'une force à laquelle il donna le nom *de force électro-motrice* qui devait provoquer un dégagement électrique capable de produire les effets de contraction observés, du moins, quand on venait à provoquer la décharge à travers l'animal, en réunissant métalliquement deux parties de son corps susceptibles d'excitation électrique. Cette opinion fut combattue par les partisans de Galvani, et c'est alors que, pour convaincre ses adversaires, Volta entreprit ses célèbres expériences qui le conduisirent à la création de sa pile. Après cette découverte, l'opinion de Volta fut généralement admise, et elle prédomina pendant plus de trente ans; mais la découverte de *l'électro-chimie* et les expériences remarquables de MM. Becquerel et de la Rive ouvrirent un autre champ aux hypothèses, et on prétendit bientôt que ce n'était pas le contact physique de corps hétérogènes qui provoquait dans la pile de Volta, le dégagement électrique, mais simplement les actions chimiques qui y étaient en jeu, et surtout *l'oxydation du zinc*. Dès lors, on voulut supprimer le mot *force électro-motrice* qui rappelait trop la théorie de Volta, et pendant quelque temps on regarda comme *retardataires* ceux qui employaient encore cette expression, même en admettant la théorie électro-chimique. Toutefois, certains physiciens, surtout en Allemagne, ne furent pas convaincus, car il y avait bien des cas où la théorie électro-chimique était en défaut. Ainsi, par exemple, comment pouvait-on expliquer, dans cet ordre d'idées, cette expérience qui montre que du zinc chimiquement pur n'est attaqué dans l'eau acidulée que quand il est électrisé positivement?... Si l'action *chimique* était, dans cette expérience, *la cause déterminante*, l'oxydation du zinc devrait *précéder le dégagement électrique et non en être la conséquence*. Cette expérience et beaucoup d'autres encore, montrèrent qu'il fallait rechercher ailleurs, sinon la cause principale, du moins *l'action déterminante*, et l'on se trouva conduit à admettre, comme Volta, que cette cause déterminante ne pouvait être autre que celle résultant du contact physique des corps hétérogènes, mis en présence dans la pile, contact que l'action chimique pouvait renouveler sans cesse et dont l'effet pouvait être rendu *continu* par cela même. On put aussi, par cette hypothèse, rendre à l'action chimique le principal rôle, en faisant remarquer qu'elle se trouvait surexcitée alors par l'action électrolytique résultant du passage du courant.

Une fois lancé dans cette voie, on dut reprendre naturellement la désignation de *force électro-motrice* donnée par Volta et adoptée par Ohm, et des expériences pour mesurer cette *force électro-motrice de contact* furent entreprises dans les différents pays avec un succès plus ou moins grand. Toutefois, beaucoup de physiciens ne sont pas encore convaincus,

Confidential," but the injurious effect such "news" [illegible] cable property leads us to say that for more [illegible]lve months we have had before us a prospectus marked "The American Cable Company of New York." This prospectus states that "the system of cables will start in America from New York, and extend to the island of Flores, &c." It also states that the Company will have the "Exclusive use of new apparatus, which will double the working speed, &c."

It is impossible to read these extracts and compare them with the *Standard* telegram without suspecting the concoctors of sinister designs upon the share market.

CORRESPONDENCE.

WHAT IS ELECTRICITY?

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Now that Mr. Johnstone has sent to you a scientific argument I am delighted that we should discuss the question with, I hope, that mutual benefit which seldom fails to follow the exchange of ideas on scientific subjects.

I will first point out that all through my book I have been most careful not to say anything committing myself to the theory of one fluid or of two. I think either would explain most electrical phenomena equally well, and that there is absolutely no proof of the truth of the one or the other, or of either. They are both merely convenient conventional ideas to assist us in describing phenomena which we cannot explain.

I know, however, the danger of using these sort of conventions, as the mind is very apt, after a time, to cease to distinguish between what is known experimentally, and what is assumed provisionally as a convenient method of simplifying our language when describing any unexplained phenomenon.

I, therefore, deeply regret it, as appears from "J. L.'s" letter, I have led any student into error by what I must confess was a somewhat careless expression. I can only plead in extenuation that I believe it is the only passage in my book which commits me to either theory.

I propose, therefore, in the next edition, to alter the sentence as follows. Instead of "that the negative electricity produced on them may escape," I will write, "that the negative electrification produced in them may disappear." I think that with this correction the passage will be as accurate as our present knowledge of the science permits.

If we assume the ideas of one or two fluids to be theories, and not mere conventions, we may "prove" either by experiment as follows:—Let us attach a wire from the rubbers to the knob of a positively charged Leyden jar. Then, when we work the machine, the positive charge will be diminished. We may either say that some of the positive electricity has been drawn up the wire, or that negative has flowed down it and neutralised some of the positive. We have no means whatever of distinguishing which is the correct view.

Let us suppose a balance placed in an inaccessible room, where we cannot see it, but having a pointer fixed to an axle passing through the wall. Then, if that pointer moves, we know that a difference has been made in the weights in the two pans, but we have no means of knowing whether the difference has been caused by the taking out of weights from one pan or by the adding of weights in the other. And, further, if instead of a pointer attached to the axis, there was a cog-wheel working into a rack carrying an index, then, as that index moved up or down, we should know that the beam of the balance was moving, but if we did not know on which side of the cog wheel the rack was placed, we should not know which direction of motion of the index corresponded to a given motion of the balance; although, if we had to speak much about it, we should probably call one motion of the index the positive motion, and the other the negative.

Similarly, in electrical phenomena, no doubt all manner of beautiful and complex actions take place in conductors carrying currents, but, alas, they are like the balance in the closed room, and we can only (as yet) see the few simple motions of the index.

I have said "I do not know the direction of the flow, or even if it has a direction at all."

When two conductors of different potentials are connected by a wire, the potentials commence to equalise themselves, and as long as this equalisation is going on the wire exhibits certain properties. It is heated, but if of even resistance it is heated equally all along, we cannot say the heating begins at one end or the other. It exhibits certain electrical and magnetic properties, but we cannot say that they are produced at one end sooner than they are produced at the other,* and here I think our actual knowledge ends. When two differently electrified bodies are brought to the same state of electrification by connecting them by a wire, we say that there has been a flow of electricity along the wire, because, *assuming that electrification is produced by an excess or defect of a fluid or fluids*, then an equalisation of potentials similar to what does actually take place would be produced if a portion of this fluid had passed along the wire.

When I was a student in Professor Clerk Maxwell's laboratory I remember his trying an experiment to see if an electric current was a flow of anything having inertia. He revolved a coil of wire, carrying a current, rapidly round the axis of the coil, and then stopped the motion suddenly, and looked for an extra current, but got no effect.

Lately Professor Boltzmann has indicated a possible method of determining the direction of flow, but, as far as I remember, he got no conclusive result. I have not his paper by me at this moment, but will send you a note of it later on.

We now come to Mr. Johnstone's experiments, but I fear that, however ingenious they are, they are hardly conclusive.

Firstly, I understand Mr. Johnstone to consider that because a shock can be obtained from a Leyden jar, whose coatings are charged to two different positive potentials, there cannot be negative electricity.

This is nearly equivalent to saying that because the number 10 is the difference between 5 and 15, that it cannot be the difference between + 5 and − 5. All shocks, and other similar phenomena, depend on the sudden connecting by a conductor of bodies electrified to different potentials. A given difference of potential will produce the same effect whether the potentials themselves are high or low. For instance, the effect produced by connecting two electrified bodies whose potentials differ by 2 would be exactly the same whether the potentials were 100 and 102, + 1 and − 1, or − 100 and − 102. As an experimental illustration of this, let a battery be connected to a galvanometer, and both placed on an insulating stand and the deflection noted. The deflection depends on the difference of potential between the poles of the battery. Let now the whole system be electrified either positively or negatively to any extent, say by connecting a wire from a machine to the fluid of the battery. The deflection will remain unchanged, showing that it depends on the difference of the potentials, and not on the potentials themselves.

The earth is arbitrarily chosen as the zero of potential, and bodies of lower potential than it are said to be negatively electrified.

Secondly, the experiments with the gas flame give us some interesting information as the action of charged conductors on particles of heated air or gas. Under certain circumstances, depending on the potential of the flame, there is attraction, and under others a repulsion, but I fail to see how this affects the question of the direction of the flow of electricity. How do we know that the motion of the gas particles is the same as that of the electricity? We *might* as well attempt to deduce the direction and speed of flow of a river from the motion of waves on its surface.

If Mr. Johnstone's view is correct we could determine the velocity of an electric current by putting an anemometer in the stream of heated air coming from the attracted or repelled gas flame.

Thirdly, "the tinfoil is unnecessary." Certainly. The only essential parts of a Leyden jar are two electrified surfaces and an insulator to separate them. It does not in the least matter whether the charges are spread over the surfaces of the glass by charging every part of it, or by sheets of tinfoil, or, as was probably the case in the experiment quoted, by films of moisture.

Fourthly, electricity will pass through glass. It passes through all substances in inverse proportion to their resistances. The resistance of glass at 200°C. is, roughly speaking, about 300,000 times that of water at 22°C. I do not quite see, however, what conclusion as to the existence or non-existence of one or two fluids can be drawn from this fact.

In my "Electricity," in my "Four Lectures on Induction," and in a lecture delivered at the London Institution (*Electrician*, Jan. 31, 1880), I have put together accounts of such facts as are actually known about the state of insulators across which electric actions are taking place. With regard to the state of conductors we have no knowledge whatever. A few years ago

* I am aware of Wheatstone's experiment with the revolving mirror and the three sparks, but I think electricians are agreed that the retardation is simply due to the gradual charging of the condenser, consisting of the wire and its insulator, as it does not give any real information about the direction of flow.

SATURDAY, MARCH 4, 1882.

ELECTRIC CONDUCTION AND DISCHARGE.

By F. E. UPTON.

The question of the nature and the vehicle of the electrical discharge is an important one, and its determination will contribute greatly to the solution of many interesting problems in cosmical physics. It is desired in this article to call attention to some recent advances that have been made in this direction.

The view that the phenomenon is one of pure conduction, though it has received the attention of eminent physicists, can be said to be no longer entertained.

When a conductor is made to connect two poles or electrodes which are at a different potential, it is well known that the greater the cross section of the conductor, or in other words, the more of the conducting material there is laid bare by a cross section, the *less* resistance will be offered to the union of the electricities of the two terminals, and the greater will be the ensuing current, with a given E. M. F.

Now, in the discharge, the contrary is observed directly. This characteristic of conduction is absent when the discharge takes place; in a tube containing air, the greater the pressure (above a certain inferior limit), or the more of the conducting material there is laid bare by a cross section, the *greater* will be the resistance to the passage of the spark, and the nearer together the terminals will have to be brought to effect a spark with a given difference of potential. Sir Wm. Snow Harris, in 1834, made an attempt to grasp at the law governing the relation of the length of spark to pressure; and he then stated that the length of spark is in the simple inverse ratio of the pressure. Gordon, in 1878, made a series of experiments to test this law, (Elec. and Mag. II. 55-62). He found that from a pressure of about eleven inches to that of the atmosphere, Harris's law held approximately good.

Representing resistance by r, and matter laid bare by cross section by s, in the case of conductor $r = \frac{1}{s}$; in the case of discharge $r = s$, approximately. Thus there is in question two entirely different order of phenomena.

Another distinctive characteristic of conduction will be recognized in the fact that whenever there is any conductor at all, however small and however long it may be, connecting two poles, some degree of current will flow, as long as there is any difference of potential. With discharge, however, a certain lower limit of distance apart of poles, and of interposed matter, is requisite for any current at all, and when that limit is reached the spark passes, instantaneously, and the discharge commences.

Whether the current passes by conduction or discharge, heat is equally developed; in the conductor in the one case, and in the interposed matter in the other. This common development of heat does not in any way assimilate the two phenomena. The condition of affairs in the two cases will perhaps become obvious if recourse is had to the corresponding hydraulic analogy.

Imagine a pond of water held in place by a dam, with a pipe leading from the bottom of the dam, for the purpose of drawing water from the pond. The smaller that pipe is in section, the smaller will be the current of water flowing through it under a given head, and a certain amount of heat will be developed by friction of the water against the interior of the pipe; moreover some degree of current will flow as long as the pipe has any size of cross section at all. That corresponds to conduction. Now let the pipe be imagined closed to the exit of water; as long as the dam is sufficient, no current at all will flow; but suppose the dam be diminished in thickness gradually and constantly, a point will be eventually reached when it will no longer suffice to hold back the water, which will break through the impediment; the friction of the water against the fragments of the dam, and of those fragments against each other will develop heat as in the first case. That corresponds to the discharge.

By this analogy the difference between conduction and discharge is clearly apparent. A conductor between two points at a different potential never offers any *resistance* to the passage of the current, strictly speaking. Instead of saying that a slender wire offers more resistance than a thick one, it would give a better understanding of the matter to say of the latter that it offered a freer passage to the current than the former. In the case of discharge, on the contrary, the matter interposed between the points acts always as a bar, or resistance to be overcome, and the more there is of it the more resistance. It is never an aid or way.

Mr. E. Goldstein, in the *Annalen der Physik*, describes an ingenious experiment bearing upon this point, which, if not conclusive, is entitled to some consideration. In a discharge tube which was filled with dry nitrogen, he placed a little sodium, which could be vaporized by heating. The positive light had a purplish red color, but in the vicinity of the sodium it was of a golden yellow. By careful heating and manipulation, the upper half of the tube could be kept red and the lower half yellow. Now the tube was brought over and near, in a horizontal and equatorial position, to a powerful magnet. The discharge light was repelled as a slender thread to the opposite (upper) side of the tube; but it was a pure reddish thread, and showed no trace of sodium yellow. So the sodium was not displaced or repelled under the influence of the magnet, as it would have been had it been a *conductor* of electricity.

There has been considered the possibility that metallic particles thrown off from the electrodes might be the conductors of the current. To determine if this were the case, Mr. Goldstein made use of a tube with platinum electrodes, in which the light from the kathode was deflected by a second kathode. The light alone underwent this deflection, while the minute particles torn off from the platinum, which lodged on the opposite wall of the tube and formed a sort of mirror there, went exactly to the same point after the deflection of the light, as before. There was thus no connection between the light of discharge and the abraded metallic particles.

But the most elegant demonstration in this matter has been furnished by the experiments of De La Rue and Müller: they arranged that the discharge of 2,400 chloride of silver cells should pass through a circuit consisting of a vacuum tube and a large variable resistance, R; now with different resistances R_1, R_2, the resistance of the vacuum tube formed a varying fraction of the whole resistance; and, according to Ohm's law for the fall of potential along a conductor, the fall of potential along the vacuum tube should have been variable, had its function been that of a conductor. It was found in fact, however, that the fall of potential along the tube remained constant, no matter what resistance was introduced in the remaining part of the circuit between the poles of the battery, showing that the discharge was not a case of true conduction, but that even at the lowest pressure it was disruptive.

ELECTRIC CURRENTS.—Professor Sylvanus Thompson, of Bristol, delivered a lecture on February 22, at the Crystal Palace, on "Electric Currents: What are they?" This lecture is the first of a series which the directors of the Palace have organised in connection with the International Exhibition of Electricity. The lecturer began with an enumeration of the multifarious services now rendered to mankind by the electric current. Yet, though its applications were endless, it was remarkable how little was known of its intimate nature. To understand the true nature of electric currents, or even of electricity itself, necessitated a wide range of study, the more careful because of the great variety in the different properties and phenomena. Electricity might remain in the form of "charges" on the surface of bodies, or might flow through their substance in continuous "currents." Yet it was not a material fluid, and the term "electric fluid" was now only used by those who knew nothing about modern investigations in the science. Nevertheless a study of the various properties of electricity, the attractions and repulsions it set up, the sparks to which it gave rise, the chemical decompositions it effected, the magnetic actions it produced, all led toward a certain theory, only to be grasped when all these diverging lines were traced back to their logical origin. It was a matter of congratulation that so many eager and able scientific men were now devoting themselves to this youngest of the sciences, more especially as it was preeminently a British science. Almost every great discovery in electricity had been made by Englishmen. From the time of Dr. Gilbert, who founded the science in 1600, Englishmen had been foremost in electric discovery. Stephen Grey discovered that electricity could be made to flow in currents through wires; John Canton discovered the influence exerted by electricity at a distance; Benjamin Franklin, the inventor of the lightning rod, was a Briton, though resident then in Philadelphia; Humphry Davy, the discoverer of the electric light; Spencer, the inventor of electro-plating; Faraday, the greatest experimentalist in electric science that ever lived, to whose fundamental discoveries modern dynamo-electric machinery may be directly traced; Ronalds, Cooke, and Wheatstone, the fathers of the electric telegraph, and Swan, the inventor of the carbon-filament lamp, were all Englishmen, while Graham Bell, the perfector of the telephone, was Briton-born. Not that some great discoveries had not come from other lands. Cuneus, a Dutchman, discovered the Leyden jar; Volta, an Italian, discovered the voltaic cell; Oersted, a Dane, discovered the relation between magnets and electric currents; Reis, a German, invented the first rude telephone by which articulate speech was transmitted; and Plante, a Frenchman, invented the storage-battery or accumulator. After referring to the relation between the power of electric currents and the power that is spent in producing them, Professor Thomson spoke of the certainty that in the near future all heavy mechanical work would be done by electric currents in the place of steam, a theme which will claim further attention in a subsequent lecture. Developing the question of the production of electric currents in voltaic batteries, the lecturer referred to the discovery that such batteries were reversible, and that in this reversibility lay the newly-discovered power of storing or accumulating electric energy in cells which could be charged and discharged at pleasure. The magnetic, thermal, and physiological properties of the electric current were illustrated experimentally, the lecturer remarking with much emphasis that the mistake of confounding physiological with medical or remedial effects led to the gross impositions of the quacks and rogues who deal in so-called magnetic appliances, and disgrace alike the sciences of electricity and of medicine, while knowing nothing of either. The nature of electric currents was reverted to, and an outline was given of the theory of Clerk Maxwell that all electric phenomena were due to actions going on in the thin medium that fills the whole universe—the æther—vibrations of which are light and heat, the accumulations of which are electric charges, the streams in which are electric currents, and which, where it was made to spin round in vortices or whirlpools, gave rise to magnetic attractions. In conclusion, the lecturer commented on the immense importance of the revolution now beginning in the substitution of electric machinery for steam engines, and urged that if England desired to reap the benefit of this impending reorganisation of the methods of mechanical production, if she desired that her workmen should rise to the immense future before them, she must not lose an hour in providing them with an education in matters electrical, seeing that a knowledge of electric currents and their properties will be of far more practical importance than a knowledge of any other branch of science. If technical education did not come in any other way, it would be forced upon us by the practical fact that electricity is to be our servant in the place of steam and of coal.

PROF. ROWLAND'S NEW THEORY OF MAGNETIC ACTION

PROF. ROWLAND has lately published in the *American Journal of Mathematics* (vol. ii., No. 4; vol. iii., Nos. 1 and 2) a series of papers on "The General Equations of Electromagnetic Action with application to a New Theory of Mag-

netic Attractions, and to the Theory of the Magnetic Rotation of the Plane of Polarisation of Light." The papers, in addition to what is stated in their title, contain the mathematical consideration of that action of magnetism on electric currents which was lately discovered by Mr. Hall, and it is proved in them that, if Maxwell's theory of light be true, this action will explain the magnetic rotation of the plane of polarisation of light. These papers will no doubt be very extensively read, both on account of the interest of their contents and the great reputation of their author, and a brief discussion of them may therefore not prove uninteresting to the readers of NATURE.

We shall commence with the "New Theory of Magnetic Attractions." This theory is of the simplest kind, and obviously suggested by the mathematics of the subject. Since the magnetic induction is related to the distribution of the vector potential of magnetic induction in exactly the same way as the angular rotation of an element of fluid is to the distribution of velocity in the fluid, Prof. Rowland suggests that the magnetic field consists of a perfect fluid, whose velocity at any point is represented in magnitude and direction by the magnetic vector potential at the point, the vortex lines in this fluid are the lines of magnetic induction, and the velocity of angular rotation, is proportional to the magnetic force. Again, since 4π times the electric current is related to magnetic induction in the same way as magnetic induction to the vector potential, Prof. Rowland considers that an electric current consists of, as it were, vortices of vortices, or in other words, that certain irregular distributions of the vortices constitute electric currents.

Maxwell has proved that the forces existing in the magnetic field could be produced by a certain distribution of stress in a medium filling the field. This stress in the simplest case consists of a tension along the lines of force equal to $\frac{H^2}{8\pi}$, along with a pressure at right angles to the lines of force equal also to $\frac{H^2}{8\pi}$, H being the intensity of the magnetic force.

Prof. Rowland goes on to show that this state of stress exists in the medium, which, according to his theory, fills the magnetic field; his proof is as follows:—"Conceive the fluid in a tube to be rotating around the axis with a certain velocity, and suppose the ends of the tube to be closed with movable pistons. Then, if the pistons are left free, there will be a centrifugal force against the sides of the tube proportional to the square of the velocity of angular rotation. If the walls are flexible and the piston immovable, then there will be a force tending to press the pistons in, and proportional also to the square of the velocity. According to our theory the magnetic force is the velocity of rotation, and so we have in the medium a tension along the lines of force and a pressure at right angles to them." Prof. Rowland does not seem to have noticed that this explanation requires the vortices to be of a finite size. It is easy to prove that in a cylindrical vortex of radius a, density ρ and angular rotation ω, the intensity of pressure on the circumference of the cylinder is greater than the mean intensity of pressure on the ends by $\frac{\rho\omega^2 a^2}{4}$; but if this is to explain the magnetic attractions the difference must be $\frac{H^2}{4\pi}$. Hence if $H = c\omega$, where c is a constant, we must have $\pi\rho a^2 = c^2$, $a = \frac{c}{\sqrt{\pi\rho}}$; we thus get a definite value for a, and the vortices must not be capable of division into bundles of smaller radius than a. Thus the fluid by which Prof. Rowland explains magnetic action cannot be the indefinitely divisible fluid treated of in theoretical hydrodynamics. It is worthy of remark that in the theory of magnetism put forth by Maxwell in the *Phil. Mag.* for 1861-62, and which agrees with the theory we are considering in explaining magnetic force by the angular rotation of a fluid, the vortices have a finite size, being done up as it were into cells, the space between the cells being filled with particles whose motion, according to Maxwell, constitutes electric currents.

Let us now go on to the explanation Prof. Rowland gives of the production of the magnetic field. He says: "Let the nature of electromotive force be such that it tends to form vortex-rings immediately round itself, not by action at a distance, but by direct action on the fluid in the immediate vicinity. The first ring will then move forward, another one will form, and so on until the whole space is filled with them, when there will be equilibrium." The consequences of this explanation, vague as it is, are somewhat startling. In the first place it is clear, from the properties of vortex motion, that every chain of particles of the fluid which possess rotation at any time must at some previous time have been in the immediate vicinity of the electromotive force; and since according to the theory there is rotation of the fluid at every point in the magnetic field, it follows that in the time taken to set up the field every particle of fluid in it has been in the immediate neighbourhood of the electromotive force. But magnetic disturbance is propagated, according to Maxwell's "Theory of Light" (which Prof. Rowland accepts), with the velocity of light; hence the streams of the fluid must be flowing with the velocity of light, and in addition every particle of fluid in the field must have rushed through the small space occupied by the seat of the electromotive force in the short time it takes to establish the magnetic field. Another difficulty which Prof. Rowland does not explain is the following: If we take a small element of electromotive force we know that to agree with the distribution of magnetic force all the vortex-rings must have the same sense of rotation; but if vortex-rings have the same sense of rotation they move through the fluid in the same direction, so that these vortex-rings when produced would all move off in the same direction, and thus leave one half of the field without rings, *i.e.*, without magnetic force. Again, the way in which these rings spread out so as to fill the field would seem to be in contradiction to the laws of vortex-motion; but as the author says he is investigating the dynamics of the subject, we may leave further comment on this point till the result of his investigation appears.

The explanation of the stress in the medium which we have referred to before is the only application of the theory worked out by Prof. Rowland. He does not explain by it any of the phenomena of induction, nor does he get from it any connection between statical and current electricity; yet he does not hesitate to speak of his theory "as one link in the chain, the first three links of which have been added by Thomson, Helmholtz, and Maxwell."

We must now leave this part of the subject and pass on to that portion of the paper which treats of the general equations of the electro-magnetic field. The mathematics of this is merely an application of the theory of the vector-potential to currents. The most important feature in the treatment of the subject is that Prof. Rowland always writes the product of the conductivity into the electromotive force instead of the intensity of the current, and claims that this is an important advance; but if there is any difference either Ohm's law must not be true, or Prof. Rowland must mean by electromotive force something different from that meant by ordinary users of the term. Prof. Rowland asserts that in an unlimited medium the action is not between magnets and currents, but between magnets and electromotive forces; he bases this assertion on the theorem that in an unlimited medium unclosed electric currents have no magnetic action. It is hard to see how this proposition can be true, for the current through any area is measured by the line integral of the magnetic force round the boundary of the area; but if the magnetic force is everywhere zero, then the line integral of it round any curve must vanish, and thus the current at any point must vanish. The proposition is based on reasoning of the following kind: the force between an electric point (by an electric point he means a point from which electricity is streaming, in fact what is usually called a source) and a magnetic pole must by symmetry be along the line joining them. But a magnetic pole of any size is always accompanied by one of the opposite sign, and the two form a vector quantity; and we think from the relation that one pole necessarily bears to another, it is not safe to reason about it as if it were a purely scalar quantity. Prof. Rowland himself acknowledges what is equivalent to this, for after saying that the force due to the unclosed currents on each pole of the magnet is zero, yet he says there is probably a force on the magnet as a whole tending to place it across the currents.

Although we think that the reasoning given for the assertion that the action is not between magnets and currents, but between magnets and electromotive forces, is unsatisfactory; yet we think that, understood in a certain sense, the proposition is mathematically true. For we can prove directly from the ordinary expressions for the magnetic action of currents, that if we have a source and a sink of equal intensities ($4\pi m$) placed close together, the magnetic action of the currents produced is

40

what strength the spring has got. Select a mainspring as near like the old one as you can. Some jobbers tell the strength by laying the spring on the first and second finger, and pressing their thumb on the middle, having the old one in one hand and the new one in the other. Then they reverse them. A gauge is easily made by two pieces of brass being riveted and soldered together (Fig. 31). First get width with your callipers, then thickness with Fig. 31. Having selected your spring, get length by old one; soften the outside end about an inch, file it, and make it weaker. Now taper the end and punch for rivet (see Fig. 31); now file up a piece of soft steel wire, size of hole in barrel; cut off inside after allowing for rivet; then place it in your pinvice and file up as shown (Fig. 32). Chamfer the inside of the hole in the spring; now place rivet in the vice. Put the spring on it; see that you have got it the right way; now with a small hammer keep tapping round the outside of the rivet. Don't touch the middle. As soon as it gets oval, file it flat. In this way you will make a good strong rivet. Leave it a *little* oval at the finish as a support to the outside; now cut off about the length required for the barrel—you can measure from the outside; file it level and polish the end. You can buy a mainspring winder for about 1s. 6d., but you can make a simple one (Fig. 33). Place the spring between your fingers, as shown in Fig. 34; put the winder between your fingers; when you have got it wound up, place your thumb upon it as shown (Fig. 35); pick up your barrel and put in spring. If you can't do it this way, you can do it by putting the outside end in its place in the barrel, and work it in, coil after coil ...

ENGLISH MECHANIC AND WORLD OF SCIENCE:

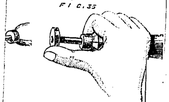
APRIL 7, 1882.

THE APPLICATIONS OF ELECTRICITY.*

I WILL endeavour, in two lectures, to review the principal applications of electricity, which you have seen working in the recent remarkable exhibition of the Palais d'Industrie. From a practical point of view we may divide electricity in two chapters: statical electricity, which is produced by friction; and dynamical electricity, which is obtained by chemical or by magnetical action. Statical electricity has so very few applications

FIG. 33.

FIG. 35



that I may almost pass it over in silence. I will only remind you that the old-fashioned frictional machines are now superseded by dielectric machines, such as Holtz's and Carré's. At the exhibition you may have noticed machines with several dozen plates turning simultaneously, and giving very powerful effects.

We will at once turn our attention to voltaic or dynamical electricity, which has received an endless number of applications, among the most important of which are telegraphy, telephony, and galvanoplasty, which will form the subject of my first lecture.

The source of electricity generally used in these branches of the science is chemical action. You remember that Volta's pile was composed of rounds of copper, wet cloth, and zinc, always piled up in

* Lectures delivered by C. DETAILLE, at the Palais du Trocadéro, Paris.

41

THE TIMES, THURSDAY, NOVEMBER 16, 1882.

SIEMENS ON ELECTRIC LIGHTING.

... meeting of the winter session of the ... was held last night in the rooms of the ... street, Adelphi, and there was a large ... scientific men to hear the address of Dr. ... newly-elected Chairman of the Council.

...ENS, who was warmly received on entering the ...m, took the chair, his address being read by his secre...y, Mr. Bamber. The address was devoted almost ...tirely to a consideration of the present condition ...nd future prospects of electric lighting. The two principal difficulties, Dr. Siemens said, which had always stood in the way of the practical introduction of the electric light were the cost of producing the electric current by means of a battery and the mechanical difficulty of constructing suitable lamps. The first of these difficulties had been disposed of by the dynamo-machine—a machine now so perfect that little advance could be expected in its construction. A well-constructed dynamo converts more than 90 per cent. of the mechanical force imparted to it into electricity, and 90 per cent. of this again can be utilized for the production of light. The margin of loss, therefore, does not exceed 20 per cent., excluding purely mechanical losses, and this is quite capable of being reduced to some extent by improved modes of construction; but it results from these figures that no great step in advance can be looked for in this direction. The dynamo-machine presents the great advantage of simplicity over steam or other power-transmitting engines; it has but one working part—namely, a shaft, which, revolving in a pair of bearings, carries a coil or coils of wire admitting of perfect balancing. Frictional resistance is thus reduced to an absolute *minimum*, and no allowance has to be made for loss by condensation or badly-fitting pistons, stuffing-boxes, or valves, or for the jerking action due to oscillating weights. The materials composing the machine—namely, soft iron and copper wire, undergo no deterioration or change by continuous working, and the depreciation of value is therefore a *minimum*, except where currents of exceptionally high potential are used, which appear to render the copper wire brittle. The essential points to be attended to in the conception of the dynamo-machine are the prevention of induced currents in the iron and the placing of the wire in such a position as to make the whole of it effective for the production of outward current. These principles, which have been clearly established by the labours of comparatively few workers in applied science, admit of being carried out in an almost infinite variety of constructive forms, for each of which may be claimed some real or imaginary merits regarding questions of convenience or cost of production. This fact, together with the public interest which had been aroused by the various displays of electric lighting, commencing with the illumination of the Place de l'Opéra in the year of the Paris Exhibition and ending with the recent exhibitions in Paris and at the Crystal Palace, had greatly encouraged the growth of companies for the purpose of introducing electric light. New companies for the purpose of introducing electric light and power had been announced almost daily, though their real claim to public attention as investments was based in some cases upon only very slight modifications of well-known forms of dynamo-machines, of arc regulators or of incandescent carbon lights, the merits of which rested rather upon anticipations than upon any scientific or practical proof. These arrangements were supposed to be of such superlative merit that gas and other illuminants must soon be matters simply of history, and hence arose the depreciation in gas shares caused by the premature announcement in 1878 of the accomplishment of the subdivision of the electric light by incandescent wire. It should be borne in mind, however, that any great technical advance is necessarily the work of time and of serious labour, and that when accomplished, it is generally found that, so far from injuring existing industries, it calls additional ones into existence to supply new demands, and thus gives rise to an increase in the sum total of our resources. It was therefore reasonable to expect that, side by side with the introduction of the new illuminant, gas lighting will go on improving and extending, although the advantage of electric light for many applications, such as the lighting of public halls and warehouses, of our drawing-rooms and dining-rooms, our passenger steamers, our docks and harbours, are so evident, that its advent might be looked upon as a matter of certainty. Commenting upon recent legislation on this subject, Dr. Siemens spoke favourably of the Electric Lighting Act passed last year, and seemed to think that the complaints now appearing in the papers that municipalities refuse their assent to applications by electric light companies for provisional orders were often not well founded. The authorities would clearly be justified in refusing any applications of a speculative character, and no licences or provisional orders should be granted unless the applicants could give assurance of being able and willing to carry out the proposed work within a reasonable time. The technical questions involved are hardly yet sufficiently understood to admit of immediate operations upon a large scale. The area that each lighting district should comprise varied according to the opinion of different witnesses before the recent Parliamentary Committee, from Dr. Siemens's own estimate of a quarter of a square mile to estimates suggested by others of as much as four square miles. In the case of gas, considering the unpleasant nature of the manufacture, it was necessary that the supply should range over a large area; in the case of electricity this did not apply, and for many reasons it might be desirable to limit the size of each district to that above-mentioned—a quarter of a square mile. Such is about the area of the parish of St. James's; and Dr. Siemens then proceeded to sketch out in some detail the arrangements which would be required for supplying this parish with a sufficient amount of the electric light. The number of incandescent lights required for a house of moderate dimensions might be taken as 100, the lights being from 16 to 18 candle power each. This is in effect the number of Swan lights employed by Sir William Thomson in lighting his house in Glasgow. Eleven-horse power would be required to excite this number of incandescent lights, and at this rate the parish of St. James's would require 3,018 multiplied by 11, or 33,200-horse power to work it. It might be fairly objected, however, that there are many houses in the parish much below the standard here referred to; but, on the other hand, there are 600 shops, involving larger requirements. Nor does this estimate provide for the large consumption of electric energy that would take place in lighting the 11 churches, 18 clubhouses, nine concert-halls, three theatres, besides numerous hotels, restaurants, and lecture-halls. A theatre of moderate dimensions, such as the Savoy Theatre, has been proved by experience to require 1,200 incandescent lights, representing an expenditure of 133-horse power; and about one-half that power would have to be set aside for each of the other public buildings here mentioned, constituting an aggregate of nearly 2,926-horse power. Again, this general estimate did not comprise street lighting, and to light the six and a half miles of principal streets of the parish with electric light would require, per mile, 35 arc lights of 350-candle power each. This, taken at the rate of 0·8-horse power per light, represented a further requirement of 182-horse power, making a total of 3,108-horse power, for purposes independent of house lighting, being equivalent to one horse power per inhabited house, and bringing the total requirements up to 109 lights, equal to 12-horse power per house. Dr. Siemens, however, could not agree with those who expect that gas lighting will be entirely superseded; on the contrary, he maintained that the electric light, while possessing great and peculiar advantages for lighting our principal rooms, halls, warehouses, &c., owing to its brilliancy, and more particularly to its non-interference with the healthful condition of the atmosphere, would leave ample room for the development of gas. Assuming, therefore, that the bulk of domestic lighting remains to the gas companies, and that the electric light is introduced into private houses only, at the rate of, say, 12 incandescent lights per house, the parish of St. James would have to be provided with electric energy sufficient to work (9+12) 3,018, equal to 63,378 lights, equal to 7,042-horse power effective; this is equal to about one-fourth the total lighting power required, taking into account that the total number of lights that have to be provided for a house are not all used at one and the same time. No allowance is made in this estimate for the transmission of power, which, in course of time, will form a very large application of electric energy; but considering that power will be required mostly in the daytime, when light is not needed, a material increase in the plant will not be necessary for that purpose. As a position for the engines and machines, Dr. Siemens suggested Golden-square. If the unoccupied area of the square were excavated and arched over to the present level, sufficient space would be provided. The cost of these works, including engine power and machines, might be estimated at £140,000, not including the conductors, &c. The size of the conductor is a most important consideration. Two things have to be considered—first the charge for interest on the original

cost and depreciation, and secondly the cost of the electrical energy lost by resistance. The sum of these two, as has been pointed out by Sir William Thomson, is least when the two components are equal, and thus we obtain the principle on which the size of the conductors should be calculated. Working on this principle, Dr. Siemens calculates that the proper size of conductor for the installation he is describing would be a rod of 8in. diameter. If the mean distance of the lamps from the station be assumed as 350 yards, the weight of copper used in the complete system of conductors would be nearly 168 tons, and its cost £15,120. To this must be added the cost of iron pipes, for carrying the conductors underground, and of testing boxes, and labour in placing them. Four pipes, of 10in. diameter each, would have to proceed in different directions from the central station, each containing 16 separate conductors of 1in. diameter, and separately insulated, each of them supplying a sub-district of 1,000 lights. The total cost of establishing these conductors may be taken at £37,000, which brings up the total expenditure for central station and leads to £177,000. It was assumed that the conductors would be placed underground, it being quite inadmissible, both as regards permanency and public safety and convenience, to place them above ground, within the precincts of towns. With this expenditure, the parish of St. James's could be supplied with the electric light to the extent of about 25 per cent. of the total illuminating power required. To provide a larger percentage of electric energy would increase the cost of establishment proportionately and that of conductor, nearly in the square ratio of the increase of the district, unless the loss of energy by resistance were allowed to augment instead. The statement that a conductor of such a size would be required to supply a single parish with electricity, might surprise many of the uninitiated who had heard of the suggested transmission of the energy of waterfalls over long distances by electrical means. In answering this question it had to be admitted that the transmission of electric energy of such potential (200 volts) as is admissible in private dwellings would involve conductors of impracticable dimensions, and in order to transmit electrical energy to such distances, it would be necessary to resort in the first place to an electric current of high tension. By increasing the tension from 200 to 1,200 volts the conductors might be reduced to one-sixth their area, and if we were content to lose a larger proportion of the energy obtained cheaply from a waterfall, we might effect a still greater reduction. A current of such high potential could not be introduced into houses for lighting purposes, but it could be passed through the coils of a secondary dynamo-machine, to give motion to another primary machine, producing currents of low potential to be distributed for general consumption. Or secondary batteries might be used to effect the conversion of currents of high into those of low potential, whichever means might be found the cheaper in first cost, in maintenance, and most economical of energy. It might be advisable to have several such relays of energy for great distances, the result of which would be a reduction of the size and cost of conductor at the expense of final effect, and the policy of the electrical engineer would, in such cases, have to be governed by the relative cost of the conductor, and of the power at its original source. If secondary batteries should become more permanent in their action than they are at the present time, they might be largely resorted to by consumers, to receive a charge of electrical energy during the day time, or the small hours of the night, when the central engine would be otherwise unemployed. The advantage of resorting to these means would depend upon the relative first cost, and the cost of working the secondary battery and the engine respectively. Working out on a similar scale the cost for the whole of London, and considering the amount of light which would be required in the richer and in the poorer districts, Dr. Siemens obtains the sum of £14,000,000, without any allowance for lamps or internal fittings. Going still further afield he finds that to extend the same system over the towns of Great Britain and Ireland would absorb a capital exceeding £64,000,000, to which would have to be added £16,000,000 for lamps and internal fittings, or a total capital of £80,000,000. Some might live to see this realised, but to find such an amount of capital, and, what was more important, to find the manufacturing appliances to produce work representing this value of machinery and wire, must necessarily be the result of many years of technical development. Dr. Siemens was, therefore, led to the conclusion that the applications now being made by electric light companies for provisional orders to supply electrical energy, not only to the towns of England, but to those of our colonies and abroad showed that their ambition was somewhat in excess of their power of performance. Turning then to the working charges of an establishment such as that above described, and assuming the 64,000 lights to be working for six hours a day, with coal at 20s. a ton, and the consumption 2lb. per effective horse-power per hour, this would come to about £18,000. Charges for wages, interest, depreciation, general management, &c., make a grand total annual charge of £41,000, or at the rate of 12s. 9½d. per incandescent lamp per annum. The cost of renewing lamps brings up the charge for each lamp to 21s. 9½d. for a year. The cost of burning gas in a good Argand burner, which would produce the same luminous effect, would be 20s., so that there is an evident balance of cheapness in favour of electric lighting. On the other hand the cost of establishing gas works would not exceed £80,000 as compared with £177,000 for electricity, so that it appears that, while it would be more costly to establish a given supply of luminous power by electricity than by gas, the former has the advantage as regards current cost of production. These calculations, however, being only based upon the present prices of gas, and not allowing for the large dividends paid by gas companies, cannot be looked upon as representing a permanent state of things. On the other hand, it is probable that electric lighting would be cheapened by resort to a larger extent to arc lights, and also by future improvements in the manufacture of incandescent lamps. Considering the two great sources for public lighting, Dr. Siemens came to the conclusion that the introduction of the electric light, even to the full extent he contemplated, would go hand in hand with an increase in the consumption of gas, and that the consequent competition could not fail to improve the quality and cheapen the supply of both greatly to the advantage of the public. As the light of luxury electricity must win, but gas will at the same time find an increasing application for the more humble purposes of diffusing light. In conclusion Dr. Siemens confirmed the remarks he made in his address last August to the British Association as to the future of gas. He thought that by the improved arrangement of the burners nearly double the amount of luminosity might be obtained, while at the same time the character of the light itself would be improved. Further, he believed, it would be advantageous for two qualities of gas to be supplied, one for heating and one for lighting. Such a general supply of heating separately from illuminating gas, by collecting the two gases into separate holders during the process of distillation, would have the beneficial effects—(1) of giving to lighting gas a higher illuminating power; (2) of relieving our towns of their most objectionable traffic, that in coal and ashes; (3) of effecting the perfect cure of that bugbear of our winter existence—the smoke nuisance; (4) of largely increasing the production of those valuable by-products, tar and ammonia, the annual value of which already exceeds by nearly £3,000,000 that of the coal consumed in the gas works.

After the reading of the paper, which was received with much applause by the crowded meeting, the chairman presented the following medals and prizes:—

The Society's silver medal for papers read before the Society during the last session.—To Professor Silvanus Thompson, D.Sc., for his paper on "Storage of Electricity;" to J. Emerson Dowson, for his paper on "The Production and Use of Gas for Purposes of Heating and Motive Power;" to Colonel G. F. Pearson, for his paper on "The Teaching of Forestry;" to Professor Barff, M.A., for his paper on "A New Antiseptic Compound, and its application to the Preservation of Food;" to Spencer Walpole, for his paper on "The Fish Supply of London;" to George F. Deacon, for his paper on "The Constant Supply and Waste of Water;" to Captain Richard F. Burton, for his paper on "Gold on the Gold Coast;" to R. Warington, for his paper on "Some Practical Aspects of Recent Investigation in Nitrification;" to S. G. Thomas and Percy C. Gilchrist, for their paper on the "Manufacture of Steel from Phosphoric Pig-iron;" to Alexander M. Chance, for his paper on "The Recovery of Sulphur from Alkali Waste by Schaffner's Process, a record of recent results;" to James Mylne, for his paper on "Experiences of an European Zemindar (landholder) in Behar." House sanitation competition.—The Society's silver medal.—To Sir Daniel Cooper, K.C.M.G., for the sanitary arrangements of his house, 6, De Vere-gardens, Kensington, W.; to Captain Charles Andrew, for the sanitary arrangements of his house, 286, Kennington-park-road, S.E.; to G. E. Mineard, for the sanitary arrangements of his house, 100, Philbeach-gardens, Kensington, S.W. Plant Label Competition.—The prize of five guineas offered through the Society by G. F. Wilson, F.R.S.—To A. J. Alment, for his improved label for plants.

SIR FREDERICK BRAMWELL said it was his privilege, as the late chairman of the Council, to move a hearty vote of thanks to Dr. Siemens for the valuable paper which had just been read. After congratulating the society upon having secured as chairman for this year one who had, in the application of pure science to the purposes of industry, so successfully carried out in his own practice the objects of this society, Sir Frederick Bramwell remarked that they had that evening had a paper devoted almost exclusively to one of the many objects of which Dr. Siemens was thorough master. Having briefly remarked upon some of the views put forward in the paper, he suggested with regard to the comparison drawn between the price at which gas and the incandescent electric light could be supplied to the consumer that it would not have been unfair to have made comparison with the more costly lights of luxury, the wax candles or lamps which many used in their sitting-rooms who would not use gas. In concluding, Sir F. Bramwell said it was a happy thing for the society that at this its 128th meeting it should have for chairman of council one so well able to promote its objects and to aid in the development of the arts and manufactures of this country. (Cheers.)

LORD A. CHURCHILL, in seconding the motion, remarked that he thought there was nothing in the papers which need place their friends the gas companies in trepidation. Whatever economy might be effected in the production of electric lighting, gas would still have its uses for heating and cooking purposes.

The vote of thanks was accorded with acclamation, and DR. SIEMENS, in acknowledging the compliment, said he had in his address endeavoured to trace out the conditions under which electricity and gas could be most advantageously distributed for practical purposes at the present time; and although he agreed with Sir F. Bramwell that conditions might arise which might alter greatly the principles upon which this was to be effected, yet there was a certain class of principles that were exceedingly stubborn. One could never get more than 20s. for a pound; and if any one stated that with a given expenditure of power more light could be produced than was theoretically represented in the equivalent luminous energy of that power, one had a right to doubt such a statement. Progress would be better insured by frankly bringing to the front the limits within which the electric light could now be produced. Having made some observations on the use of gas engines, which, valuable machines as they were, yet as motors for the production of electricity for lighting purposes required to be much improved, he returned his thanks to the mover and seconder of the motion and to the meeting for their kind reception.

Electricity and Telegraphy.

THE THEORY OF MAGNETISM.—Professor D. E. Hughes, F.R.S., delivered a lecture on "The Theory of Magnetism," illustrated by experiments, before the Royal Institution, on February 29. The mechanical theory of magnetism may be deemed to be the proper style and title of that brought forward by the lecturer. The phenomena of magnetism he explains by a simple rotation of the molecules of iron, as well as of all metals, nay more, of all matter, solid, liquid, gaseous, or other. All matter, according to his views, has inherent magnetic power, varying in degree in molecules of different nature, but not to any great extent. The lecturer demonstrated each portion of his theory by experiment, so that the effects were visible to the audience. The striking effects of vibration, torsion, or mechanical strain upon the destruction or creation of manifest magnetism he showed in a variety of ways, the soft iron obeying the slightest mechanical tremor, while hard iron or steel resisted the most violent treatment. The molecules of the same bar behave with extreme freedom, as in the instance of soft iron, but when a slight strain was put upon them, as when slightly bent, like an archer's bow, the bar became as rigid as steel, and mechanical action had no longer any effect. A detailed account was given of the lecturer's researches upon the atmosphere, in the course of which he has discovered that it has a saturating point, like iron, and that it is just like iron itself. This was illustrated by striking experiments upon the magnetism of the atmosphere as compared with that of iron, and with the effects of vibrations in allowing freedom of motion to magnetic conduction in iron, by means of which a magnetic pole was pushed forward to four times its previous distance. Heat and electricity produced like effects, whence Professor Hughes drew the conclusion that these three forces, each allowing molecular freedom when frictional resistance is lessened, must have a like origin, and that electrical currents can be fairly classed with heat as a mode of motion. When a bar of soft iron is strongly magnetised, as in the instance of an electro-magnet, it returns, like a spring, to a neutral state upon the cessation of the inducing force. This well-known fact has long remained a mystery. All theories of magnetism up to the present time supposed that the molecules became, on the removal of the induced current, mixed or heterogeneous. Professor Hughes believes he has made a great discovery in having solved this problem, leaving no mystery any longer, as the demonstration which he will bring forward this week before the Royal Society will reduce the matter within the domain of absolute fact. He proved his case before his audience at the Royal Institution in a less formal way, but quite as effectually, rendering a bar of iron sensibly neutral or polarised at will by simply turning it upside down. The mechanical inertia of the molecules was demonstrated by magnetising a bar, and then changing its polarity by the earth's influence alone. The inertia of magnetism and of electricity was illustrated by two bars of diverse hardness. Having dealt with other points of great interest, the lecturer concluded by saying that scientific men are agreed that heat is a mode of motion, and that the molecules of the most solid bar of iron can move in a certain space with comparative freedom, the oscillations being greatly increased with every rise in temperature. If, as already well known, the molecules can move in all planes, then there could be no valid objection to the idea of their rotation, in fact they were known to rotate in the act of crystallisation. Thus, according to Professor Hughes, magnetism is an endowment of every atom of matter.

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P. O. Box 3888.

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The growth of abstract science in this country is perhaps no better illustrated than by the advance which has been made of late years in the various departments of mathematics. It is only a few years since Prof. Peirce was about the only person in the United States who held a position among the original mathematicians of the world, while to-day there are in this country a number of persons whose writings are destined to rank among the classics, and a journal of mathematics of the highest rank is published under the auspices of the Johns Hopkins University and sustained almost entirely by American contributors. Among the best of the abstract writers referred to is Mr. William Ferrel, who has been hitherto best known by his tidal researches, but is now engaged in investigations on the mathematical principles of meteorology. His latest work, just published by the Coast Survey, is now before us, and although nominally consisting only of researches on Cyclones, Waterspouts and Tornadoes, is in reality a valuable contribution to the theory of storms in general.

The Board of Directors of the Ohio Mechanics' Institute have organized a "*Department of Science and Arts*" for the purpose of increasing the usefulness of the Institution. A Section of Mechanics and Engineering under the chairmanship of Professor H. T. Eddy, and one of Chemistry under Professor F. W. Clark, have been arranged. Meetings for the public discussion of scientific subjects will be held once a month, and various other arrangements are in progress which will contribute to the success of the present attempt to provide increased facilities for technical and scientific education for the youths of Cincinnati.

SCIENTIFIC SOCIETIES OF WASHINGTON.

THE BIOLOGICAL SOCIETY, WASHINGTON.—Since our last report the following papers have been read: "Roan Mountain, North Carolina, and its Flora," by Prof. J. W. Chickering, Jr.; "Notes on the Flowering of *Solanum rostratum* and Cassia chamaecrista, with illustrations," by Prof. J. E. Todd; "A Critical Review of Günther's Ichthyology," by Prof. Theodore Gill; "On the Mortality of Marine Animals in the Gulf of Mexico," by Mr. Ernst Ingersoll: "A Statistical View of the Flora of the District of Columbia," by Prof. Lester F. Ward. It is to be regretted that the absence of our Washington correspondent from the meetings deprives us of abstracts of these valuable papers.

THE ANTHROPOLOGICAL SOCIETY.—The Constitution of this society, now in its third year, makes it obligatory upon the President to prepare at the commencement of each year, a summary of the transactions of the organization during the past year. At the close of the first year, the President overlooked this fact, but made ample amends at the commencement of the third year by preparing a pamphlet containing both annual addresses, and copious abstracts of all the papers that had ever been read.

Since our last report, the following papers have been read: "The Savage Mind in the Presence of Civilization," by Prof. Otis T. Mason; "Prehistoric Trephining," by Dr. Robert Fletcher; "Some Superstitions of the Sioux Indians," by Dr. H. Yaddow; "The Chief's Son and the Thunders: An Omaha Myth," by Rev. J. Owen Dorsey.

The design of the first named paper was two-fold: first, to show that the presence of other peoples better furnished and skilled in some respect had always operated as a stimulus in the onward march of civilization; and second to draw attention to the fact that in the treatment of the Indians, Chinese, and Negroes, the phenomena of the past history of civilization were being re-presented. The two latter papers were recitals of exceedingly interesting Indian myths. Dr. Fletcher, who is associated with Dr. Billings in publishing "Index Medicus," having collected all that could be gathered on the subject of prehistoric-trephining, from two years reading, gave an elaborate summary of his investigations.

THE PHILOSOPHICAL SOCIETY OF WASHINGTON.—THE SPECTROPHONE.—At the 198th meeting of the Philosophical Society of Washington, Prof. Alexander Graham Bell communicated the announcement of his discovery of the Spectrophone, the latest outgrowth of the Photophone.

In a paper read before the American Association for the Advancement of Science, in which he announced the discovery of the photophone, Mr. Bell ventured the prediction that probably all matter would be found to posses sonorous properties of the same nature as those manifested by the discs used in that instrument. More recent investigations in Europe with gases and liquids have fully verified this prediction. Any liquid or gas placed in a test tube and exposed to the action of a beam of light condensed upon it by a lens can be made, by means of an interrupter, to emit musical tones. This has been shown by Prof. Tyndall in his memoir, to the Royal Society, on Radiant Heat. Some substances thus emit feeble sounds, others stronger ones. Iodine vapor, Nitrogen Oxide and Bromine give very loud sounds. It is found that those substances which emit loud sounds are those which absorb heat in a high degree, and among these lamp-black is especially remarkable. It has been questioned whether such sounds are provoked by the luminous rays or by the dark ones. M. Mercadier expressed the belief that the inciting rays are the red and dark ones. This led Mr. Bell, with the assistance of Mr. Sumner Taintor, to experiment with the sonorous properties of Carbon Disulphide, actuated by the light of the Spectrum.

When lamp-black is exposed to the action of the light of the spectrum it is found to give a sonorous response to all of its rays as far as the middle of the violet, and perhaps beyond. The intensity of the sound, however, varies remarkably in different parts of the spectrum. Taking the rays successively from different parts, from the violet towards the red, the sounds begin very feebly and increase in intensity, reaching a maximum in the ultra red. Beyond that point they suddenly cease. The increase of intensity is very gradual, the decrease very sudden.

Other substances have been experimented with, and while exhibiting similar properties, each has a range of its own. Porous and fibrous substances give loud sounds. Thus, common wool or worsted are found to be very sonorous, but the sounds are obtained wholly from the visible parts of the spectrum and have the maximum intensity in the green. In all substances tried success has resulted, but nearly all have a very short range.

In experimenting with more homogeneous substances of simpler constitution, still more definite results are obtained. The rays of the spectrum are passed through sulphuric ether. Outside of the ultra red is a very narrow band which cause sounds while the other parts fail to produce them. Hydrogen peroxide gives sounds at several places wholly within the visible parts of the spectrum, and these places are found to coincide with the positions of the known absorption bands of that substance. The same is found to be true of Nitrogen Oxide and a solution of Ammonia, Sulphate of Copper, and many other substances. The general law deduced is that *sounds are produced in any substance by the rays which it absorbs.*

Thus a kind of spectrum analysis can be obtained through the intermediation of sound. The principal value of the spectrophone, Mr. Bell believes, will be found in the investigation of absorption bands in the ultra red part of the spectrum.

Mr. William B. Taylor inquired whether the sounds observed from the two absorption bands of ammonia, sulphate of copper, were octaves. Mr. Bell replied that this question had not as yet been investigated.

Mr. G. Brown Goode read portions of a paper on the sword-fish and its allies, which paper will be published in full in the next annual report of the U. S. Fish Commission.

ON THE MODERN DEVELOPMENT OF FARADAY'S CONCEPTION OF ELECTRICITY.*

By Professor Helmholtz.

The majority of Faraday's own researches were connected, directly or indirectly, with questions regarding the nature of electricity, and his most important and most renowned discoveries lay in this field. The facts which he has found are universally known. Nevertheless, the fundamental conceptions by which Faraday has been led to these much-admired discoveries have not been received with much consideration. His principal aim was to express in his new conceptions only facts, with the least possible use of hypothetical substances and forces. This was really a progress in general scientific method, destined to purify science from the last remnants of metaphysics. Now that the mathematical interpretations of Faraday's conceptions regarding the nature of electric and magnetic force has been given by Clerk Maxwell, we see how great a degree of exactness and precision was really hidden behind his words, which to his contemporaries appeared so vague or obscure; and it is astonishing in the highest to see what a large number of general theories the methodical deduction of which requires the highest powers of mathematical analysis, he has found by a kind of intuition, with the security of instinct, without the help of a single mathematical formula.

The electrical researches of Faraday, although embracing a great number of apparently minute and disconnected questions, all of which he has treated with the same careful attention and conscientiousness, are really always aiming at two fundamental problems of natural philosophy, the one more regarding the nature of physical forces, or of forces working at a distance; the other, in the same way, regarding chemical forces, or those which act from molecule to molecule, and the relation between these and the first.

The great fundamental problem which Faraday called up anew for discussion was the existence of forces working directly at a distance without any intervening medium. During the last and the beginning of the present century the model after the likeness of which nearly all physical theories had been formed was the force of gravitation acting between the sun, the planets, and their satellites. It is known how, with much caution and even reluctance, Sir Isaac Newton himself proposed his grand hypothesis, which was destined to become the first great and imposing example, illustrating the power of true scientific method.

But then came Oerstedt's discovery of the motions of magnets under the influence of electric currents. The force acting in these phenomena had a new and very singular character. It seemed as if it would drive a single isolated pole of a magnet in a circle around the wire conducting the current, on and on without end, never coming to rest. Faraday saw that a motion of this kind could not be produced by any force of attraction or repulsion, working from point to point. If the current is able to increase the velocity of the magnet, the magnet must react on the current. So he made the experiment, and discovered induced currents; he traced them out through all the various conditions under which they ought to appear. He concluded that somewhere in a part of the space traversed by magnetic force there exists a peculiar state of tension, and that every change of this tension produces electromotive force. This unknown hypothetical state he called provisionally the electrotonic state, and he was occupied for years and years in finding out what was this electrotonic state. He discovered at first, in 1838, the dielectric polarisation of electric insulators, subject to electric forces. Such bodies show, under the influence of electric forces, phenomena perfectly analogous to those exhibited by soft iron under the influence of the magnetic force. Eleven years later, in 1849, he was able to demonstrate that all ponderable matter is magnetized under the influence of sufficiently intense magnetic force, and at the same time he discovered the phenomena of diamagnetism, which indicated that even space, devoid of all ponderable matter, is magnetizable; and now with quite a wonderful sagacity and intellectual precision Faraday performed in his brain the work of a great mathematician without using a single mathematical formula. He saw with his mind's eye that by these systems of tensions and pressures produced by the dielectric and magnetic polarisation of space which surrounds electrified bodies, magnets or wires conducting electric currents, all the phenomena of electro-static, magnetic, electro-magnetic attraction, repulsion, and induction could be explained, without referring at all to forces acting directly at a distance. This was the part of his path where so few could follow him; perhaps a Clerk Maxwell, a second man of the same power and independence of intellect, was necessary to reconstruct in the normal methods of science the great building, the plan of which Faraday had conceived in his mind and attempted to make visible to his contemporaries.

Nevertheless the adherents of direct action at a distance have not yet ceased to search for solutions of the electro-magnetic problem. The present development of science, however, shows, as I think, a state of things very favorable to the hope that Faraday's fundamental conceptions may in the immediate future receive general assent. His theory, indeed, is the only existing one which is at the same time in perfect harmony with the facts observed, and which at least does not lead into any contradiction against the general axioms of dynamics.

It is not at all necessary to accept any definite opinion about the ultimate nature of the agent which we call electricity.

Faraday himself avoided as much as he could giving any affirmative assertion regarding this problem, although he did not conceal his disinclination to believe in the existence of two opposite electric fluids.

For our own discussion of the electro-chemical phenomena, to which we shall turn now, I beg permission to use the language of the old dualistic theory, because we shall have to speak principally on relations of quantity.

I now turn to the second fundamental problem aimed at by Faraday, the connection between electric and chemical force. Already, before Faraday went to work, an elaborate electro-chemical theory had been established by the renowned Swedish chemist, Berzelius, which formed the connecting-link of the great work of his life, the systematisation of the chemical knowledge of his time. His starting point was the series into which Volta had arranged the metals according to the electric tension which they exhibit after contact with each other, a fundamental point which Faraday's experiment contradicted with the supposition that the quantity of electricity collected in each atom was dependent on their mutual electro-chemical differences, which he considered as the cause of their apparently greater chemical affinity. But although the fundamental conceptions of Berzelius's theory have been forsaken, chemists have not ceased to speak of positive and negative constituents of a compound body. Nobody can overlook that such a contrast of qualities, as was expressed in Berzelius's theory, really exists, well developed at the extremities, less evident in the middle terms of the series, playing an important part in all chemical actions, although often subordinated to other influences.

When Faraday began to study the phenomena of decomposition by the galvanic current, which of course were considered by Berzelius as one of the firmest supports of his theory, he put a very simple question; the first question, indeed, which every chemist speculating about electrolysis ought to have answered. He asked, What is the quantity of electrolytic decomposition if the same quantity of electricity is sent through several electrolytic cells? By this investigation he discovered that most important law, generally known under his name, but called by him the law of definite electrolytic action.

Faraday concluded from his experiments that a definite quantity of electricity cannot pass a voltametric cell containing acidulated water between electrodes of platinum without setting free at the negative electrode a corresponding definite amount of hydrogen, and at the positive electrode the equivalent quantity of oxygen, one atom of oxygen for every pair of atoms of hydrogen. If instead of hydrogen any other element capable of substituting hydrogen is separated from the electrolyte, this is done also in a quantity exactly equivalent to the quantity of hydrogen which would have been evolved by the same electric current.

Since that time our experimental methods and our knowledge of the laws of electrical phenomena have made enormous progress, and a great many obstacles have now been removed which entangled every one of Faraday's steps, and obliged him to fight with the confused ideas and ill-applied theoretical conceptions of some of his contemporaries. We need not hesitate to

say that the more experimental methods were refined, the more the exactness and generality of Faraday's law was confirmed.

In the beginning Berzelius and the adherents of Volta's original theory of galvanism, based on the effects of metallic contact, raised many objections against Faraday's law. By the combination of Nobili's astatic pairs of magnetic needles with Schweigger's multiplicator, a coil of copper wire with numerous circumvolutions, galvanometers became so delicate that the electro-chemical equivalent of the smaller currents they indicated was imperceptible for all chemical methods. With the newest galvanometers you can very well observe currents which would want to last a century before decomposing one milligram of water, the smallest quantity which is usually weighed on chemical balances. You see that if such a current lasts only some seconds or some minutes, there is not the slightest hope to discover its products of decomposition by chemical analysis. And even if it should last a long time the feeble quantities of hydrogen collected at the negative electrode can vanish, because they combine with the traces of atmospheric oxygen absorbed by the liquid. Under such conditions a feeble current may continue as long as you like without producing any visible trace of electrolysis, even not of galvanic polarisation, the appearance of which can be used as an indication of previous electrolysis. Galvanic polarisation, as you know, is an altered state of the metallic plates which have been used as electrodes during the decomposition of an electrolyte. Polarised electrodes, when connected by a galvanometer, give a current which they did not give before being polarised. By this current the plates are discharged again and returned to their original state of equality.

This depolarising current is indeed a most delicate means of discovering previous decomposition. I have really ascertained that under favorable conditions one can observe the polarisation produced during some seconds by a current which decomposes one milligram of water in a century.

Products of decomposition cannot appear at the electrodes without motions of the constituent molecules of the electrolyte throughout the whole length of the liquid. This subject has been studied very carefully, and for a great number of liquids, by Prof. Hittorff, of Münster, and Prof. G. Wiedemann, of Leipsic.

Prof. F. Kohlrausch, of Würzburg, has brought to light the very important fact that in diluted solutions of salts, including hydrates of acids and hydrates of caustic alkalies, every atom under the influence of currents of the same density moves on with its own peculiar velocity, independently of other atoms moving at the same time in the same or in opposite directions. The total amount of chemical motion in every section of the fluid is represented by the sum of the equivalents of the cation gone forwards and of the anion gone backwards, in the same way as in the dualistic theory of electricity, and the total amount of electricity flowing through a section of the conductor corresponds to the sum of positive electricity going forwards and negative electricity going backwards.

This established, Faraday's law tells us that through each section of an electrolytic conductor we have always equivalent electrical and chemical motion. The same definite quantity of either positive or negative electricity moves always with each univalent ion, or with every unit of affinity of a multivalent ion, and accompanies it during all its motions through the interior of the electrolytic fluid. This we may call the electric charge of the atom.

Now the most startling result, perhaps, of Faraday's law is this: If we accept the hypothesis that the elementary substances are composed of atoms we cannot avoid concluding that electricity also, positive as well as negative, is divided into definite elementary portions, which behave like atoms of electricity. As long as it moves about on the electrolytic liquid each atom remains united

* The Faraday Lecture, delivered before the Fellows of the Chemical Society in the Theatre of the Royal Institution, on Tuesday, April 5th, 1881, by Professor Helmholtz. Abstract revised by the author.

with its electric equivalent or equivalents. At the surface of the electrodes decomposition can take place if there is sufficient electromotive power, and then the atoms give off their electric charges and become electrically neutral.

Now arises the question, Are all these relations between electricity and chemical combination limited to that class of bodies which we know as electrolytes? In order to produce a current of sufficient strength to collect enough of the products of decomposition without producing too much heat in the electrolyte, the substance which we try to decompose ought not to have too much resistance against the current. But this resistance may be very great, and the motion of the ions may be very slow, so slow indeed that we should need to allow it to go on for hundreds of years before we should be able to collect even traces of the products of decomposition; nevertheless all the essential attributes of the process of electrolysis could subsist. If you connect an electrified conductor with one of the electrodes of a cell filled with oil of turpentine, the other with the earth, you will find that the electricity of the conductor is discharged unmistakably more rapidly through the oil of turpentine than if you take it away and fill the cell only with air.

Also in this case we may observe polarisation of the electrodes as a symptom of previous electrolysis. Another sign of electrolytic conduction is that liquids brought between two different metals produce an electromotive force. This is never done by metals of equal temperature, or other conductors which, like metals, let electricity pass without being decomposed.

The same effect is also observed even with a great many rigid bodies, although we have very few solid bodies which allow us to observe this electrolytic conduction with the galvanometer, and even these only to temperatures near to their melting-point. It is nearly impossible to shelter the quadrants of a delicate electrometer against being charged by the insulating bodies by which they are supported.

In all the cases which I have quoted one might suspect that traces of humidity absorbed by the substance or adhering to their surface were the electrolytes. I show you therefore this little Daniell's cell, in which the porous septum has been substituted by a thin stratum of glass. Externally all is symmetrical at both poles; there is nothing in contact with the air but a closed surface of glass, through which two wires of platinum penetrate. The whole charges the electrometer exactly like a Daniell's cell of very great resistance, and this it would not do if the septum of glass did not behave like an electrolyte. All these facts show that electrolytic conduction is not at all limited to solutions of acids or salts.

Hitherto we have studied the motions of ponderable matter as well as of electricity, going on in an electrolyte. Let us study now the forces which are able to produce these motions. It has always appeared somewhat startling to everybody who knows the mighty power of chemical forces, the enormous quantity of heat and of mechanical work which they are able to produce, and who compares with it the exceedingly small electric attraction which the poles of a battery of two Daniell's cells show. Nevertheless this little apparatus is able to decompose water.

The quantity of electricity which can be conveyed by a very small quantity of hydrogen, when measured by its electrostatic forces, is exceedingly great. Faraday saw this, and has endeavored in various ways to give at least an approximate determination. The most powerful batteries of Leyden jars, discharged through a voltameter, give scarcely any visible traces of gases. At present we can give definite numbers. The result is that the electricity of 1 m.grm. of water, separated and communicated to two balls, 1 kilometre distant, would produce an attraction between them, equal to the weight of 25,000 kilos.

The total force exerted by the attraction of an electrified body upon another charged with opposite electricity is always proportional to the quantity of electricity contained in the attracting as on the attracted body, and therefore even the feeble electric tension of two Daniell's elements, acting through an electrolytic cell upon the enormous quantities of electricity with which the constituent ions of water are charged, is mighty enough to separate these elements and to keep them separated.

We now turn to investigate what motions of the ponderable molecules require the action of these forces. Let us begin with the case where the conducting liquid is surrounded everywhere by insulated bodies. Then no electricity can enter, none can go out through its surface, but positive electricity can be driven to one side, negative to the other, by the attracting and repelling forces of external electrified bodies. This process going on as well in every metallic conductor is called "electrostatic induction." Liquid conductors behave quite like metals under these conditions. Prof. Wüllner has proved that even our best insulators, exposed to electric forces for a long time, are charged at last quite in the same way as metals would be charged in an instant. There can be no doubt that even electromotive forces going down to less than 1-100 Daniell produce perfect electrical equilibrium in the interior of an electrolytic liquid.

Another somewhat modified instance of the same effects is afforded by a voltametric cell containing two electrodes of platinum, which are connected with a Daniell's cell, the electromotive force of which is insufficient to decompose the electrolyte. Under this condition the ions carried to the electrodes cannot give off their electric charges. The whole apparatus behaves, as was first accentuated by Sir W. Thomson, like a condenser of enormous capacity.

Observing the polarizing and depolarizing currents in a cell containing two electrodes of platinum, hermetically sealed and freed of all air, we can observe these phenomena with the most feeble electromotive forces of 1-1000 Daniell, and I found that down to this limit the capacity of the platinum surfaces proved to be constant. By taking greater surfaces of platinum I suppose it will be possible to reach a limit much lower than that. If any chemical force existed besides that of the electrical charges which could bind all the pairs of opposite ions together, and require any amount of work to be vanquished, an inferior limit to the electromotive forces ought to exist, which forces are able to attract the atoms to the electrodes and to charge these as condensers. No phenomenon indicating such a limit has as yet been discovered, and we must conclude, therefore, that no other force resists the motions of the ions through the interior of the liquid than the mutual attractions of their electric charges.

On the contrary, as soon as an ion is to be separated from its electrical charge we find that the electrical forces of the battery meet with a powerful resistance, the overpowering of which requires a good deal of work to be done. Usually the ions, losing their electric charges, are separated at the same time from the liquid; some of them are evolved as gases, others are deposited as rigid strata on the surface of the electrodes, like galvanoplastic copper. But the union of two constituents having powerful affinity to form a chemical compound, as you know very well, produces always a great amount of heat, and heat is equivalent to work. On the contrary, decomposition of the compound substances requires work, because it restores the energy of the chemical forces, which has been spent by the act of combination.

Metals uniting with oxygen or halogens produce heat in the same way, some of them, like potassium, sodium, zinc, even more heat than an equivalent quantity of hydrogen; less oxidisible metals, like copper, silver, platinum, less. We find, therefore, that heat is generated when zinc drives copper out of its combination with the

compound halogen of sulphuric acid, as is the case in a Daniell's cell.

If a galvanic current passes through any conductor, a metallic wire, or an electrolytic fluid, it evolves heat. Mr. Prescott Joule was the first who proved experimentally that if no other work is done by the current the total amount of heat evolved in a galvanic circuit during a certain time is exactly equal to that which ought to have been generated by the chemical actions which have been performed during that time. But this heat is not evolved at the surface of the electrodes, where these chemical actions take place, but it is evolved in all the parts of the circuit, proportionally to the galvanic resistance of every part. From this it is evident that the heat evolved is an immediate effect, not of the chemical action, but of the galvanic current, and that the chemical work of the battery has been spent in producing only the electric action.

If we apply Faraday's law, a definite amount of electricity passing through the circuit corresponds to a definite amount of chemical decomposition going on in every electrolytic cell of the same circuit. According to the theory of electricity the work done by such a definite quantity of electricity which passes, producing a current, is proportionate to the electromotive force acting between both ends of the conductor. You see, therefore, that the electromotive force of a galvanic circuit must be, and is, indeed, proportionate to the heat generated by the sum of all the chemical actions going on in all the electrolytic cells during the passage of the same quantity of electricity. In cells of the galvanic battery chemical forces are brought into action able to produce work; in cells in which decomposition is occurring work must be done against opposing chemical forces; the rest of the work done appears as heat evolved by the current, as far as it is not used up to produce motions of magnets or other equivalents of work.

Hitherto we have supposed that the ion with its electric charge is separated from the fluid. But the ponderable atoms can give off their electricity to the electrode, and remain in the liquid, being now electrically neutral. This makes almost no difference in the value of the electromotive force. For instance, if chlorine is separated at the anode, it will remain at first absorbed by the liquid; if the solution becomes saturated, or if we make a vacuum over the liquid, the gas will rise in bubbles. The electromotive power remains unaltered. The same may be observed with all the other gases. You see in this case that the change of electrically negative chlorine into neutral chlorine is the process which requires so great an amount of work, even if the ponderable matter of the atoms remains where it was.

The more the surface of the positive electrode is covered with negative atoms of the anion, and the negative with the positive ones of the cation, the more the attracting force of the electrodes exerted upon the ions of the liquid is diminished by this second stratum of opposite electricity covering them. On the contrary, the force with which the positive electricity of an atom of hydrogen is attracted towards the negatively charged metal increases in proportion as more negative electricity collects before it on the metal, and the more negative electricity collects behind it in the fluid.

Such is the mechanism by which electric force is concentrated and increased in its intensity to such a degree that it becomes able to overpower the mightiest chemical affinities we know of. If this can be done by a polarized surface, acting like a condenser, charged by a very moderate electromotive force, can the attractions between the enormous electric charges of anions and cations play an unimportant and indifferent part in chemical affinity?

You see, therefore, if we use the language of the dualistic theory and treat positive and negative electricities as two substances, the phenomena are the same as if equivalents of positive and negative electricity were attracted by different atoms, and perhaps also by the different values of affinity belonging to the same atom with different force. Potassium, sodium, zinc, must have strong attraction to a positive charge; oxygen, chlorine, bromine to a negative charge.

Faraday very often recurs to this to express his conviction that the forces termed chemical affinity and electricity are one and the same. I have endeavored to give you a survey of the facts in their mutual connection, avoiding, as far as possible, introducing other hypotheses, except the atomic theory of modern chemistry. I think the facts leave no doubt that the very mightiest among the chemical forces are of electric origin. The atoms cling to their electric charges and the opposite electric charges cling to the atoms. But I don't suppose that other molecular forces are excluded, working directly from atom to atom. Several of our leading chemists have begun lately to distinguish two classes of compounds, molecular aggregates and typical compounds. The latter are united by atomic affinities, the former not. Electrolytes belong to the latter class.

If we conclude from the facts that every unit of affinity of every atom is charged always with one equivalent either of positive or of negative electricity, they can form compounds, being electrically neutral, only if every unit charged positively unites under the influence of a mighty electric attraction with another unit charged negatively. You see that this ought to produce compounds in which every unit of affinity of every atom is connected with one and only with one other unit of another atom. This is, as you will see immediately, indeed, the modern chemical theory of quantivalence, comprising all the saturated compounds. The fact that even elementary substances, with few exceptions, have molecules composed of two atoms, makes it probable that even in these cases electric neutralization is produced by the combination of two atoms, each charged with its electric equivalent, not by neutralization of every single unit of affinity.

But I abstain from entering into mere specialties, as for instance, the question of unsaturated compounds; perhaps I have gone already too far. I would not have dared to do it if I did not feel myself sheltered by the authority of that great man who was guided by a never-erring instinct of truth. I thought that the best I could do for his memory was to recall to the minds of the men, by the energy and intelligence of whom chemistry has undergone its modern astonishing development, what important treasures of knowledge lie still hidden in the works of that wonderful genius. I am not sufficiently acquainted with chemistry to be confident that I have given the right interpretation, that interpretation which Faraday himself would have given perhaps, if he had known the law of chemical quantivalence, if he had had the experimental means of ascertaining how large the extent, how unexceptional the accuracy of his law really is; and if he had known the precise formulation of the law of energy applied to chemical work, and of the laws which determine the distribution of electric forces in space as well as in ponderable bodies transmitting electric current or forming condensers. I shall consider my work of to-day well rewarded if I have succeeded in kindling anew the interest of chemists for the electro-chemical part of their science.

MANUFACTURE OF SODA FROM SULPHATE.—Salt-cake is produced in quantity in California in the manufacture of nitric acid. As coal and lime-stone are dear in California, Le Blanc's process is not economical. The author therefore proposes to mix a solution of salt cake with calcium sulphite and pass in sulphurous acid. Soluble calcium bisulphite is formed, and by decomposition calcium sulphate and sodium bisulphite. The two salts are separated by filtration, and the sodium bisulphite is treated with milk of lime. The result is a solution of caustic soda, retaining a certain quantity of sodium sulphite and sulphate, which is evaporated down in the usual manner, and calcium sulphite, which is used again in the process.—J. PUTZKOW.

46 Engineering July 1881.

MOLECULAR MAGNETISM.

On a former occasion (see page 388 of our last volume) we gave an account of the principal results of Professor Hughes' latest experiments on the essential nature of magnetism and electricity, and we have now to give some supplementary facts which he has observed more recently, and embodied in a communication to the Royal Society. These facts may all be regarded as fresh evidence in favour of the molecular theory of magnetism, and antagonistic to the fluid theory of electricity.

In his previous researches Professor Hughes demonstrated that an electric current could be produced in an iron wire when under the influence of magnetism if it were twisted, that is subjected to a torsional stress, and conversely he showed that if an electric current is sent through an iron wire while it is magnetised, it experiences a molecular twist. The magnetism of the wire may be produced in several ways; by a permanent magnet held near the wire; by the magnetic medium surrounding a coil traversed by a current, illustrated in *Fig.* 1 of our former article, and by the magnetic field of the earth itself. In the latter case the iron wire should lie along the direction of the earth's lines of magnetic force and not at right angles to them, else there will be no effect. But the passage of an electric current through the wire also produces this magnetic condition very strongly, and Professor Hughes now finds that he is unable to restore the wire by means of mechanical stress exactly to its original non-magnetic state after the current passes. The magnetism produced by the passage of the current is far more powerful and persistent in soft iron than tempered steel. Only wire of a magnetic metal will give these results, and it must also contain at least a trace of magnetism, whether produced by the influence of a magnet or an electric current. In short, all the effects obtained by Professor Hughes in these present experiments are due, in some way, to the magnetisation of the wire. The torsion currents are best observed by twisting the wire to right and left by a see-saw movement, and listening to them in a telephone, whose circuit is interrupted by a rheotome, or watching the oscillation of a galvanometer needle swinging in time with the torsional movement. At the moment of reversing the torsion a peculiar click is heard, which Professor Hughes attributes to a sudden change in the polarity of the iron molecules. This click is heard equally well with an iron or a steel wire, but the after-currents are very much weaker in the case of steel, a result which may mean that while the polarisation of the molecules is equally strong in both iron and steel, the rigidity of the steel molecules prevents their being turned round by the torsion. Thus, if the iron wire be permanently twisted it behaves in some degree like rigid steel.

We have said that the magnetism produced in the wire by the passage of a current through it is, unlike that due to the touch of a permanent magnet, very difficult to get rid of by stress; but Professor Hughes finds that it can be cleared away either by heating the wire red hot, or stroking it with a magnet. This curious fact is explained by the hypothesis that the passage of the current produces a transverse or radial polarity of the molecules, which is difficult to alter by torsional stress, whereas the touch of the magnet changes it into a longitudinal polarity which can readily be disturbed.

The supposed spiral path of the current in the wire was next investigated by Professor Hughes, who has verified the celebrated experiment of De la Rive for solid conductors as well as vacuo. De la Rive showed that an electric current in a vacuum tube travels a spiral path round a magnet, and in a direction depending on the pole of the magnet presented to the current. Professor Hughes shows that a current traverses a magnetised steel wire in a spiral path; if the current is positive and enters at the north pole the spiral is right-handed; if it is negative entering the same pole the spiral is left-handed.

It is further remarkable that if while a current is traversing the wire, the latter is magnetised by the stroking of a permanent magnet, a strong disturbance takes place and the spiral path of the current appears to become fixed. For whether the current sent through it be positive or negative its path is the same as that of the current traversing its wire when it was being magnetised. Of course the direction of this permanent spiral depends on the direction of the magnetic stroke and the pole of the magnet employed, and if the stroke was made from both ends of the wire to the centre the spiral path which remains changes its direction from right to left at the middle of the wire. Heating the wire red-hot while it is being traversed by a current, and then cooling it, has also the effect of fixing for a time the spiral path of the current and determining the course of other currents whether positive or negative.

In his earlier experiments Professor Hughes succeeded in evoking distinct musical tones from a fine soft iron wire through which a current interrupted by a rhythmic rheotome was flowing. The cadence of these tones was, of course, that of the rheotome, but it is curious that the pitch is evidently independent alike of the diameter of the wire and its length and tension. Indeed, Professor Hughes is of opinion that it depends entirely on the molecular strain of the wire, a conclusion justified by several experiments which we need not repeat.

Enough, however, has been said to show the important part played by the molecular arrangement in a magnet and a conductor. It is evidently by the rotation of its polarised molecules that an electric current is generated in an iron wire by tension, and on the other hand the passage of a current in the wire apparently rotates its molecules.

THE APPLICATIONS OF ELECTRICITY.*

The second of the series of six lectures on the applications of electricity was delivered at the Institution of Civil Engineers on March 1, by Sir Frederick Bramwell, F.R.S., V.P.Inst.C.E., the subject being "Telephones." The following is an abstract of the lecture:—

Prior to the invention of the telephone, by making and breaking circuit at the transmitting station sounds had been produced at the receiving station—such as the striking of bells, or the vibration of a Morse sounder—but these were independent of sound at the transmitting station, and they varied according to the implement used at the receiving station, and were and are used for purposes of audible telegraphy. Also, prior to the invention of the telephone, it was possible to reproduce at the receiving station, say, by a tuning-fork, the vibrations of which break and make contact, the same note produced by a similar tuning-fork at the transmitting station; and in this case there was a reproduction at the receiving station of the sound at the transmitting station. But the only thing that was ensured was the repetition of the same note—there was no reproduction of the same sound. For example, the note might have been uttered by a violin-string, by a tuning-fork, or by a clarionet at the transmitting station; at the receiving station, however, nothing would be given forth but the note of the particular tuning-fork, or other vibrating implement, which was in accord with the number of the vibrations transmitted in a given time. All these modes were due to the variations of the current caused by break and make in the circuit, and were therefore abrupt. The best result obtained with such an agency was in the machine of Reis, who, in 1862, reproduced tones, and it is said some words were heard. That machine received no development, and telephony lay dormant for fourteen years, until the invention of Professor Graham Bell, patented in this country in December 1876. In 1874 Mr. William Henry Barlow, F.R.S., past-president Inst.C.E., turned his attention to the recording of the vibrations produced by speech. He effected this by means of an instrument called a logograph. This was communicated to the Royal Society, and exhibited in operation there. By its agency there was depicted on a travelling band of paper the motions derived from the vibration of a membrane under the influence of speech; but had the results been known they would probably have deterred an inventor seeking to produce a telephone, as it appeared the vibrations were not always the same for the same syllable, but varied with the speaker and from the circumstances. Professor Graham Bell graphically represented the variations in the electric current, either direct or reversed, caused by break and make, and showed that these were too abrupt for his purpose—namely, the reproduction of articulate speech. He proposed to attain the object sought by having the circuit always closed, and by causing rises and falls, or reversals, as the case might be, of electricity which should be made gradually, instead of abruptly, as before. The simplest mode in which he attained this end was in one of the original forms of the Bell transmitter or receiver (for the instrument was capable of fulfilling either function) by placing an iron or a steel plate in the neighbourhood of a permanent magnet surrounded by a coil of insulated wire, so that on the plate being set into vibration by the voice it should induce, in the coil, reversed currents of electricity which could travel along the wire in prolongation of the coil to the coil of the similar instrument at the receiving station, thereby varying the power of the magnet at that station and setting up vibrations in the corresponding iron disc. This disc, acting upon the air, gave to it vibrations similar to those which had put the first disc into motion, and in that way a reproduction of the original sound (as Professor Bell said, a facsimile) was obtained. Other modes were employed by him, such as the use of a battery in the line-wire, and, best of all, the use of two local batteries to send the current to a primary coil round a core, the line-wire being connected with secondary coils acting by induced electricity. As transmitters these instruments were necessarily somewhat feeble, since the whole of the electricity in the first of the three cases mentioned, and what might be called the operative electricity in the other two cases, had to be derived from the microscopic movements of the disc, under the influence of the sound-waves produced by the speaker.

Edison's phonograph was exhibited, in order to show that a disc, when caused to vibrate under speech, could by a central needle impress those vibrations on tin foil, and that on the tin foil being caused to traverse under the needle, the reproduction on the disc of those vibrations caused it to repeat the speech which had originally set the disc in motion. This was appealed to as a convincing proof that a disc, when mechanically vibrated in a manner corresponding to the vibrations which had been imparted to it by speech was sufficient, wholly irrespective of any electrical agency, to impress upon the air the needful vibrations to reproduce speech. Edison then devised a transmitter, wherein the disc need not be metallic, but might be mica, and its vibrations were caused to operate upon a small block of carbon, which carbon was introduced in the circuit of a battery. It was thus found that the almost inappreciable variation in pressure due to the vibration of the disc was sufficient, for some not very well understood reason, to alter the conducting power of the carbon, and to cause varying currents to be transmitted along the line-wire to the Bell receiver at the opposite end. At the present day the universal transmitting instrument for commercial purposes is the carbon transmitter of Edison or some modification thereof. Professor Hughes's microphone was next alluded to, and it was stated how by its means the most minute sounds were rendered audible, and how, from the delicacy of the instrument, it is applicable to many scientific purposes. Edison's chalk receiver was subsequently explained. Prior to Edison's time, it had been known that the friction of certain surfaces varied with the electric current passing through them, notably under such circumstances the friction of the human tissue. Among other appropriate substances prepared chalk was one, and it was shown how Edison availed himself of this. By attaching a stem to the centre of the disc, and pressing this stem by means of an adjustable pressure upon the periphery of a chalk cylinder, a current of electricity passed from the centre of the cylinder through the stem. Upon the cylinder being turned by hand the friction on the stem caused it to move the centre of the disc—its edge being fixed—to a definite position depending on the friction, and on the rigidity of the disc; but, on a variation in the current, the change produced thereby in the friction caused the stem either to be drawn in further or to yield to the elasticity of the disc and to allow it to be moved backwards. In this manner vibrations were set up in the disc corresponding with the vibrations of the transmitter that had sent the varying electrical currents. As in the case of this receiver the power was derived, not from the electricity, but from the hand of the operator turning the chalk cylinder, very considerable loudness was obtained, so that the utterances of the receiver were audible in a large room. Mr. Shelford Bidwell having lent a photophone, that beautiful invention of Professor Graham Bell was explained. Mr Bidwell showed how, by speaking to a disc, the front being a mirror on which a powerful light was directed, that light could be reflected on to a selenium cell, and as the disc vibrated under the influence of the voice the light playing on the selenium cell varied. Selenium was a material the conductivity of which changed with the amount of light upon it. It was therefore possible in this manner to cause a Bell receiver to speak, and reproduce the speech which had been uttered to the mirror disc. It was pointed out that, in this manner, there was no need of a wire connection between the transmitter and the receiver, the passage of a beam of light being all that was required.

Reference was then made to the various purposes to which the telephone might be put, and to the exchange system and the necessary apparatus for receiving the calls and making the connections between the different subscribers to the exchange. Amongst special uses, a very interesting one was shown—that of the application of telephony to the diver's helmet. Thanks to the kindness of the captain of the H.M.S. *Vernon* and of Mr. Gorman, a helmet with the whole of the apparatus was exhibited. It was shown how the application of the telephone in no way introduced any complication, as the single wire needed was in the middle of the old call-rope, the return being made by the water itself. Thus, if the telephone went wrong, the diver was left without additional apparatus of any kind to encumber him, and yet with all the resources that he would have had in the absence of the telephone. It was stated that the development of the telephone had been far more rapid in America than in England. As an instance it was mentioned that in the city of Washington, with a population of about 120,000 white persons, as many as 800 telephones were used. Then, a return, circulated that very day by the United Telephone Company, was read, showing that on February 28 in 1881 there were, independent of private lines, 845 subscribers to the London exchange; that on the same day in 1882 the number had increased to 1,505—or an addition of 660; and on February 28 this year the number was 2,541, or an addition of 1,036; and that contemporaneously with these increases the use of the telephone by each subscriber had augmented, until it now reached more than 7½ calls per day for each subscriber, which—at a cost of £20 a year—represented only twopence a call; or, bearing in mind that each call involved a return message, it only amounted to one penny for the message sent each way.

The lecturer had the assistance of Mr. E. H. Johnson, who had been so much associated with Mr. Edison in carrying out many of his inventions, and who put into work both the phonograph and the chalk receiver.

* See page 158, *ante*.

48 The Iron Age — Dec. 18, 1884.

Electrical Units and Nomenclature.

BY JOHN W. NYSTROM.

We take the following from *Mechanics* for December:

The notation of electrical quantities will herein be the same as those in the preceding article, page 257, namely: F = electromotive force. V = velocity or intensity of current in Ampères. T = time in seconds. P = power. K = work. R = resistance in ohms, and S = linear space in meters or 1000 kilometers.

UNIT-AMPÈRE.

It is stated by the Electrical Congress that "the Ampère is represented by that quantity of current which is capable of depositing 4.025 grams of silver per hour, or 0.001118 grams per second."

The depositing of silver or any other metal by electric currents is work, which is accomplished by the product of the three simple physical elements, *force, velocity* and *time*. $K = F V T$. No work can be done and no metal can be deposited without any one of these three simple elements. It is, therefore, not correct to say that "so much metal can be deposited per Ampère." When F and T are constant and the Ampère V varies, the quantity of metal deposited will be proportionate to the Ampère, but the work is still $K = F V T$. If V and T are constant and the electro-motive force varies, then the weight of metal deposited will be proportionate to the electro-motive force F, and the work will be the same, namely, $K = F V T$.

UNIT COLOMB.

The Electrical Congress says "the Colomb is the unit of dynamic quantity, and its value corresponds with that of the Ampère."

Dynamics is the name of the science of forces in motion, producing power and work, which name cannot be measured by quantity. It is evident from the drift of their vague explanations that Colomb is intended to mean quantity of electricity, which is work, $K = F V T$, which cannot correspond or compare with one of its elements, Ampères. The Colomb can be measured or expressed by the weight of metal deposited by a current.

UNIT FARAD.

They say that "Farad is the unit of capacity, which value is equal to 1 colomb divided by 1 Volt." If Colomb means quantity of electricity, which is work, $K = F V T$, and this work divided by the electro motive force F, then the Farad becomes $S = V T$, which is linear space.

It is stated that a Farad represents a length of 5,600,000 kilometers, and a micro-farad 5.6 kilometers. It appears to me that it is intended that Farad should mean the quantity of static electricity contained in a definite conductor, which quantity is $K = F V T$, and that this work should be proportionate to the volume of the conductor multiplied by the electro-motive force. If I am wrong in this, I beg to be corrected.

It would be well to establish regular units and nomenclature of quantities of electricity based upon the metric system corresponding with mechanical work, namely, the main standard of quantity should be that quantity which represents the work of one kilogrammeter. The two sub-units should be grammeter and milligrammeter.

For distinction in the application of these terms to quantities of electricity it would be well to abbreviate them as follows:

Kramet for kilogrammeter.
Gramet for grammeter.
Milgramet for milligrammeter.

UNIT OF LIGHT.

Light is power, and therefore the standard unit of light should correspond to one unit of power, namely, *effect*.

One electric arc light is a power of about 50 effects, and they are about 40-candle power per effect, as realized by electric currents.

The power of a light should always be expressed in effects. In my "Elements of Mechanics," published in 1875, it is explained on page 285 that "light is power, which is the product of force and velocity." Was such an explanation of light over made prior to the year 1875?

UNIT DYNE.

In my last article I made a mistake in stating (page 236) that "the dyne is 0.98 of the milligram." It is the other way, namely, the milligram is 0.98 of a dyne. I am not sorry for having made this mistake, because it is a fair sample of the confusion of the C. G. S.

The value of the dyne is obtained in the following way: A force acting for a time of one second on a mass of one gram free to move, and give that mass a final velocity of one centimeter per second, is called one dyne.

F = the unknown force, one dyne.
W = one gram, the weight of the mass.
V = final velocity 0.01 meter per second.
g = 9.81, the acceleratrix of gravity at Paris.
T = one second, the time of action.

$$\text{Dyne } F = \frac{W V}{g T} = \frac{1 \times 0.01}{9.81 \times 1} = 0.001019 \text{ of a gram.}$$

The dyne is consequently 1.019 milligrams.

This *dyne-force* is theoretically constant in every part of the world, whether on the top of the highest mountain, on the equator or in the highest latitude; its value never changes, which is no doubt the aim of the B. A. to have such a unit of force, but this fact does not compensate for the inconvenience of not having a unit of force in electro-dynamics which corresponds with an established unit of weight. The small difference of attraction in latitude is of no practical inconvenience in mechanics, because the standard weights made in France are distributed all over the civilized world, so that a mass of matter weighing one kilogram in the highest latitude, would also weigh one kilogram on the highest mountain on the equator. With this practical consideration, the C. G. S. is a botch.

A milligram weighed in a constant latitude, say that of Paris, is as much a constant and unvariable force as is the *dyne*. A metric weight in any part of the world, multiplied by the local acceleratrix and divided by the Paris acceleratrix, gives the actual weight as if weighed in Paris. When great accuracy is required the same operation must be gone through with the *dyne*, which is not 1.019 milligrams in latitudes outside of Paris.

W = weight in milligrams in any latitude outside of Paris.
g = 9.81 the acceleratrix in Paris.
G = local acceleratrix in latitude outside of that of Paris.

$$D = \frac{1.019\, W g}{G} = \frac{9.99639\, W}{G}.$$

It is to be hoped that the electricians will reject the *dyne* nuisance.

ENERGY.

I will avail myself of this opportunity to call the attention of bodies of scientific authority to the fact that the term *energy* is promiscuously used for the three distinct and different quantities, *force, power* and *work*. I have often noticed this indefinite use of the term *energy*, both in lectures and in books; and at a late meeting of electricians one of the party read a paper on C. G. S. units, and chalked a formula on the blackboard which represented *power*, but which he called *energy*. A little further on he chalked another formula which represented *work*, but which he also called *energy*. Another member of the party asked, "What is the reason that this formula means *energy* and that formula, which is entirely different, also means *energy?*" An evasive answer was given.

The term *energy* is generally applied to work, but my individual opinion is that it should be applied to power exclusively, for the reason that we say that Mr. A. has a great deal of energy when he accomplishes much work in a short time. If Mr. B accomplishes the same amount of work, but in a much longer time, we say that Mr. A has more energy than has Mr. B. Therefore, the popular idea of energy is power. For my part, I have no use for the term *energy*.

CONFUSION OF POWER AND WORK.

The difficulty which the B. A. has to encounter in distinguishing power from work appears to be in the application of the unit *time*. When a quantity is multiplied or divided by a unit quantity, the numerical value is not changed, but the nature of the quantity is changed. For instance, if power is multiplied by a unit of time the product will be work, while the numerical value remains unchanged. If work is divided by a unit of time the quotient becomes power, but the numerical value of that power is the same as that of the work. This is fully explained in my "Elements of Mechanics," but it appears that the B. A. is not able to take it in. I am informed by a member of that body that my ideas of dynamics have been ridiculed there.

Mr. W. H. Preece, F.R.S., complains that Professor Adams has, in a lecture, treated the power *Watt* as work. That mistake is quite common, particularly so in the B. A., and we can expect that that mistake will be continued as long as the B. A. calls power *the work done in a unit of time.*

In Holmes's work on electric light, page 75, it is stated that "the electrical energy or work can be calculated by multiplying the current in Ampères by the electro-motive force in Volts. ($W = C E$)." He calls it *energy* or *work*, while the explanation and formula is *power*.

49

...of the blast upon these is quite intelligible. ...nsen and Playfair estimated that in every cubic ...etre of gas at a height of 2·75 feet above ...e level of the tuyere in the Alfreton furnace ...ere were eight or ten grammes of cyanide of potassium ...r cubic metre of gas. Mr. Lowthian Bell's experiments ...dicate about 4 lb. of cyanogen per ton of iron produced, ...hich, combined with potassium, would amount in round ...mbers to 10 lb. of the salt. The alkaline cyanides are ...ducing agents, but whether they act with any practical ...fect in the furnace is still doubtful. Mr. Lowthian Bell ...ys, "The whole subject is one upon which my mind is by ...means made up." As the writer is in a similar state of ...ind, the problem must be here left as stated, but not ...lved.

THE SALT DEPOSITS OF MIDDLESBROUGH.

...N address on this subject was delivered by Mr. T. H. ...ell, before the Cleveland Institution of Engineers. The ...cturer first traced the conditions under which salt was ...und in the globe. It occurred in very large quantities, ...d was very solvable in water. He went on to give two ...three instances in which it occurred in solution in very ...rge quantities, referring to the Red Sea, the Caspian Sea, ...d the Baltic Sea. These were instanced as probable ...urces of a future salt supply. Water would absorb 2,707 ...arts of salt to every 10,000, or four ounces to the ...allon. Turning to the geology of salt, he said it ...as to be found in almost every form. It occurred ...ten as a colourless material, but they were acquainted ...ith it coloured with iron—of the red colour. The ...alt at Middlesbrough is heavily charged with nitrogen. It ...ntained 94 per cent. of nitrogen and 4 per cent. of ...xygen; and at Port Clarence, during the construction of ...bore-hole, quantities of gas had bubbled up. Referring ...an illustrated section between Stonegate and Upsall, he ...ated that the salt of Middlesbrough belonged to a far ...wer series of rocks than was the case in Cheshire. Salt ...curred throughout Europe in beds of limited size, and ...casionally in great thickness, and one difficulty at ...ddlesbrough was to ascertain the thickness and extent ...the salt bed. Messrs. Bolckow, Vaughan & Co. had ...nd it, and his firm had struck it at Port Clarence; but ...t was all—they did not know how far it extended. The ...tion as to whether it extended north, south, east, or ...st was a matter upon which other people would have to ...nd their money and take their chance. Mr. Bell ...d then touched upon the Cheshire salt deposits, and stated ...at the apparatus used in the manufacture was very crude. ...e believed the salt manufacturers of Middlesbrough ...ld be shortly in a position to teach the world how to ...ake salt. In Cheshire the salt occurred comparatively ...ar the surface, and the water got at it, and had only to ...pumped up in the form of brine; but at Middlesbrough ...e deposit was at a much greater depth, and the salt was ...rfectly dry. Different means had, therefore, to be em...oyed in winning it. The specific gravity of salt was ...205. He had estimated the quantity of salt at Middles...ough to be about 2,000 tons per acre; therefore, ...essrs. Bolckow, Vaughan, & Co. and Messrs. Bell ...rothers would be able to supply some quantity ...salt for a time to come. Water at 60 degrees ...sorbed 27 per cent. of salt, but with it came ...quantity of sulphate of lime, for, when the water had ...sorbed all the salt it could contain, it commenced taking ...the lime. This was extremely inconvenient to the ...anufacturer, and the Cheshire people had tried all ...anner of ways to get rid of it. The manufacture ...ppeared to be one of the simplest of all industries to an ...tsider, but it was not so. In 1857 Mr. Vaughan, ...oking for a supply of water for boiler purposes, sank a ...re-hole, and, not finding water, went on with it until ...came to salt. The firm turned their attention to ...inning the salt for a time, but other things intervened, ...d, ultimately the scheme was abandoned, as it was ...ought the expense would be too great. In 1875 Messrs. ...ll Bros. endeavoured to find if the salt extended ...ross the river, and they found salt at 80 feet less ...pth. Warned by the experience of the other firm, ...owever, they did not care to incur the expense, and it ...as not until Thomas Bell suggested the method now ...ing adopted that the thing was again taken up. They ...d since found that the method was in use in the East of ...ance, but when it was adopted by them this fact was ...t known, and it was to them an entirely new invention ...Thomas Bell. Mr. Bell then went on to describe the ...anner of constructing No. 1 bore-hole, and the strata ...ne through. When the salt was found they went ...0 feet lower, for the sake of experiment, in search ...coal, but none was found. The Diamond Boring Com...ny did the work. The hole was lined from top to ...ttom, and the bottom part perforated. A second ...be was then inserted. He described how the ...sh water was admitted into the hole and the brine ...mped up. There was no witchcraft about any ...rt of the system; it was as simple a piece of mechanism ...anybody could desire. A great consideration in the ...atter was, What would be the effect upon Middlesbrough ...10 feet of salt was removed and the upper crust left? ...the east of France the subsidence occurring was con...ed to the immediate neighbourhood of the bore-hole. ...present they were raising about 320 tons of salt per ...eek. When the brine was raised it was stored in a ...servoir, and then put into evaporating pans. For a time ...had a difficulty in getting the evaporation to go on ...factorily; but by using Stockton and Middlesbrough ...or the difficulty had been overcome. Salt was largely ...for domestic purposes, and on the Tyne in the manu...ture of carbonate of soda. The trade there, however, ...not very brisk, and what the future would bring for... no one could say. Was it not desirable that they ...uld be considering whether some new method could not ...discovered for using the salt? They might adopt the ...monia process.

THE ENGINEERING TRADE.

THE thirty-second annual report of the Amalgamated Society of Engineers has this week been issued to the members, and the general secretary, Mr. John Burnett, in his introductory remarks, states that the hopeful anticipations of the previous year as to the prospects of trade have been to a great extent realised. It would, perhaps, be too much to say that the general trade of the country, or even of their own trade, had been in a state of unprecedented activity during 1882. There might have been a few years in their trade experience which had been better in point of value of production than last year, but they were few in number. It was, however, almost certain that in no previous year did Great Britain send abroad such a quantity of the various kinds of articles and commodities which they produced for the use of foreign nations. Taking exclusively their own department, they found that the foreign demand for their engines and machinery had increased vastly both in quantity and value. Indeed, it might safely be asserted that never before were the engineers of Britain called upon to produce so much of their work to meet the requirements of foreign customers, and there could be no doubt that so far as their trade was concerned we stood to-day in a better position in the markets of the world than ever we did before. That this had been accomplished in face of the heavy tariffs imposed by foreign nations was a matter of amazement. In most of these countries there seemed to be a tendency to increase rather than decrease their tariffs; but in the United States there seemed to be just now a reaction against protection, and any reduction of their excessive duties could not fail for a time to give a great increase to our American trade. Good as their general trade had been, there could be no doubt that it was in marine engineering they had been most successful. Shipbuilding during 1882 had been carried on to an extent hitherto undreamed of, and the efforts of previous years had been far exceeded. During 1881 the increase of tonnage built by us was something astounding, and reached a total of about 1,000,000 tons. In 1882, however, we far exceeded that great figure, and had constructed 1,200,000 tons of shipping in iron and steel. Under such circumstances as those, their members engaged in the manufacture of marine engines had been well employed, and wages had risen with them to a higher point than before, especially in those places where the organisation of the men was complete. Yet good as this and some other branches of their trade had been, their unemployed list had remained much heavier than in past years of good trade. At the close of 1881 they had 412 branches on their roll. In the course of 1882 they opened new ones at Stockton-on-Tees, Newton Heath, Sunderland, Colchester, Gainsborough, Openshaw, Glasgow, and Woolston at home, and in America at Plainfield, Denver, Taunton, and Erie. Owing to falling off in local trade and removal of members, they had had to close small branches at Inverness, Constantinople, and Port Jervis, and Tredegar from the results of a special audit, leaving them thus to enter 1883 with a total list of 420 branches. Of these they had in England, 302; Scotland, 41; Ireland, 14; Australia, 9; Canada, 6; New Zealand, 4; Queensland, 1; India, 1; United States, 39; Turkey, 1; Malta, 1; and France, 1. This improvement in the number of branches had been due to the increase and spread of trade, and at the close of 1881 they had a grand total of 46,101 members, which they had augmented last year to 48,388, being a gain of 2,287 after allowing for deaths and exclusions. The income of 1882 was not so large as in some previous years, but the amount raised by levying had been remarkably small, the total asked for in this way during the year being only 1s. 3d. per member. Under the head of contributions they had received £115,176, against £124,109 in the previous year; propositions of members had realised £1,214, and entrance fees £3,223, an increase under these two heads of £1,059, and bank interest had amounted to £3,497. Their outlay had fallen considerably as compared with 1881, and was enormously less than in 1879-80. In 1881 they expended £116,623, last year but £102,165, which showed a falling off amounting to £14,458. The greatest saving had taken place under the head of donation benefit, the expenditure in 1882 being only £21,936, as against £38,083 in the previous year. Sick benefit had cost them more than in the previous year, being £25,295, or £603 more than in 1881 and £2,000 more than in 1880. Funerals cost them £216 less than in 1881, being £7,648 against £7,864. The average age of their members at death had also gone up from 45¼ years to 45¾ years. Superannuation benefit had again increased, and to such an extent as to eat very materially into their savings, having reached the great total of £26,312, which was an increase of £2,788 on 1881. The peaceful state of their relations with their employers was vouched for by the very trifling sum of £860 spent on contingent benefit, and £35 in grants in defence of their own trade. Benevolent grants had been made in cases of extreme distress to the sum of £1,031, which was almost as low as they could ever expect to have that item of their expenditure. Their general position might be concisely stated as follows:—They had 420 branches, containing an aggregate of 48,388 members. Their total income for 1882 was £124,408 0s. 0½d., and their total expenditure £102,165 7s. 3d., leaving a surplus of income over outlay of £22,243 1s. 9½d., which, added to their last year's balance, gave them an accumulated capital of £168,200 6s. 3d., or £3 9s. 6½d. per member.

THE APPLICATIONS OF ELECTRICITY.*

THE fourth of the series of six lectures on the applications of electricity was delivered at the Institution of Civil Engineers on April 5, by Dr. J. Hopkinson, F.R.S., M.I.C.E., the subject being "Some Points in Electric Lighting." The following is an abstract of the lecture.

The science of lighting by electricity was divided by the lecturer into two principal parts—the methods of production of electric currents, and of conversion of the energy of those currents into heat at such a temperature as to be given off in radiations to which the eye was sensible. The laws known to connect together those phenomena called electrical were essentially mechanical in form, closely correlated with mechanical laws, and might be most aptly illustrated by mechanical analogues. For example, the terms "potential," "current," and "resistance," had close analogues respectively in "head," "rate of flow," and "co-efficient of friction," in the hydraulic transmission of power. Exactly as in hydraulics head multiplied by velocity of flow was power measured in foot-pounds per second or in horse-power, so potential multiplied by current was power and was measurable in the same units. Again, just as water flowing in a pipe had inertia and required an expenditure of work to set it in motion, and was capable of producing disruptive effects if that motion were too suddenly arrested, so a current of electricity in a wire had inertia; to set it moving electromotive force must work for a finitive time, and if arrested suddenly by breaking the circuit the electricity forced its way across the interval as a spark. Corresponding to mass and moments of inertia in mechanics there existed in electricity co-efficients of self-induction. There was, however, this difference between the inertia of water in a pipe and the inertia of an electric current—the inertia of the water was confined to the water, whereas the inertia of the electric current resided in the surrounding medium. Hence arose the phenomena of induction of currents upon currents, and of magnets upon moving conductors—phenomena which had no immediate analogues in hydraulics. The laws of induction were then illustrated by means of a mechanical model devised by the late Professor Clerk Maxwell. In the widest sense, the dynamo-electric machine might be defined as an apparatus for converting mechanical energy into the energy of an electro-static charge, or mechanical power into its equivalent electric current through a conductor. Under this definition would be included the electrophorous and all frictional machines; but the term was used in a more restricted sense, for those machines which produced electric currents by the motion of conductors in a magnetic field, or by the motion of a magnetic field in the neighbourhood of a conductor. The laws on which the action of such machines was based had been the subject of a series of discoveries. Oersted discovered that an electric current in a conductor exerted force upon a magnet; Ampère that two conductors conveying currents generally exerted a mechanical force upon each other; Faraday discovered—what Helmholtz and Thomson subsequently proved to be the necessary consequence of the mechanical reactions between conductors conveying currents and magnets—namely, that if a closed conductor moved in a magnetic field, there would be a current induced in that conductor in one direction if the number of lines of magnetic force passed through the conductor was increased by the movement, in the other direction if diminished. Now all dynamo-electric machines were based upon Faraday's discovery. Not only so; but however elaborate it might be desired to make the analysis of the action of a dynamo-machine, Faraday's way of presenting the phenomena of electro-magnetism to the mind was in general the best point of departure. The dynamo-machine, then, essentially consisted of a conductor made to move in a magnetic field. This conductor, with the external circuit, formed a closed circuit in which electric currents were induced as the number of lines of magnetic force passing through the closed circuit varied. Since, then, if the current in a closed circuit was in one direction when the number of lines of force was increasing, and in the opposite direction when they were diminishing, it was clear that the current in each part of such circuit which passed through the magnetic field must be alternating in direction, unless indeed the circuit was such that it was continually cutting more and more lines of force, always in the same direction. Since the current in the wire of the machines was alternating, so also must be the current outside the machine, unless something in the nature of a commutator was employed to reverse the connections of the internal wires in which the current was induced, and of the external circuit. There were then broadly two classes of dynamo-electric machines; the simplest, the alternating-current machine where no commutator was used; and the continuous-current machine, in which a commutator was used to change the connection with the external circuit just at the moment when the direction of the current would change. The theory of the alternate-current machine was then explained, and it was proved that two independently driven alternate-current machines could not be worked in series, but that they might be worked in parallel circuit, and hence were quite suitable for distribution of electricity for lighting without the necessity of providing a separate circuit for each machine.

It was easy to see that, by introducing a commutator revolving with the armature, in an alternate-current machine, and so arranged as to reverse the connection between the armature and the external circuit just at the time when the current would reverse, it was possible to obtain a current constant always in direction; but such a current would be far from constant in intensity, and would certainly not accomplish all the results obtained in modern continuous-current machines. This irregularity might, however, be reduced to any extent by multiplying the wires of the armature, giving each its own connection to the outer circuit, and so placing them that the electromotive force attained a maximum successively in the several coils. A practically uniform electric current was first commercially produced with the ring armature of Pacinotti, as perfected by Gramme. A dynamo-machine was not a perfect instrument for converting mechanical energy into the energy of the electric current. Certain losses inevitably occurred. There was the loss due to friction of bearings, and of the collecting brushes upon the commutator; there was also the loss due to the production of electric currents in the iron of the machine. When these were accounted for, there remained the actual

* See pages 188, 227, 291, *ante*.

50

MOLECULAR MAGNETISM.*

By Prof. D. E. Hughes, F.R.S.

DURING the course of some late researches, which I had the honour to communicate to the Royal Society (p. 57), and experimentally illustrate on the reading of my second paper (p. 105), so many experimental facts occurred, all pointing to the conclusion that ordinary molar magnetism is entirely due to the symmetrical arrangement of its polarised molecules, and that these molecules can be rotated by torsion, so as to decrease its longitudinal magnetism, or increase it if the effect of the elastic torsion is to rotate the molecules in its required longitudinal symmetrical arrangement, and observing that molecular magnetism could induce an electric current upon its own molar constituents, or that an electric current by its passage through an iron wire would produce molecular magnetism, I have continued these researches in the hope of elucidating, as far as possible, the phenomenon of the transformation of electricity and magnetism by the changes produced in the molecular structure of its conducting wire.

For this purpose I have employed three separate methods of investigation, each requiring a slightly modified form of apparatus. The first relates to the influence of an elastic torsion upon a magnetic or conducting wire; the second the influence upon the molecular structure of an iron wire by electricity or magnetism; the third was the evident movement of the molecules themselves as given out in sonorous vibrations. The general details of the apparatus employed having been given (see pp. 57, 81, ante), I will only briefly indicate any modification of the method employed.

1. Influence of an Elastic Torsion upon a Magnetic or an Electric Conducting Wire.

In the paper just referred to I showed that induced currents of electricity would be induced in an iron wire placed on the axis of a coil through which intermittent currents were passing, and that these currents were produced only when the wire was under the influence of a torsion not passing its limit of elasticity. It became evident that if the intermittent magnetism induced by the coil produced under torsion intermittent currents of electricity, that an intermittent torsion under the influence of a constant current of electricity or a constant magnetic field would produce similar currents. This was found to be the case, and as some new phenomena presented themselves indicating clearly the molecular nature of the actions, I will describe a few of them directly relating to the subject of this paper. An iron wire of 20 centims. was placed in the centre or axis of a coil of silk-covered copper wire, the exterior diameter of the coil being 3½ centims., having an interior vacant circular space of ¾ centims. The iron wire is fastened to a support at one end, the other passing through a guide, to keep it parallel but free, so that any required torsion may be given to the wire by means of a connecting arm or index. A sensitive telephone is in direct communication with the coil, or a galvanometer may be used, as the currents obtained by a slow elastic torsion are slow and strong enough to be seen on a very ordinary galvanometer. I prefer, however, the telephone, because it has the inestimable advantage in these experiments of giving the exact time of the commencement or finish of an electric current. It has, however, the disadvantage of not indicating the force or direction of the current; but by means of the sonometer the true value and direction of any current is at once given. Again, the telephone is useless for currents of slow intermittence, but by joining to it the microphonic rheostat described in the previous paper a slowly intermittent or permanent current is broken up into rapid intermittent currents, and then we are able to perceive feeble constant currents. For this reason a microphonic rheostat is joined to the telephone and coil. The current from a battery of two bichromate cells is sent constantly through the wire if we wish to observe the influence of the torsion of the wire upon the electric current, or a constant field of magnetic energy is given to the wire by either a separate coil or a permanent magnet. The currents obtained in the coil are induced from the change in the molecular magnetism of the wire, but we may equally obtain these currents on the wire itself without any coil by joining the telephone and rheotome direct to the wire; in the latter case it is preferable to join the wire to the primary of a small induction coil, and the telephone and rheotome upon the secondary, as then the rheotome does not interrupt the constant electric current passing through the wire. As the results are identical, I prefer to place the telephone on the coil first named, as the tones are louder and entirely free from errors of experimentation.

If we place a copper wire in the axis of the coil we produce no effect by torsion, either when under the influence of a constant magnetic field or a current passing through it, nor do we perceive any effects if we place an iron wire (2 millims. in diameter), entirely free from magnetism and through which an electric current has never passed. I mention this negative experiment in order to prove that all the effects I shall mention are obtained only through the magnetism of the wire. If now I pass an electric current for an instant through this same wire, its molecules are instantly polarised, and I have never yet been able to restore the wire to its original condition; and the magnetisation induced by the passage of a current is far more powerful and more persistent in soft iron than tempered steel. This may be due, however, to the fact that in tempered or softened steel we find traces only of a current during the rotation by torsion of its molecules some two to three degrees of sonometer, whilst iron gives constantly a current of 70 sonometric degrees.*

In order to obtain these currents, we must give a slight torsion of 5° or 10° to and fro between its zero point. We then have a current during the motion of the index to the right, and a contrary current in moving the index to the left. If we use a galvanometer, we must time these movements with the oscillations of the needle; but with the telephone it gives out continuous sounds for either movement, the interruptions being only those caused by the rheotome. The direction of the current has no influence on the result; either positive to the free arm or index or negative gives equal sounds, but at the moment of reversal of the current a peculiar loud click is heard, due to the rapid change or rotation of the polarisation of its molecules, and this peculiarly loud momentary click is heard equally as well in steel as in iron, proving that it is equally polarised by the current, but that its molecular rigidity prevents rotation by torsion. We can imitate in some degree the rigidity of steel by giving the iron wire several permanent twists. The current due to elastic torsion is then reduced from 70° to 40°, due to the mechanical strain of the twists remaining constant; and a weakening of the current is also remarked if with a fresh wire we pass in torsion its limit of elasticity.

If a new soft iron wire of 2 millims. (giving no traces of a current by torsion) has passed through it a momentary current of electricity, and then wire observed free from the current itself, it will be found to be almost as strongly polarised as when the current was constantly on, giving by torsion a constant of 50 sonometric degrees. If, instead of passing a current through this new wire, I magnetise it strongly by a permanent magnet or coil, the longitudinal magnetism gives also 70° of current for the first torsion, but weakens rapidly, so that in a few contrary torsions only traces of a current remain, and we find also its longitudinal magnetism almost entirely dissipated. Thus there is this remarkable difference, and it is that whilst it is almost impossible to free the wire from the influence produced by a current, the longitudinal magnetism yields at once to a few torsions. We may, however, transform the ring or transversal magnetism into longitudinal magnetism by strongly magnetising the wire after a current has passed through it; this has had the effect of rotating the whole of the molecules, and they are now symmetrical with longitudinal magnetism, then by a few torsions the wire is almost as free as a new wire; and I have found this method more efficacious than heating the wire red hot, or any other method yet tried. If I desire a constant current from longitudinal magnetism, I place at one of the extremities of the wire a large permanent magnet, whose sustaining power is 5 kilos, and this keeps the wire constantly charged, resembling in some respects the effects of a constant current. The molecular magnetism of the current obtained by torsion is not so powerful as that from this, my strongest magnet, as that produced by the simple passage of a current, being only 50 sonometric degrees in place of 70° for that due to the passage of a current. The mere twisting of the longitudinal magnet, without regard to the rotation of its molecule having no effect, is proved by giving torsion to a steel wire strongly magnetised, when only traces of a current will be seen, perhaps one or two degrees, and a constant source of magnetism or electricity then giving no measurable effect. Evidently we have equally twisted the magnetised steel as the soft iron. In the steel we have a powerful magnet, in the soft iron a very feeble one; still the molecular rotation in iron produces powerful currents to the almost absolute zero of tempered steel.

If we magnetise the wire whilst the current is passing, and keep the wire constantly charged with both magnetism and electricity, the currents are at once diminished from 70° to 30°. We have two distinct magnetic polarisations at right angles to each other, and no matter what pole of the magnet or of the current the effect is greatly diminished; the rotation of the two polarities would now require a far greater arc than previously. The importance of this experiment cannot as yet be appreciated until we learn of the great molecular change which has really occurred, and which we observe here by simply diminished effects.

If we heat the wire with a spirit flame, we find the sounds increase rapidly from 70 to 90, being the maximum slightly below red heat. I have already remarked in my previous paper this increased molecular activity due to heat, and its effects will be more clearly demonstrated when we deal with the sounds produced by intermittent currents.

Another method, by means of which I have again received proofs of the rotation of the polarised molecule, is to pass an intermittent current through a soft 0·5 millim. iron wire, listening to the results by the telephone joined direct and alone to the coil. If, then, the wire is entirely free from strain, we have silence, but a torsion of 20° produces some 50 sonometric degrees of electric force. If, now (the wire being at zero strain), I bring one pole of the permanent magnet I have already described near the side of the wire, the sounds increase from zero up to 50°, being at their maximum when this magnet is 5 centims. distant; but if we continue to approach the magnet the sounds gradually weaken to an almost zero. The explanation of this fact can be found when we know that the greatest inductive effect on the wire would be when a magnet is at an angle of 45° with the wire. And, also, considering each molecule as a separate independent magnet, we find that at a given distance for a given magnet the force of rotation is equal to that of 45°; by approaching the magnet we increase the rotation but diminish the angular polarity in relation to the wire, hence the decrease of force by the near approach of the magnet. And to prove that the function of the elastic torsion is simply to rotate the polarised molecules similarly to the magnet, we place the wire under an elastic torsion of 20°, and approach gradually the magnet as before. One pole now will be found to increase the sounds or its angular polarity, the other will decrease until at 5 centims. distance as before we have perfect silence; the torsion exists as before, but the molecules are no longer at the same angle. On removing the magnet we find that instead of the usual 50 of current we obtain barely 5 or 10; have we then destroyed the polarity of the molecules, or do they find a certain resistance to their free rotation to their usual place? To solve this question we have only to shake or give the wire a slight mechanical vibration, and then instantly the molecules rotate more freely, and we at once find our original current of 50°. I will forbear mentioning many other experimental proofs of my views by this method, as there are many to relate by different methods in the following chapters.

(*To be continued.*)

* A paper read at the Royal Society on May 10.

* 0·8 of a Daniell battery.

51

for the Chamber Organ (see *Department* of PED.-BOARD) there can *always* be insured ½ an in. land at bottom of Plinth, even when the Pedal Keys are only 3½ in. above the bottom edge of Plinth (measuring from latter to upper edge of [Ped.] Naturals; see 81, z).

(*To be concluded.*)

MOLECULAR MAGNETISM.*

By Prof. D. E. Hughes, F.R.S.

(*Concluded from page 276.*)

2. Influence upon the Molecular Structure of an Iron or Steel Wire by Electricity or Magnetism.

BEING desirous to modify the apparatus already described, so that it would only give indications of a current if they were of a spiral nature, the wire was kept rigidly at its zero of strain or torsion, and the coil was made so that it could revolve on an axis perpendicular to the wire; by this means, if the wire was free from strain, the centre or axis of the coil would coincide with that of the wire. Thus with a straight copper wire, we should have a complete zero, but if this wire formed a right or left-handed helix, the coil would require moving through a given degree (on an arbitary scale) corresponding to the diameter and closeness of the spirals in the helix; the degrees through which the coil moved, were calibrated in reference to known copper helices. 50° equalled a copper wire 1 millim. diameter, formed into a helix of 1 centim. diameter, whose spiral turns were separated 1 centim. apart.

In order to obtain a perfect zero and wide readings, with small angular movement of the coil, it is necessary that the return wire should be of copper, 2 millims. diameter, offering comparatively little resistance, and that it should be perfectly parallel with the steel or iron wire. In order that it may react upon the exterior of the coil, it is fastened to the board, so that it is near (1 centim.) the exterior of the coil, and parallel to the iron wire, at a distance of 4 centims. If we consider this return wire alone, we find, as in the sonometer, that if the wire is perpendicular to the exterior wires of the coil, we have a zero or silence, but moved through any degree, we have a current proportionable to that degree; by this means we have an independent constant acting on the coil, constantly aiding the coil in finding its true zero, and allowing of very wide readings, with a comparatively small angular movement of the coil.

The rheotome is joined to a battery of two bichromate cells, and by means of a reversing switch an intermittent current of either direction can be sent through the wire. The telephone is joined direct and alone to the coil, thus no currents react upon the coil when perpendicular to the iron, and its return wire, if not of a spiral nature.

Placing an iron wire 0·5 diameter, and passing a current through it, I found a change had taken place similar to those indicated in my second paper (p. 106), but it was so difficult to keep the wire free from magnetism and slight molecular strains, that I preferred and used only in the following experiments tempered steel wire (knitting needles I found most useful). All the effects are greatly augmented by the use of iron wire, but its molecular elasticity is so great that we cannot preserve the same zero of reading for a few seconds together, whilst with steel, 0·5 millim. diameter, the effects remained a constant until we removed the cause.

I have not as yet been able to obtain a steel wire entirely free from magnetism, and as magnetism in steel has a remarkable power over the direction of the spiral currents, I will first consider those in which I found only traces. On passing the intermittent current through these, the sounds were excessively feeble for either polarity of current, but at each reversal a single loud click could be heard, showing the instant reversal of the molecular polarity. The degree of coil indicating the twist or spirality of the current was 5° on each side of its true zero. The wire was now carefully magnetised, giving 10° on each side for different currents. The positive entering at north pole indicating 10° right-handed spiral, negative entering the same pole, a left-handed spiral, we here see in another form, a fact well known and demonstrated by De la Rive by a different method, that an electric current travels in spirals around a longitudinal magnet, and that the direction of this spiral is entirely due to which pole of an electric current enters the north or south pole. I propose soon, however, to show that under certain conditions these effects are entirely reversed.

If through this magnetised wire I pass a constant current of two bichromate cells, and at the same time an intermittent one, the spiral is increased to 15°, but the direction of the intermittent current entirely depends on that of the constant current; thus, if the positive of the constant current enters the north pole, the intermittent positive slightly increases the spiral to 17°, and the negative to 13°, both being right-handed; the two zeros of the constant battery are, however, as we might expect from the preceding experiment, on equal opposite sides of the true zero; but if we magnetise the wire whilst a constant current is passing through it, a very great molecular disturbance takes place; loud sounds are heard in the telephone, and it requires for each current a movement of the coil of 40°, or a total for the two currents of 80°. This, however, is not the only change that has taken place, as we now find that both constant currents have a right-handed spiral; the positive under which it was magnetised a right-handed spiral of 95°; the negative, a right-handed spiral of 15°, and the true central or zero point of the true currents indicates a permanent spiral of 55°.

This wire was magnetised in the usual way, by drawing the north pole of my magnet from the centre to one extremity, the south from the centre to the other, and this repeated until its maximum effects were obtained; in this state I found, sliding the coil to different portions, that the spiral currents were equal, and in the same direction throughout.

It now occurred to me to try the effect of using a single pole of the magnet; this was done whilst a constant current was passing through the wire, commencing at the extremity, where the positive joined, drawing the north pole through the length of the wire, from positive towards the negative; the effect was most remarkable, as the steel wire now gave out as loud tones as a piece of iron, and the degree on the coil showed 200°. The constant and intermittent currents now showed for either polarity a remarkably strong right-handed twist; the positive 200 right, and the negative 160 right-handed spirals; the molecular strain on its wire from the reaction of the electric current upon the molecular magnetism was so great, that no perfect zero could be obtained at any point, a fact already observed when a wire was under an intense strain, producing tertiary currents that superposed themselves upon the secondary. In order to compare these spiral currents with those obtained from a known helix, I found that taking a copper wire of similar diameter (0·5 millim.), and winding it closely upon the steel wire ten turns to each centimètre, having a total of 200 turns, with an exterior diameter of 1·5 millims., withdrawing the steel wire, leaving this closely wound helix free, that it gave some 100°, instead of the 200 of the steel wire alone; thus the spiral currents fully equalled a closely wound copper wire helix of 200 turns in a similar length.

If it were possible to twist a magnetised wire several turns to the right, and that its line of magnetism would coincide with that of the twist, then on passing a positive or negative current, there would be an apparent augmented or diminished spirality of the currrent, but both would have a right-handed twist. The result would be identical with the phenomenon described, although the cause is different.

The explanation of this phenomenon can probably be found in the fact that the constant spirality now observed is that of the electric current under which it was magnetised, for whilst magnetising it we had a powerful source of magnetism constantly reacting upon the electric current, and the constant spirality now observed is the result or remains of a violent molecular reaction at the instant of magnetisation, and the remaining evident path or spiral is that of the electric current. On testing this wire as to its longitudinal magnetic force, I found that it was less than a wire simply magnetised in the usual way; thus the effects are internal, affecting the passage of the electric current, giving, however, no external indications (except apparent weakness) of the enormous disturbance which has taken place.

If, instead of drawing the north pole of the magnet as above, from positive towards negative, I draw it from negative to positive, all the effects are repeated, except we have now, as we should expect, a left-handed spiral, but if I draw the magnet from the extremities of the wire to the centre, then at this centre I find an absolute zero of twist, but on each side a contrary twist, the wire then having a left and right-handed twist, the positive travelling towards the centre in a right-handed twist gradually ceasing in zero; this is as we might expect, but if done under the influence of a constant current, no matter what pole of the battery enters afterwards the north pole of the magnet, it will have during its first half a right-handed, and in its second a left-handed spiral. It became important to know if a wire, which had been magnetised under the influence of a current, could be restored to something like its original condition. Electric currents had no effect. Heat, which would not destroy its temper, had no effect. Mechanical vibrations and torsions failed to disturb the molecular arrangement; but by magnetising it strongly by a magnet, when no current was passing, at once brought the wire to its usual apparently rigid state, and the constant or intermittent currents now indicated only 18° of spiral currents against a previous 200°, and the sounds were, as usual, from steel, excessively weak. I have since used this method with invariable success, when I wished to preserve or repeat the experiments upon the same wire. If these experiments are repeated on an iron wire, the effects are far greater in the first instance, so great that they were thrown out of the range of my measurements; it was only after a few seconds of successive reversals that the zero of the wire was brought within range, and although these rapidly decreased, exactly similar effects were observed as in the steel, and as with all moderate ranges, I could bring the iron at once to a complete zero by torsion, and as torsion alone would produce this complete zero, I believe we have here effects from identical causes to those related in the first chapter.

Having noticed in my previous papers the increased molecular activity caused by the approach of a powerful permanent magnet, and believing that the permanent spirality above mentioned was due to this alone, and not to an increased polarity, I magnetised strongly an iron wire giving, as usual, a reversed spiral for different currents of but 10°. I now heated the wire by a spirit-flame to a dull-red heat, whilst the current was passing through it, and on cooling I found a similar but stronger permanent torsion of 250°; both currents, as in the previous experiments, have a right-handed spiral. Thus, a current of electricity passing through a wire, nearly red hot, determines molecular arrangement, or path, which, on cooling, forces currents of either direction to follow the path which had been determined under the influence of heat.

3. Molecular Sounds.

The passage of an intermittent current through iron or other wire gives rise to sounds of a very peculiar and characteristic nature. Page, in 1837, first noticed these sounds on the magnetisation of wires in a coil. De la Rive published a chapter in his "Treatise on Electricity" (1853) on this subject, and he proved that not only were sounds produced by the magnetisation of an iron wire in an inducing coil, but that sounds were equally obtained by the passage direct of the current through the wire. Gassiot, 1844, and Du Moncel, 1878-81, all have maintained the molecular character of these sounds. Reis made use of them in his, the first electric telephone invented, and these sounds have been, since the appearance of Bell's telephone, often brought forward as embodying a new form of telephone. These sounds, however, for a feeble source of electricity, are far too weak for any applied purposes, but they are most useful and interesting where we wish to observe the molecular action which takes place in a conducting wire. I have thus made use of these sounds as an independent method of research, and by their means verify any point left doubtful by other methods, some of which I have already described.

The apparatus was the same as in the last chapter, except that no telephone was used. The intermittent electric current was connected by means of switch key, either with the coil inducing longitudinal magnetism in the wire, or could be thrown instantly through the wire itself, thus rapid observations could be made of any difference of tone or force by these two methods; a reversing key also allowed when desired a constant current of either polarity to pass through the wire under observation.

Iron of all metals that I have yet tried gave by far the loudest tones, though by means of the microphone I have been able to hear them in all metals; but iron requires no microphone to make its sounds audible, for I demonstrated at the reading of my paper, March 31st, that these sounds with two bichromate cells were clearly audible at a distance. A fine soft iron wire (No. 28) is best for loud sounds to be obtained by the direct passage of the current, but large wires (1 millim.) are required for equally loud tones from the inducing coil. By choosing any suitable wire between these sizes we can obtain equal sounds from the longitudinal magnetism or direct current. The wire requires to be well annealed; in fact, as in all preceding experiments, the sounds are fully doubled by heating the wire to nearly red heat. There are many interesting questions that these molecular sounds can aid in resolving, but as I wish to confine the experiments to the subject of the two preceding chapters, I will relate only a few which I believe bear on the subject.

On sending an intermittent electric current through a fine soft iron wire we hear a peculiar musical ring, the cadence of which is due to that of the rheotome, but whose musical note or pitch is independent both of the diameter of the wire and the note which would be given by a mechanical vibration of the wire itself. I have not yet found

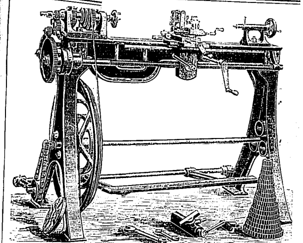
* A Paper read at the Royal Society on May 10.

52 Eng. Mech. + World of Science Jan 2, 1885

THE NATURE OF ELECTRICITY.

IN two lectures recently delivered before the Royal Institution, Prof. O. J. Lodge, F.R.S., endeavoured to explain to crowded audiences the modern views of the real nature of electricity. It was often said, he remarked, that we did not know what electricity was, and the statement was still largely true, but it was not so true as it was twenty years ago. Some things were beginning to be known about it, and though modern view were tentative, and might well require modification, nevertheless, some progress had been made, and it was not unsuitable at the beginning of a new year of progress and discovery to try and set forth the position of thinkers on electrical subjects at the present time. It had been discovered by Faraday and by Clerk-Maxwell how like the behaviour of electricity was to that of an incompressible fluid or liquid. One was not thereupon justified in asserting that electricity was a liquid, but it was perfectly certain that it behaved in many respects exactly like one, and it was, therefore, a step necessary to be made to understand and grasp the analogy between electricity and a liquid—in other words, to develop a liquid theory of electricity. Let them imagine a fish in the deep sea; he was surrounded and permeated by water, but must be completely unconscious of its existence. For a fish near the surface even to postulate the existence of water from the effects of currents and waves would be an act of scientific discovery analogous to our discovery of the existence of the atmosphere; but for a fish in the serene depths of the ocean the discovery of water would be an almost impossible one. Now, we were living immersed in electricity in precisely the same way, but we were in a more favourable position for discovering its existence, because it behaved for the most part more like a liquid entangled in some elastic medium or jelly than like a freely moving liquid. Substances in which it could freely move about were called conductors, substances in which it was entangled were insulators or dielectrics. Conductors must be regarded as holes and tubes in the jelly, permitting storage and transfer. The jelly was such as only to resist the motion of electricity; it permitted the free locomotion of ordinary matter. The existence of these two classes of bodies, conductors, and insulators, had enabled the human race with difficulty at length to discover the existence of this all-permeating liquid. An electrical machine was to be regarded as a pump which could transfer the fluid from one cavity to another; thus charging one conductor negatively, the other positively. Charge was to be regarded as either excess or defect from the normal supply of fluid, causing a strain. Electrical attraction and repulsion were all explicable by the strains thus set up in the surrounding elastic medium or jelly. The increase of the capacity of a conductor by bringing an earth-connected body near it was accurately representable by thinning the elastic coat surrounding a cavity, and a hydrostatic model of a Leyden jar could be easily made with an elastic bag inside a rigid vessel, with pressure gauges for electrometers; this behaved in all respects exactly as a Leyden jar—exhibiting discharge by alternate contacts and everything. Discharge was typified by a relaxing of the strain and by twisting of the dielectric medium in some place. Certain phenomena connected with discharge suggested obscurely that what we called negative charge was not merely a defect of supply, but was a supply of a something of an opposite kind—that there were, in fact, two electricities, positive and negative, which combined together into a neutral liquid. It might be that the other was then composed, and that what we called an electric current was really the simultaneous transfer of the true components of this liquid in opposite directions, and that strains in dielectrics were due to attempted shear of the other. The phenomena of electrolysis strongly suggested and supported this view. Was any other motion possible to a liquid? Yes, a whirling and vibrating motion. By coiling up a conductor so as to get an electrical whirl, we discovered that we had produced a magnet, and all the phenomena of magnetism could be developed on the hypothesis that magnets consisted of such electrical whirlpools. One whirl had the power of exciting another in neighbouring conductors, and these so excited whirls were repelled. In this way could be explained the phenomena of diamagnetism. A disc of copper at the end of a torsion arm was repelled by a magnet until the current induced in it had died away, which was very soon in that particular case; but currents in molecules might, for all we knew, last for ever until actively destroyed. Atoms were already endowed with perfect elasticity—why not with perfect conductivity too? Finally, electricity in vibration, if rapid enough, constituted light; and it was easy to see that on this hypothesis conductors must be opaque, and that transparent bodies must insulate, which agreed with observation. If a ray of light were passed along a line of magnetic force, it ought to be twisted, as was shown by the pertinacious experimental power of Faraday before the fact could be understood and before the scientific world was ready to receive it. The profound significance of this fact was first perceived by Sir William Thomson, and stated by him in a most powerful and remarkable note, and upon this Maxwell founded his electrical theory of light. "I have endeavoured," added the lecturer, "to give you pictorial and mechanical representations of electrical phenomena, and thus to lead you a step in the direction of the truth; but I must beg you to remember, that it is only a step, and that what modifications and addenda will have to be made to the views here explained I am wholly unable to tell you."

53



THE BRITANNIA COMPANY'S SCREW-CUTTING LATHES.

ON page 101, Vol. XXXIII., we illustrated and described a new self-acting screw-cutting lathe, brought out by the Britannia Company, as a serviceable machine at a low price. At that time there was nothing like it in the market, and so much success has followed its introduction, that the company now make larger lathes of the same design, which have received the attention of the Government in the shape of orders, the best of testimonials. The illustration in Vol. XXXIII. represented lathe No. 13. The present engraving serves for either No. 15 or No. 16, the difference being only in dimensions and weight. Supposing it to represent No. 15, it is a self-acting, sliding, and screw-cutting lathe, with a 4ft. gap-bed, and centres of 4, 4½, and 5in., as may be desired, at a small difference in cost. The cast-steel mandrel has conical necks running in gun-metal collars; the cone pulley has three speeds for gut band, and is fitted with reversing motion for cutting right or left-hand screws. The compound slide-rest has long bearings, the top slide swivelling to 50° each side of centre. The bed is 6¾in. wide, and 4⅞in. deep, with a gap of 4⅞in. The lead screw is 1⅛in. diameter, and ½in. pitch, and the gun-metal nut is in halves, so as to be readily detached. There is a rack and pinion for quick return. A full set of twenty-two change-wheels, to cut from one to sixty threads per inch, is supplied, and the lathe can be fitted with overhead motion for a comparatively small extra charge. The No. 15 lathe measures 2ft. 6in. between centres, swings 1ft. 4in. in gap, and 8in. over bed; but, as mentioned above, it can be had with 5in. centres. The No. 16 lathe is similar in design and fitting, but is much heavier. It is nominally a 5in. lathe, with a 6ft. gap-bed, the gap being 5½in. deep, by 6½in. wide, but it can be had, at a small extra cost, with 6ft. bed, 6in. centres, and with flat pulleys for belts. The Company make larger lathes, but Nos. 13, 15, 16 are especially adapted for the amateur's workshop, and for any purposes to which a foot-lathe is applicable. They, in fact, supply a want—a cheap sliding and screw-cutting lathe.

THE AGE OF ELECTRICITY.*

By Prof. S. P. Thompson.

IT is the fashion amongst ethnologists to classify the successive stages of development in the primitive races of mankind by reference to the kind of implement which marked the degree of civilisation to which they had attained. A chipped flint arrow, a bronze spear-head, an iron dagger are typical of the several grades of advancement in material civilisation which we familiarly name the age of stone, the age of bronze, the age of iron. To these three primitive ages you must allow me to add three others, equally well defined—the age of gunpowder, the age of coal and steam, and the age of electricity. The world is even now entering upon a new, and I am fain to believe a happier, age, wherein, whilst delivered to a large degree from the darker aspects, we shall enjoy to a degree hitherto unknown the advantages of machine-aided production. Our machinery will be driven, not by steam, but by electricity; for electricity will be our servant to do the hard work of the world in the coming age. For a quarter of a century we have harnessed that messenger, more nimble than fleet-footed Iris, to convey our thoughts. We have but lately discovered that electricity could also convey the actual tones of our speech. It is electricity that rings our bells, that silvers our pewter and gilds our pinchbeck, that fires our torpedoes, and brings Greenwich time to our clocks. True, these are light and easy duties, but it has taken us many years to adopt in practical life these simplest applications. And, mark you, the delay is not to be imputed to science, for science has known most of these things for forty years. Mines were fired by electricity in 1749; electro-plating with silver was discovered in 1805; an electric telegraph was in actual operation in London in 1816; electric bells were invented in 1831; electric clocks were made in 1840; and speech was transmitted by an electric telephone in 1861. But, familiar as are these services to mankind, there are other services of a very important nature which electricity is perfectly competent to perform which, unless the world has grown wiser, will not, I suppose, be generally adopted for the next 40 years. Electricity can bring us a magnificent and economical light. It can smelt our most refractory metals. It can bleach our cottons and print our calicoes. It can detect base coins without cutting them, and can discover a bullet in a wound without probing it. It can stencil our circulars, grind our coffee, gather our apples and walnuts, protect us against burglars, turn our sewing machines, drive our tricycles. Nay, it can perform much heavier work. It can turn lathes, saw timber, grind scissors and knives, plane planks, propel tramcars, and, as I can personally testify, can furnish motive power of a very effective kind to an iron boat. Surely we have reason to say that the age of electricity has already begun. The success of primitive attempts to utilise electricity as a motive power was not very encouraging, for their cost was great and their power weak. The fact was that though the machinery—on a small scale at any rate—was ready, the time was not ripe for it. Compact and light in weight, these little electric motors presented, for light kinds of work, an enormous advantage over steam-engines; yet these advantages were far outweighed by the consideration that the cost of generating electric currents in the voltaic battery

* From a lecture delivered Octob.r 7, at the University ...ge, Bristol.

ato opponents. If the bill now before the Commons eaches the House of Lords by the middle of July, the ate of the ventilators is sealed. There will, we fear, o a desperate effort to obstruct the measure on the part f the railway interest, however, and it is just possible hat its passage may be postponed until next session.

A GREAT WIRE ROPE.

The great driving-rope which is to pull the cars across he new Brooklyn bridge has arrived at New York. The ope is 1½ inch in diameter, 11,700 feet long, and weighs 9 tons. It is accompanied by a duplicate rope of the ame weight and strength, which is to be held in reserve or use when the first rope wears out. The test which it has been subjected to gives ample assurance of its strength. Before it left the works, every wire held at least 1,000 lb., and was stretched from 4 to 6 per cent. more. In order to protect it from the atmosphere, and also to supply to the nterior a kind of lubricator when it comes to be used, he rope has received a coating of tar. The rope was manufactured by the J. A. Roebling Company's Wire-works, Trenton, New Jersey.

A NEW STEELWORKS.

The North-Eastern Steel Company made their first heat of steel in the Bessemer department on May 31, with highly satisfactory results, the rolling operations, both of blooms and finished rails, being also very successfully conducted at the same time. The works (as we learn from the *North-Eastern Daily Gazette*, from which the following particulars have been taken) are situated in the marshes on land adjoining the North-Eastern Railway Company's marsh sidings at Middlesbrough. They occupy 22 acres of ground, which is in the form of a triangle lying with its base towards the river—the river itself being the north boundary. The general manager (Mr. Cooper) in planning the works has contrived that the basic shop shall be at the northern end of the land, and the Bessemer shop, cogging and rail mills, and finishing shop, shall follow in the order named towards the south. The raw material for the lining of the vessels is taken up an incline and shot into bunkers, from which it is drawn in barrows, and elevated by means of a hydraulic hoist to a height of 34 feet, where it is charged into the basic cupolas, three in number, and there burnt. When sufficiently burnt it is drawn out at the bottom and allowed to cool on the floor, and sorted. It is then loaded into barrows and taken up another hoist, and shot into hoppers over the stone crushers. Passing through the crushers it again falls into hoppers, from which it is emptied by gravitation into several other grinding and mixing machines. By means of this machinery it is mixed with a certain quantity of tar to the consistency of stiff paste. It is then considered in proper form for lining the converters, and for the making of converter plugs. When the converters are lined, fire and coke are put into them until the lining is sufficiently baked. The converter shells, whilst being lined, are ranged under a 30-ton steam travelling crane, having a span of 45 feet, by which means they are readily handled and moved to any desired position. After being lined they are placed upon suitable carriages and taken underneath the converter stage, and are lifted into position either by means of an hydraulic jack-ram or a 60-ton steam travelling crane, as the case may be. The firm propose to work, eventually, on the direct system—that is, taking molten iron from the surrounding furnaces direct to the converter; but at present they are working cold pig only, which is, of course, bought in the Cleveland and surrounding district.

The pig-iron cupolas, three in number, are arranged so that the raw material is taken up to a height of 21 feet by means of a 20-ton hydraulic lift, and there charged with the necessary quantity of coke and limestone. When melted the iron is drawn out on the ground floor into 12-ton ladles, and then pushed forward by means of a small locomotive to another 20-ton lift, by which it is hoisted to the converters' stage level, which is 21 feet above the ground line, also on the same level as the charging stage. It is then pushed forward to the front of the converter by a small locomotive which is in waiting on the converter staging. The ladle is then tipped by means of a worm-and-wheel into a short spout, from which it runs into the converter. The ladle is withdrawn, the blast is put on, the vessel turned up, and the process of blowing begun. After the usual careful tests have been taken, and the steel found to be sufficiently blown, it is poured into a ladle carried by a transfer crane. This crane receives from two converters, another similar crane receives from other two converters, there being four 15-ton converters in the plant. The steel in the ladle carried by the transfer crane is poured into another ladle carried by a centre casting crane, which covers a pit 60 feet in diameter. This crane was specially designed for the plant by Messrs. Head & Wrightson, of Stockton, the type having been patented by Mr. Wrightson. In this pit moulds of any required form are placed, and steel is then drawn off, ingot by ingot, until the ladle is exhausted. The ingot moulds are removed by means of four 6-ton cranes, which are arranged round the pit, and the ingots are placed on bogies and taken to Mr. Gjers' soaking pits. After remaining in these pits about twenty minutes, they are taken out by a hydraulic crane, which lifts them on to the cogging mill rollers. The cogging mill has rolls 36 inches diameter, and 7 feet 6 inches long. The engines for driving this mill have cylinder 40 inches diameter, 5 feet stroke, and geared at 2 to 1. In this mill large slabs 16 inches wide will be made; also rail blooms for export or the English trade. The bloom, or slab, having been brought down to the required size in the mill, is passed forward by means of life-rollers to the bloom shears, where the crop ends are cut off, and the bloom itself cut to any requisite length. The blooms, if required for export, are then placed on a skid and moved along to the outside of the mill, where they are arranged on extensive banks for inspection; but if they are to be still further manipulated, they are run down by means of life-rollers to the roughing mill. The roughing rolls are 28 inches diameter and 7 feet long, and are driven by a pair of engines having cylinders 50 inches diameter and 5 feet stroke, working direct. The bloom here is again passed backwards and forwards until it reaches the desired form. On coming out of the last hole it is directed to a train of rollers, which takes it to the billet shears or the rail saw, as the case may be. If billets are being made, after being cut to requisite length they are taken on a skid to the outside of the mill, as in hot banks, and allowed to cool. When sufficiently cooled, they are removed by means of two 3-ton steam portable cranes to the cold banks, thence to the straightening machines and rail drills, and afterwards to the benches, where they are inspected and loaded on trucks, which are placed in docks alongside these benches. The company have commodious sidings connected, of course, with the North-Eastern Railway system. Such is a brief account of the works as they now stand; but the company have in reserve 13 acres of land for further extensions.

THE APPLICATIONS OF ELECTRICITY.*

The last of the series of six lectures on the practical applications of electricity, being on "Electrical Units of Measurement," by Sir William Thomson, F.R.SS.L. and E., M.I.C.E., was delivered on May 3, at the Institution of Civil Engineers. The following is an extract of the lecture:—

The lecturer began by observing that no real advance could be made in any branch of physical science until practical methods for a numerical reckoning of phenomena were established. The "scale of hardness" for stones and metals used by mineralogists and engineers was alluded to as a mere test in order of merit in respect to a little understood quality, regarding which no scientific principle constituting a foundation for definite measurement has been discovered. Indeed, it must be confessed that the science of strength of materials, so all important in engineering, is but little advanced, and the part of it relating to the quality known as hardness least of all. In the last century Cavendish and Coulomb made the first advances towards a system of measurement in electrical science, and rapid progress towards a complete foundation of the system was effected by Ampère, Poisson, Green, Gauss, and others. As late as ten years ago, however, regular and systematic measurement in electrical science was almost unknown in the chief physical laboratories of the world; although as early as 1858 a practical beginning of systematic measurement had been introduced in the testing of submarine telegraph cables. A few years have sufficed to change all this, and at this time electric measurements are of daily occurrence, not in our scientific laboratories only, but also in our workshops and factories where is carried on the manufacture of electric and telegraphic apparatus. Thus, ohms, volts, ampères, coulombs, and micro-farads are now common terms, and measurements in these units are commonly practised to within 1 per cent. of accuracy. It seems, indeed, as if the commercial requirements of the application of electricity to lighting and other uses of every-day life were destined to influence the higher region of scientific investigation with a second impulse, not less important than that given thirty years ago by the requirements of submarine telegraphy. A first step toward the numerical reckoning of properties of matter, is the discovery of a continuously-varying action of some kind, and the means of observing and measuring it in terms of some arbitrary unit or scale division; while the second step is necessarily that of fixing on something absolutely definite as the unit of reckoning.

A short historical sketch was given of the development of scientific measurement, as applied to electricity and magnetism, from its beginning with Cavendish, about 100 years ago, to the adoption of the absolute system of measurement by this country in 1869, at the instance of the British Association Committee on Electric Standards. The importance in this development of the originating works of Gauss and Weber was pointed out, as also of the eight years' labours of the British Association committee. This committee not only fairly launched the absolute system for general use, but also effected arrangements for the supply of standards for resistance coils, in terms of a unit, to be as nearly as possible 10^9 centimetres per second. This unit afterwards received the name of the ohm, which was adopted from a highly suggestive paper which had been communicated to the British Association in 1861 by Mr. Latimer Clark and Sir Charles Bright, in which some very valuable scientific methods and principles of electric measurement were given, and a system of nomenclature—ohms, kilohms, farads, kilofarads, volts, kilovolts—now universally adopted with only unessential modification, was proposed for a complete system of inter-dependent electric units of measurement. At the International Conference for the Determination of Electrical Units, held at Paris in 1882, the absolute system was accepted by France, Germany, and the other European countries; and Clark and Bright's nomenclature was adopted in principle and extended. Gauss' principle of absolute measurement for magnetism and electricity is merely an extension of the astronomer's method of reckoning mass in terms of what may be called the universal gravitation unit of matter, and the reckoning of force, according to which the unit of force is that force which, acting on unit of mass for unit of time, generates a velocity equal to the unit of velocity. The universal gravitation unit of mass is such a quantity of matter, that if two quantities, each equal to it, be placed at unit distance apart, the force between them is unity. Here mass is defined in terms of force and space, and in the preceding definition force was defined in terms of mass, space, and time. Eliminating mass between the two, it will be found that any given force is numerically equal to the fourth power of the velocity with which any mass whatever must revolve round an equal mass, fixed at such a

* See pages 158, 227, 291, 301, 377, *ante*.

hand to gain their confidence, and they easily learn to come to take it without fear. The young chicks are given a few earth-worms to counteract any tendency to constipation when first put upon the dry, fine feed, and that is the only medicine they ever get or require.

We have heretofore had to contend with all the ills to which chickens are supposed to be heirs, and have used innumerable nostrums, scarcely ever raising a brood free from ailments. But for the last two years no lice, no gapes, no influenzas, no deformities or weaknesses have invaded our precincts. Our eggs are large, rich and fertile, scarcely any failing to hatch; our chicks are healthy, vigorous, independent, and rapid growers. The old fowls are now beginning to moult. We sold once nine dozen eggs per hen in the first six months of the year, besides all we used in the family, and that is the primary object of keeping the fowls.

THREE USEFUL HINTS.

The nuts on hand-hole plates at the rear end of a horizontal tubular boiler, being exposed to considerable heat, are very apt to stick. The most common way of removing them is to use a hammer and chisel, which either breaks the bolt or takes the corners off the nuts. My plan (writes a correspondent of the *American Machinist*) is, at night to saturate a piece of cotton waste with kerosene oil and lay it over the nut till the next morning; then I frequently find I can remove it with my fingers, not requiring even a wrench.

It frequently takes hard hammering to get manhole covers loose. I fill the annular space around the outside with kerosene, and the next morning find the rubber and scale entirely loose, and can remove the cover without trouble.

To cut a water-line glass to right length, I wind a fine cord each side of where I want to break it, leaving room between the two cords for a thicker cord; then put cloth around the glass and hold it in the vice, pass the thick cord (about 3ft. long) once round the glass between the two cords, pull it back and forth till it burns, cool the hot place in the glass with water, and it will break square across. This is much better than using a file, as then you are never sure where the glass will break.

Hudson's Bay as a Grain Route.—The Newfoundland sealing steamship *Neptune*—the same which two years ago was sent in search of Lieut. Greely—sailed from Halifax, N.S., July 22, in command of Lieut. A. R. Gordon, of the Canadian meteorological service, for the purpose of establishing stations for scientific observations in Hudson's Bay. The stations are to be located six on the strait and one on the west shore of the bay. At all the stations the usual meteorological observations will be made; heavy tides will be measured; the drift of water will be noticed, and the conditions and state of the ice. Each station party will consist two men and an Esquimau interpreter, besides the officer in charge, and sufficient provisions and fuel for fifteen months will be supplied. The observatories are made in sections, and will be taken out by the steamer, and put up on the sites selected by the commander as the vessel progresses through the strait. Next year these stations will be revisited, and other parties left in charge. The most important work the parties will be called upon to perform will be to carefully watch and note the breaking up of the ice, the tides, and all other characteristics pertinent to navigation. The sum of 70,000 dols. has been appropriated by the Canadian Government to make these explorations; but the immediate end in view is practical rather than scientific. It is thought that, notwithstanding all the unfavourable reports so far received, it may be found that Hudson Strait is open a sufficiently long period in the late summer and early fall of each year to make it profitable to ship grain by that way to Liverpool from the Winnipeg Valley, which is directly connected with the western shore of Hudson's Bay by the Nelson and Churchill rivers. Lieut. Gorringe investigated this question about three years ago, on behalf of the Northern Pacific Railroad Company, but he reported that any successful trade in this way was impracticable, on account of the fogs as well of the ice, which would hardly leave an average period of six weeks for tolerably safe navigation, while even this period varied with the season, and during such time navigation was often interrupted. The Manitobans are not yet convinced, however, and the recent rapid growth of that province has induced the Dominion government to send out this expedition to make a more thorough investigation.

It has been found that a mixture of seventy parts of air and thirty parts of hydrogen gas ignites at a temperature between 1,026° and 1,028° Fah., while the ignition point of a mixture of coal gas with air in similar proportions varies from 1,202° to 1,216°.

BRITISH ASSOCIATION.

PRESIDENT'S ADDRESS.

The fifty-fourth annual meeting of the British Association for the Advancement of Science, was opened at Montreal on Wednesday last, the 27th inst., by Lord Rayleigh, M.A., F.R.S., Professor of Experimental Physics in the University of Cambridge, with the following address :—

It is no ordinary meeting of the British Association which I have now the honour of addressing. For more than fifty years the Association has held its autumn gathering in various towns of the United Kingdom, and within those limits there is, I suppose, no place of importance which we have not visited. And now, not satisfied with past successes, we are seeking new worlds to conquer. when it was first proposed to visit Canada, there were some who viewed the project with hesitation. For my own part, I never quite understood the ground of their apprehension. Perhaps they feared the thin edge of the wedge. When once the principle was admitted, there was no knowing to what it might lead. So rapid is the development of the British Empire, that the time might come when a visit to such out-of-the-way places as London or Manchester could no longer be claimed as a right, but only asked for as a concession to the susceptibilities of the English. But, seriously, whatever objections may have at first been felt soon were outweighed by the consideration of the magnificent opportunities which your hospitality affords of extending the sphere of our influence and of becoming acquainted with a part of the Queen's dominion which, associated with splendid memories of the past, is advancing daily by leaps and bounds to a position of importance such as not long ago was scarcely dreamed of. For myself, I am not a stranger to your shores. I remember well the impression made upon me, seventeen years ago, by the wild rapids of the St. Lawrence, and the gloomy grandeur of the Saguenay. If anything impressed me more, it was the kindness with which I was received by yourselves, and which I doubt not will be again extended, not merely to myself, but to all the English members of the Association. I am confident that those who have made up their minds to cross the ocean will not repent their decision, and that, apart altogether from scientific interests, great advantage may be expected from this visit. We Englishmen ought to know more than we do of matters relating to the Colonies, and anything which tends to bring the various parts of the Empire into closer contact can hardly be overvalued. It is pleasant to think that this Association is the means of furthering an object which should be dear to the hearts of all of us; and I venture to say that a large proportion of the visitors to this country will be astonished by what they see, and will carry home an impression which time will not readily efface.

To be connected with this meeting is, to me, a great honour, but also a great responsibility. In one respect, especially, I feel that the Association might have done well to choose another President. My own tastes have led me to study mathematics and physics rather than geology and biology, to which naturally more attention turns in a new country, presenting as it does a fresh field for investigation. A chronicle of achievements in these departments by workers from among yourselves would have been suitable to the occasion, but could not come from me. If you would have preferred a different subject for this address, I hope, at least, that you will not hold me entirely responsible.

At annual gatherings like ours, the pleasure with which friends meet friends again is sadly marred by the absence of those who can never more take their part in our proceedings. Last year my predecessor in this office had to lament the untimely loss of Spottiswoode and Henry Smith, dear friends of many of us, and prominent members of our Association. And now, again, a well-known form is missing. For many years Sir W. Siemens has been a regular attendant at our meetings, and to few indeed have they been more indebted for success. Whatever the occasion, in his Presidential Address of two years ago, or in communications to the Physical and Mechanical Sections, he had always new and interesting ideas, put forward in language which a child could understand, so great a master was he of the art of lucid statement in his adopted tongue. Practice with Science was his motto. Deeply engaged in industry, and conversant, all his life, with engineering operations, his opinion was never that of a mere theorist. On the other hand, he abhorred rule of thumb, striving always to master the scientific principles which underlie rational design and invention.

The Conditions of Successful Invention.

It is not necessary that I should review in detail the work of Siemens. The part which he took, during recent years, in the development of the dynamo-machine must be known to many of you. We owe to him the practical adoption of the method, first suggested by Wheatstone, of throwing into a shunt the coils of the field-magnets, by which a greatly improved steadiness of action is obtained. The same characteristics are observable throughout—a definite object in view and a well-directed perseverance in overcoming the difficulties by which the path is usually obstructed.

These are, indeed, the conditions of successful invention. The world knows little of such things, and regards the new machine or the new method as the immediate outcome of a happy idea. Probably, if the truth were known, we should see that, in nine cases out of ten, success depends as much upon good judgment and perseverance as upon fertility of imagination. The labours of our great inventors are not unappreciated, but I doubt whether we adequately realise the enormous obligations under which we lie. It is no exageration to say that the life of such a man as Siemens is spent in the public service; the advantages which he reaps for himself being as nothing in comparison with those which he confers upon the community at large.

As an example of this it will be sufficient to mention one of the most valuable achievements of his active life—his introduction, in conjunction with his brother, of the regenerative gas furnace, by which an immense economy of fuel (estimated at millions of tons annually) has been effected in the manufacture of steel and glass. The nature of this economy is easily explained. Whatever may be the work to be done by the burning of fuel, a certain *temperature* is necessary. For example, no amount of heat in the form of boiling water, would be of any avail for the fusion of steel. When the products of combustion are cooled down to the point in question, the heat which they still contain is useless as regards the purpose in view. The importance of this consideration depends entirely upon the working temperature. If the object be the evaporation of water or the warming of a house, almost all the heat may be extracted from the fuel without special arrangements. But it is otherwise when the temperature required is not much below that of combustion itself, for then the escaping gases carry away with them the larger part of the whole heat developed. It was to meet this difficulty that the regenerative furnace was devised. The products of combustion, before dismissal into the chimney, are caused to pass through piles of loosely-stacked firebrick, to which they give up their heat. After a time the firebrick, upon which the gases first impinge, becomes nearly as hot as the furnace itself. By suitable valves the burnt gases are then diverted through another stack of brickwork, which they heat up in like manner, while the heat stored up in the first stack is utilised to warm the unburnt gas and air on their way to the furnace. In this way almost all the heat developed at a high temperature during the combustion is made available for the work in hand.

The Study of Physics.

As it is now several years since your presidential chair has been occupied by a professed physicist, it may naturally be expected that I should attempt some record of recent progress in that branch of science, if indeed such a term be applicable. For it is one of the difficulties of the task that subjects as distinct as mechanics, electricity, heat, optics and acoustics, to say nothing of astronomy and meteorology, are included under physics. Any one of these may well occupy the life-long attention of a man of science, and to be thoroughly conversant with all of them is more than can be expected of any one individual, and is probably incompatible with the devotion of much time and energy to the actual advancement of knowledge. Not that I would complain of the association sanctioned by common parlance. A sound knowledge of at least the principles of general physics is necessary to the cultivation of any department. The predominance of the sense of sight as the medium of communication with the outer world, brings with it dependence upon the science of optics; and there is hardly a branch of science in which the effects of *temperature* have not (often without much success) to be reckoned with. Besides, the neglected borderland between two branches of knowledge is often that which best repays cultivation, or, to use a metaphor of Maxwell's the greatest benefits may be derived from a cross fertilisation of the sciences. The wealth of material is an evil only from the point of view of one of whom too much may be expected. Another difficulty incident to the task, which must be faced but cannot be overcome, is that of estimating rightly the value, and even the correctness, of recent work. It is not always that which seems at first the most important that proves in the end to be so. The history of science teems with examples of discoveries which attracted little notice at the time, but afterwards have taken root downwards and borne much fruit upwards.

The Development of Electricity.

One of the most striking advances of recent years is in the production and application of electricity upon a large scale—a subject to which I have already had occasion to allude in connection with

56 The Iron Age - Nov. 13, 1884.

Electrical Measurements and Nomenclature.

BY JOHN W. NYSTROM.

The metric system was originated for the purpose of removing the confused systems of weights and measures which existed in France about a century ago. It was intended to make the metric system uniform for all measurements, but it was found to be impracticable for the circle and time, but with these exceptions it is a uniform system for all measurements. By the introduction of the metric system into England for electrical measurements, the British Association for the Advancement of Science undertook to destroy the uniformity of that system by introducing an odd unit of force called *dyne*, which is 0.98 of a milligram. The B. A. has also introduced an odd unit of work called *erg*, and finally an odd unit of power which they call *Watt*. These three units, *dyne*, *erg* and *Watt*, do not agree with the metric nor with any other established system of measurement, and they are therefore an unnecessary confusion.

The English have so many different units of forces that it is unnecessary to increase the confusion with more of them. They have the *avoirdupois*, the *troy*, the *apothecary*, the *carat* and two kinds of tons, &c., and why not have a separate unit of force for steam, a second for water and a third for air, and call these three forces *Tom*, *Dick* and *Harry*, which would not be more ridiculous than to establish odd units and names of force, power and work in electro-dynamics.

The reason given by the English for christening a unit of electric power with the name *Watt* is, they say, that James Watt discovered power, which is a great error. The English, including the B. A., do not know to this day what power is; but they treat it as work done in a unit of time, and the nearest definition they can give of power is that it is the *rate of doing work*. Power and work are two distinct principles, neither one of which can be converted into the other. Had the B. A. defined power to be the product of force and velocity, it would have indicated that they understood the subject; but, although that definition has been before them for some 20 years, they do not seem to be able to take it in.

The small unit of electric power which they propose to call *Watt* is based upon the *dyne* and *erg*, which were established by the B. A. some 60 odd years after the death of James Watt, who had therefore nothing to do with it, and it is therefore unreasonable to call that unit *Watt*. It would be more reasonable to call that unit of power *Thomson* or *Sir William*, because Sir William Thomson is the ostensible father of the units *dyne* and *erg*.

One objection to the name *dyne* is that the English do not know the proper pronunciation of the letter *y*, and, in the languages in which that is known, the word *dyne* will be pronounced with an entirely different sound from that in English. There are no new names nor new units of force, power and work necessary in electro-dynamics, for we have in the metric system all that is required. The milligram should be the unit of electro-motive force, even if is called *Volt*, but it would be better to call it with its proper name.

The present value of the *Ampère* corresponds with a velocity of current of about 101.5 kilometers per second, which should be increased to 1000 kilometers. This unit should be called *velocity*, instead of Ampère or intensity. The object of increasing the unit Ampère from 101.5 to 1000 kilometers per second is to bring electro-dynamics to the level with ordinary mechanics, which would make the subject easily understood in conceiving and comparing magnitudes of electrical and mechanical quantities, as will be seen hereafter. The present values of the units Volt and Ampère destroy the uniformity of the metric system in electro-dynamics, while by changing these units as herein proposed, that uniformity would be preserved.

The present galvanometer will be correct for the metric system within 1½ per cent., but one more decimal should be pointed off for the new reading; that is, 15 old Ampères should be noted 1.5 new Ampères, and 8 old Ampères should be 0.8 new Ampères, &c. A force of 1 miligram moving with a velocity of 1000 kilometers per second is equal to a power of 1 kilogram moving 1 meter per second, which unit of power should be called *effect*, and 75 such effects is 1 horse-power.

It may be remarked that this unit of power is too large for small electric currents, which objection can be removed by a smaller unit of power, namely, *milleffect*—that is, one effect is 1000 millefects, or 1 milleffect is a power of lifting 1 gram 1 meter per second, or 1 milligram 1 kilometer per second. A still smaller unit of power may be adopted, namely, *microfect*, which would be the raising of 1 milligram with a velocity of 1 meter per second. The term *effect*, as applied to power, was, I believe, originated by Arthur Morin, at Metz, over 50 years ago, and I learned that term from Morin's Mechanics and at the Royal Technological Institute, Stockholm, and it therefore comes natural to me to call that unit of power *effect*.

The unit of resistance, or Ohm, should be diminished in proportion to the increase of the new unit Ampère, or unit of velocity—that is, when the electro-motive force is 1 miligram and the current 1 new Ampère, or 1000 kilometers, per second, the resistance in the conductor should be 1 unit, to be called Ohm. The units of electric work should be expressed in kilogrammeters or grammeters—that is, 1 kilogrammeter is 1000 grammeters.

The electro-dynamic notation for the above metric units should be as follows:

F = electro-motive force expressed in milligrams; that is, the available difference of electrical potential.

V = velocity of current expressed in 1000 kilometers per second, corresponding to what is now called Ampères, or intensity of current.

T = time of operation in seconds.

P = power in effects, or kilogrammeters per second.

$H. P.$ = horse power of 75 effects each.

K = work, expressed in kilogrammeters.

R = resistance to current expressed in Ohms.

ELECTRO-DYNAMIC FORMULAS.

Electro-motive force.
$$F = R\,V \quad \ldots\ldots 1$$
$$F = \sqrt{P\,R} \quad \ldots\ldots 2$$
$$F = \frac{P}{V} \quad \ldots\ldots 3$$

Velocity or intensity of current.
$$V = \frac{F}{R} \quad \ldots\ldots 4$$
$$V = \sqrt{\frac{P}{R}} \quad \ldots\ldots 5$$
$$V = \frac{P}{F} \quad \ldots\ldots 6$$

Time of operation.
$$T = \frac{K}{R\,V^2} \quad \ldots\ldots 7$$
$$T = \frac{K\,R}{F^2} \quad \ldots\ldots 8$$
$$T = \frac{K}{F\,V} \quad \ldots\ldots 9$$

Power in effects.
$$P = R\,V^2 \quad \ldots\ldots 10$$
$$P = \frac{F^2}{R} \quad \ldots\ldots 11$$
$$P = F\,V \quad \ldots\ldots 12$$

Horse-power of current.
$$H.\,P. = \frac{R\,V^2}{75} \quad \ldots\ldots 13$$
$$H.\,P. = \frac{F^2}{75\,R} \quad \ldots\ldots 14$$
$$H.\,P. = \frac{F\,V}{75} \quad \ldots\ldots 15$$

Work of current.
$$K = R\,V^2\,T \quad \ldots\ldots 16$$
$$K = \frac{F^2\,T}{R} \quad \ldots\ldots 17$$
$$K = F\,V\,T \quad \ldots\ldots 18$$

Resistance of current.
$$R = \frac{F}{V} \quad \ldots\ldots 19$$
$$R = \frac{P}{V^2} \quad \ldots\ldots 20$$
$$R = \frac{F^2}{P} \quad \ldots\ldots 21$$

This system will bring electro dynam[ics] down to the level of ordinary mechan[ics] and its units, nomenclature and nota[tion] will convey to the mind the real substan[ce of] the subject.—*Mechanics for November.*

57

ELECTRICAL RESISTANCES.

(For description, see page 497.)

PLATE 1.

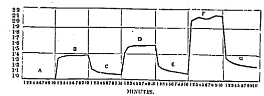


PLATE 2.

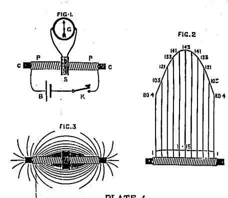


PLATE 3.

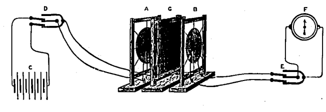
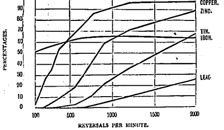


PLATE 4.



or flanges, or with thickened up pieces on either side or any part of their surface. "Armour-plates so made may be bolted together round their edges in the same manner as a cast-iron tank is generally made." "Or thicker parts are forged here and there on the armour plate, and the bolts are tapped into these thicker parts for fastening on the plates, so that the strength would be little or no less at the tapped part than at the other parts." Or projections similar to short bolts or studs may be formed on the inside surface of the plate, for fastening the plates to the skin of the vessel where there is no backing. Or where there is a backing this stud may be of little larger size, so that a hole tapped in its centre for receiving the screw bolt from inside for fastening on the plate will not pass beyond the ordinary surface of the plate, and therefore not weaken it. (Provisional only.)

THE PROGRESS OF ELECTRICAL SCIENCE.*

My first duty this evening is to thank you for the honour you have conferred upon me in electing me your president for the ensuing year. Knowing as I do the illustrious men who have preceded me as presidents of this society, I should not have presumed to accept so exalted a position had I not felt confidence in your kind indulgence, and in the assurance that the council would extend to me that kind assistance which they have ever been ready to render to my predecessors. This is but a young society, and necessarily so, for the branch of science in which we have enrolled ourselves as members is a very young shoot in comparison with many of the other branches of the same tree. Telegraph engineers and electricians have no great masters of antiquity to imitate or revere; most of their great men are of the present age. Since the formation of this society eleven presidential addresses have been given by such men, who have so thoroughly covered all the ground, and I might add the bottom of the sea also, that I feel a great difficulty in delivering to you the usual inaugural address, which is always looked forward to with so much interest by the members of this and kindred societies; for rapid as has been, and still is, the adaptation of electrical science to every-day life, were I to confine my remarks solely to the new matter which has been introduced since you heard the able address of the gentleman who has just vacated the position I now occupy, I am sure it would be as disappointing to you as it would be unsatisfactory to me. Still, it is not my intention to ask you to accompany me to speculative heights or theoretical depths, but rather to walk leisurely along the well-known

* Inaugural address delivered by Mr. Willoughby Smith, president, before the Society of Telegraph Engineers and of Electricians.

due to a spirit of conciliation which could do no harm; but if this sudden change of the character of the unit were done in the same spirit it might lead to inconvenience hereafter. To the practical electrician the material standard, not the definition, is the important point; consequently the next proposition—"That an international commission should be entrusted with the ascertaining by a new set of experiments for practical purposes the length of column of mercury, having a section of one square millimetre, at the temperature zero degree centigrade, which shall represent the value of the ohm"—was of more interest. The members of that commission met in Paris early in November last, and after passing several resolutions adjourned for twelve months. The adjournment is, I presume, to allow time for desired experiments; so that when the members re-assemble they will be prepared to publish their report, which, it is to be hoped, will embrace the whole question of units and fix them on a sound and lasting basis. In order to better illustrate the necessity of fresh measurements, I will direct your attention to Table I.

TABLE I.

Samples of Copper.	Conductivity.		
	First Test.	Second Test.	Third Test.
A	101·4	101·1	101·02
B	44·7	44·87	44·51
C	98·7	99·63	98·64
D	101·3	100·2	101·14
E	18·7	18·63	—

The figures show the specific conductivity of five samples of copper wire, assuming that of pure copper to equal 100, as given by Dr. Mathessen, viz. 100 inches of annealed pure copper, weighing 100 grains, has a resistance of 0·1516 ohm at 60° Fahr. The tests were made by three persons, each one making his tests quite independently, and by means of his own apparatus and method. The results show that with good apparatus and careful manipulation very accurate and reliable tests can be made. They also show what great differences there are in the specific conductivity of ordinary commercial copper, and confirm what I have already mentioned, that some commercial copper has a higher specific conductivity than the long recognised standard for pure copper. Late in the year 1837 Professor Faraday proved by actual experiment that different kinds of matter possessed different inductive capacities, and wrote of "The Specific Inductive Capacity of Dielectric Bodies." We of to-day use the same language, but our correct knowledge of the subject is very limited, and I believe a careful investigation of the whole matter at the present time would be most valuable. It is customary to consider the specific increase in its inductive capacity. Had more frequent tests been taken than are here shown, at temperatures varying from 32° to 100° Fahr., it would still have been found that each series would differ from the other in polarisation, resistance, and induction, and that the formula applied to one series would not be correct for any one of the others. To obtain accurate measurements in experiments of this kind it is essential that a constant electro-motive force should be employed, but unfortunately I know of no means by which such a force can be maintained; for although great and important improvements have been, and still are being, made in batteries, there has not yet, to my knowledge, been produced one that combines all the essential elements of constancy.

If it were necessary numerous instances might be given to show how slow the human mind is, and always has been, to comprehend and utilise the rich and wonderful gifts which nature is constantly casting before it. Thales 2,400 years ago is said to have discovered what we now term the electric qualities of amber, but it was not until the seventeenth century that this phenomenon began to attract public attention, and, under the keen observations of the philosophers of that time, to rapidly develop into a science. To the alchemists of the sixteenth century belongs the honour of having first noticed the change which took place in silver chloride by exposure to light; but photography, which sprang from that very fact, is but of very recent date. It is now nearly ten years—alas! how swift is time!—since I first called attention to the wonderful effects light, and especially solar light, has on the electrical qualities of selenium; but to the present time we have not been able to realise any one of the results which, I feel sure, will ultimately arise from it: for where there is absorption of light, whether of dark or visible rays, by any body, work of some description must have been performed in that body. Of all the endeavours to utilise this property of selenium the photophone appeared the most promising; but knowing what I did of the behaviour of selenium, I was not sanguine of its application for the purpose proposed, for as electricity acts by what we know as induction on a dielectric, so does the action of light act on selenium, that is to say, it absorbs slowly, and as slowly gives it back. My meaning will perhaps be more intelligible by reference to Plate 1 (see page 493). A bar of selenium in a small room from which all light was excluded was connected by means of insulated wires to a battery of one hundred cells and an astatic mirror galvanometer in an adjoining room. The vertical figures represent the ratios of the galvanometer deflections obtained. While the light was excluded the deflection remained quite steady for ten minutes, as shown at A, but on exposing the bar to the light from an ordinary wax candle placed one metre from the bar the deflection immediately increased from 1 to 1·4 and then continued slowly increasing until at the end of ten minutes it reached 1·45, as shown at B. Immediately

Character of article *Rept*

From the *Times*

Published at *Indianapolis Ind.*

Date *Aug. 4. 85*

ELECTTRICITY, ELECTRO-MAGNETISM AND EFFECTS.

When in 1752, Benjamin Franklin, by means of his kite and wired string attached thereto brought sparks of electricity from the clouds, during a thunder storm, that scientist, philosopher, journalist and statesman declared that some day this subtle fluid electricity, would be a power which would be an immense factor in the affairs of man, when we had learned how to manipulate and control it, and he then invented and proved the efficiency of the lightning rod almost as it is to-day. Since his experiments but 133 years have gone by, and already Franklin's predictions are verified. The Morse telegraph in 1844 astounded the world by speeding messages across the country with the rapidity of thought almost) and his science is now so perfected that a telegram can be transmitted around the earth, about 25,000 miles, in three minutes. Following quickly upon the heels of telegraphy came the discoveries of Professor Farraday and others in the science of electricity and electro-magnetism.

Then came Edison, our modern magician, whose powerful wand quickly revealed new wonders. Not only has he taught us to apply the mysterious power of this subtle fluid, for the practical benefit of mankind in multitudinous ways, but he has also developed innumerable resources of electricity, many of which are practically applied. After the sensation created by the Morse telegraph mankind did not seem to wonder much at later methods of employing electricity in every day affairs of life, so that even the telephone stepped into its place of usefulness without attracting very great attention, and was not a nine days' wonder even to the progressive civilized world.

The electric light, so commonly used for illuminating purposes, is no new thing so far as discovery is concerned. Its production and quality have long been taught and demonstrated in high schools and colleges, where the necessary philoshphical apparatus is a part of the outfit. The dynamo is but an ordinary battery, run by steam, to continuously generate the fluid. The question with which the electricians of to-day had to deal was that concerning carbon points, and, while they have so far succeeded in this as to be able to evolve light successively from a set of points, yet are there many improvements needed, and will doubtless be made ere the electric light is a grand success.

As it is, however, the telegraph, telephone and electric light wires stretch over a large portion of the globe, often in unbroken chain for thousands of miles. Along railroads, highways, rivers and canals are strung the inevitable wires for the transmission of thought and voice. The cities are occupied by vast net-works of these lines, making so many conductors for the free and ready passage of this powerful agent of nature, so little understood even yet as regards the causes of its production, its transmission, or its laws.

Strange atmospheric phenomena, unusual storms, cyclones and other disturbances of the air and our surroundings are on the increase, and strangely enough in about the same ratio as have increased the numbers of telegraph, telephone and electric light wires. Is not the cause of these strange effects to be herein found? In chaining the lightning have we not undertaken to curb and tame a monster of power which may compass our destruction? May it not be the reason of our climatic changes and fearful tornadoes? Scientists are paid to attempt the solution of these problems, and it is to be hoped they may speedily master everything concerning electricity. All nature is pervaded with it, and the world ought to know everything about this natural dynamite whose power is inconceivable. Late freaks of electricity during severe cyclones have caused the total demolition in some places of telephone wires and boxes, and the destruction of every species of property near by. A full understanding of the subject will undoubtedly be made, and we be enabled to apply proper remedies for preventing disastrous effects.

Menlo Park Scrapbook, Cat. 1049

No. 34. "Transmission of Power"

This scrapbook covers the years 1877-1885 and contains clippings about the transmission of power. There are 140 numbered pages.

Blank pages not filmed: 104-140.

1049

Transmission of Power

34

Transmitting Power by Electricity.—Time will probably reveal to us effectual means of carrying power to great distances, but I cannot refrain from alluding to one which is, in my opinion, worthy of consideration, namely, the electrical conductor. Suppose water-power to be employed to give motion to a dynamo-electrical machine, a very powerful electrical current is the result. This may be carried to a great distance, through a large metallic conductor, and there be made to impart motion to electro-magnetic engines to ignite the carbon points of electric lamps, or to effect the separation of metals from their combinations. A copper rod of 3 in. in diameter would be capable of transmitting 1,000 horse power a distance of, say, thirty miles, an amount sufficient to supply one quarter of a million candle power, which would suffice to illuminate a moderately sized town. The use of electrical power has sometimes been suggested as a substitute for steam power; but it should be borne in mind that so long as the electric power depends upon a galvanic battery it must be much more costly than steam power, inasmuch as the combustible consumed in the battery is zinc, a substance necessarily much more expensive than coal. But this question assumes a totally different aspect if in the production of the electric current a natural force is used, which could not otherwise be rendered available. 77

Direct Conversion of Mechanical Work into Electricity.—M. E. Guignet.—The Polytechnic School of Rio Janeiro possesses an electro-motor formed of five fixed electro-magnets, and of a movable drum furnished with six bars of soft iron. The current of ten Bunsen elements being passed along the wire of the electro-magnets the drum revolves quickly. This apparatus has long been employed to show how a current of electricity, whatever its origin, may act as a motive power. The same apparatus may serve for the inverse demonstration. If the two ends of the wire of the electro-magnets are connected with a galvanometer, and if the apparatus is turned by hand, a continuous current is produced. 77

SIEMENS'S ELECTRIC RAILWAY.—As the next meeting of the Iron and Steel Institute will, at the end of August, be held at Dusseldorf, many readers will have an opportunity of seeing this railway, which has been laid in that portion of the Exhibition Grounds, near Krupp's Pavilion.

Electrician May 22 1880

ON THE ECONOMIC DUTY OF ELECTRIC MOTORS, AND THE MEASUREMENT OF THE QUANTITY OF ENERGY TRAVERSING AN ELECTRIC CIRCUIT.

BY M. MARCEL DEPREZ.

[Translated from the *Comptes Rendus.*]

When a motor is inserted in the circuit of a battery, the intensity of the current differs when the motor is inactive and when it moves with the production of a certain quantity of work. Let I be the current when the motor is at rest, and i the current when it is in action. After measuring these two values let us stop the motor and introduce in the circuit a resistance such as will reduce the current from I to i. Under these conditions the production of energy by the battery is evidently the same as when the motor was at work; since the electromotive force and the current are the same. Moreover the expenditure of energy evidently has not varied in that portion of the circuit external to the motor and to the additional resistance. We are therefore justified in stating that, in regard to expenditure of energy, the motor in action on the one hand, and the motor at rest, with the additional resistance, on the other hand, are precisely equivalent.

Now the quantity of energy absorbed in a simple resistance and converted into heat, in unit time is expressed by the product of the resistance into the square of the intensity of the current.

Calling r_1 the resistance of the motor at rest, r_2 the additional resistance necessary to reduce the current to the intensity i, and Q the quantity of heat evolved in these two resistances, we have

$$Q = (r_1 + r_2)\, i^2.$$

In accordance with what precedes, this is also the quantity of energy manifested as heat and work, absorbed by the motor when it is in action. Calling T the work here referred to, we have

$$T + r_1 i^2 = (r_1 + r_2)\, i^2, \text{ or } T = r_2 i^2.$$

Comparing this portion of energy converted into useful work with the total quantity absorbed by the motor, we obtain an expression for the duty:—

$$\frac{T}{Q} = \frac{r_2}{r_1 + r_2}.$$

This very simple expression may be replaced by another, which is of great importance in the case where the current is produced by a dynamo-electric machine. Let us call $E_,$ the electromotive force of the generating machine and E the opposing E M F of the receiving machine, which, by the effect of its rotation, tends to generate a current in the direction contrary to that of the working current. The current traversing the two machines is due to the difference $E_, - E$; and if we call R the sum of the *static** resistances of the two machines and of the external circuit it will be expressed by

$$I = \frac{E_, - E}{R}.$$

Let us now find the value of the resistance r_2, which must be added in the circuit in order that the current traversing it may still have the intensity I, when the rotation of the receiving machine is arrested. This is obtained from the equation

$$\frac{E_, - E}{R} = \frac{E_,}{R + r_2},$$

whence

$$r_2 = \frac{E_, R}{E_, - E}.$$

The value of the absolute economic duty of the receiving machine will be equal, in accordance with the preceding theorem to $\frac{r_2}{r_1 + r_2}$, in which the total resistance, R, of the whole circuit should be substituted for r_1.

* [The author explains in a foot note that he means by this the resistance of the machines in a state of rest. We should prefer the expression "wire resistance," or simply "resistance;" since at a given temperature the resistance, properly speaking, is constant, and quite independent of any opposing E.M.F.—ED. E.]

value,

$$\frac{E}{E_,},$$

a remarkable expression, which is independent of the resistance of the external circuit.* This fact may at first sight seem extraordinary, and even contradictory to certain experiments in which perhaps sufficient care was not taken to realise the conditions of maximum duty. It becomes less paradoxical when it is remembered that whenever a current is employed to develop energy in a form other than mechanical work, for instance, to produce the decomposition of water in a voltameter, the number of equivalents of water decomposed is always equal to the number of equivalents of zinc dissolved in each of the elements of the battery, whatever may be the length of the external circuit. The latter, moreover, does not affect the number of elements necessary to produce this decomposition. We have therefore a well-verified experimental fact in which the economic duty is not influenced by the external circuit.

I pass now to the description of the apparatus allowing of the measurement of the quantity of energy passing during unit time electric circuit included between two points, A and B.

Let us unite these two points through an auxiliary (derived) circuit of high resistance, in which is inserted a galvanometer coiled with a long and fine wire, whilst another constructed with a short and thick wire is placed in the main circuit. This being understood, let us endeavour to find the expression for the quantity of energy passing in the principal circuit in terms of the intensities of these two currents, measured by the deviations of the galvanometer needles.†

Let us call I and R the intensity and the resistance of the main circuit, $I_,$ and $R_,$ the corresponding values for the derived circuit. Let E be the difference of the potentials at A and B. The quantity of energy passing in the main circuit is expressed by RI^2 or EI; whilst the intensity of the current in the derived circuit is

$$\frac{E}{R_,} = I_,,$$

whence

$$E = R_, I_,,$$

and, consequently,

$$E I = R_, I I_,.$$

The quantity of energy is therefore proportional to the product of the intensities of the two currents, or to the product of the deviations of the needles.

An instrument may be constructed which will indicate at any time the value of this product.

4

The English ...
AND
WORLD OF SCIENC...
FRIDAY, JULY 1...

ARTICLE...

ROPE GEAR...

depth to allow the rope to sink beneath the surface of the periphery of the wheel are invariably preferred. As, however, the returning side of the rope is as much slackened as the working side is tightened, it is advisable to so arrange the pulleys and driving wheels that the tight or driving side of the ropes is at the bottom, by which means the returning or slack side of the ropes is made to lap round the upper part of the pulleys, and bearing surface is thus obtained which would be lost if the slack side ran from the bottom. In the majority of mills where rope gearing is employed, power is taken off both sides of the driving pulley, and then the ropes on one side must obviously drive from the top; but the disadvantage is probably compensated for by other advantages. It is believed that the friction of rope-gearing, especially at high speeds, is considerably less than that of toothed wheels; but on this point, amongst some others, information is wanted. Comparing ropes with belts, it is calculated that a rope 6½in. in circumference does as much work at a given speed—say 3,000ft. per minute—as a 4in. leather belt. The bearing surface of the rope on a 4ft. 6in. pulley will be 85in., or half of the circumference; and allowing the rope to be in contact with the pulley for a width of half an inch on each side, the total bearing surface will be 85in. With a leather belt 4in. wide, it would be 340 square inches, or four times the amount. To obtain equal results, therefore, the effective pressure of the rope per square inch of bearing surface must be four times that of a belt. The few experiments that have been made show that ropes in a V-shaped groove have a much greater effective pressure per square inch of bearing surface than belts. The results of experiments made with different sizes of ropes, and not always in grooves adapted for them, however, were so discordant as to render it impossible to arrive at any definite conclusion as to the proportion between the friction of ropes and belts. It is known from the experience of ordinary working that the ropes are superior to the spur or bevel wheels, and equal, at least, to leather belts in steadiness of driving and all that the engineer aims for, while they are much cheaper than either in first cost and maintenance—the annual cost of ropes being only about £5 per 100 indicated horse-power. Possibly the largest mill driven by ropes is the Samnuggur Jute Factory, at Calcutta, where the engines are of 1,000 indicated horse-power, making 43 revolutions per minute. The fly-wheel is 28ft. in diameter, and 6ft. 7in. wide, the peripheral velocity being 3,784ft. per minute. The 25 ropes transmit 40 horse-power each, and have thus a tension of 349lb., the result of the experiment, which there was some hesitation in making, owing to a want of knowledge of the effects of the warm and humid climate, having been most satisfactory. At North Oakland, in California, a manufactory has been recently established for the construction, on a large scale, of gut ropes. The entrails of sheep, which average about 55ft. in length, are pickled in brine, and twisted into ropes or plaited into belts. It is said that the ropes thus made will last 10 years, whereas good hemp ropes do not average much over three years, though ropes used for driving-gear have been known, according to Mr. Durie, to last 10 years and a half. The great advantage of gut ropes, however, would appear to be in their enormous strength compared with their size—a cord three-eighths of an inch in diameter withstanding a strain of about 4 tons. Belts will still hold their place for certain work in a factory, to which their shape renders them specially adapted; but for driving shafting we may now expect to see ropes come into very general favour.

THE TELEMACHON.—Another new name in mechanics has been required by the invention of Mr. William Wallace, of Ansonia, Conn., who claims to have devised an electro-dynamic machine whereby power can be transmitted to any distance by electricity. This apparatus has been termed the "Telemachon." In the Wallace instrument no battery is used to produce the electricity. The current generated by his electro-dynamic machine is carried by two copper wires to the Telemachon. This converts the electricity into mechanical power. It consists of electro magnets and revolving armatures. The electro magnets are so arranged that they attract the poles of the armature, causing it to move. Each new position brings pieces in contact with a spring, which causes a re-distribution of the magnetism. Again, attraction takes place as before, and again the direction of the current is changed by the break-pieces. The magnetic effect being repeated, the rotation is continuous, increasing constantly in speed until the friction and the magnetic power balance each other, the machine being able to make 3,000 revolutions a minute. Dec 78

The electricity from the Telemachon may be applied to illumination. It solves the problem of the division of electric lights. Both the Wallace foundry and the Farrel foundry, near by, are illuminated by these lights, the army of men being formed in two divisions, one working during the day and the other up to midnight. Thickly studded as these foundries are with heavy machinery, and obstructed as the light must necessarily be by the ponderous cranes, drills, supporting columns and projections, a clear light is thrown upon the machinery, perfectly illuminating it. Adjustments to the 32d part of an inch may be made without the least strain upon the eyes. A beautiful effect of this light is its polarization—that mottled appearance which it assumes when falling through glass. This is the only artificial light, it is said, that is capable of producing it.

It is claimed that Mr. Wallace has succeeded in transmitting power from the Naugatuck river to his factory, a distance of a quarter of a mile, and that the power of this stream is sufficient to run the machinery of the Wallace factory, where three hundred men are employed. It is claimed that experiments show only about 10 per cent loss of power by the transmission.

5

CAN WE TRANSMIT POWER IN LARGE AMOUNT BY ELECTRICITY?*

By N. S. KEITH, Newark, N. J.

THIS question is suggested by a statement made by Dr. Siemens, widely printed in the journals of the day, that a continuous rod of copper thirty miles in length and three inches in diameter is capable of conveying that distance, electrically, energy equal to 1,000 horse power. It is not attempted to advance the statement that the source of power shall be zinc, nor even coal, but waterfalls, which from their situation are not practically available for manufacturing establishments in their immediate vicinity.

In order to fully consider this subject, we must understand the doctrine, I may say the science, of the correlation of the the forces, so called. We must understand that all matter is endowed with an amount of FORCE, and that each atom and molecule, simple and compound, has its specific portion of the whole. This force, at rest, is called latent heat, intrinsic energy, or potential. In motion it is called heat, light, electricity, chemical affinity, attraction, magnetism, power, etc., according to its sensible manifestations. These are the effects of the one force in motion in different substances, or in different assemblages of matter. Force put in motion comes to rest by reason of the resistance to motion which it encounters; in overcoming of resistance the manifestation is sensible heat. Each of these manifestations of force is convertible to one or all of the others, and they are all caused by some mode of motion. Force may be illustrated by a spring under tension, or by a suspended weight. Release the spring and weight, and they give off as much force or energy as was used in setting up the tension of the spring, and in raising the weight perpendicularly the length of its fall. Any of these forces then may, figuratively speaking, release the weight and spring.

While there is but one electricity, there are two conditions of it, namely, *static*, which is electricity at rest but under high tension, and *voltaic* electricity or *galvanism*, which is a mode of motion. It has but one cause, and that is force, or matter in motion. Yet we, for perspicuity, call electricity by friction, *static* or *frictional;* electricity by chemical affinity, *chemical* from its immediate cause, or *voltaic* or *galvanic* from its discoverers; electricity by magnetism, *magnetic;* electricity by heat, *thermic;* electricity by mechanical power, *dynamic*.

As chemical and thermic electricity have too costly sources for our purpose, we must consider the magnetic and dynamic.

Now that we have learned what electricity is, we must understand what it is not. As an entity it does not exist; it is a signification simply. When we comprehend it as a condition or quality of matter in self-containing motion, not as a current or flow of something through matter, we will be able to deduce facts in the science, and sustain them by practical illustration. The first conception by the mind of a force or motion having its source within a circuit, and manifesting itself at all parts thereof, is that of a current or flow of something. The probability is, electric current is molecular change of form caused by tension upon the atoms composing the molecules in the direction of disrupting them. There is certainly a change of dimensions of matter subjected to electricity, as there is with heat and magnetism. This change of form causes friction of adjacent molecules and its resultant heat. This heat is the exact equivalent of the energy causing the electric current. Energy, when used as electricity, is called *electromotive force;* this varies in degree with its tension, as in case of its illustration by a weight in suspension or by a spring. Some use the term *intensity* to express the same. The tension of a spring may illustrate the electromotive force of static electricity, which imparts its charged energy with a single impulse. A suspended weight released increases its speed each foot of fall, and consequently its force and effective quantity. So with voltaic electricity: each cell in circuit increases the speed and quantity of current. In case of dynamic electricity, each increment of circuit receiving electric impulse adds to speed and quantity of current.

All matter offers an amount of resistance to changes of form or arrangement of molecules, whether by heat, electricity, magnetism, or any other of the forces. This resistance is specific for each substance. The specific resistances opposed to electromotive force have been tabulated relatively in the cases of metals common in the arts, and with the important alloys. The metals are the best conductors, or, in other words, offer the least resistance. These follow solutions of binary salts, other liquids, *et sequentes*. Copper and silver offer the least resistance, are relatively alike, and are graded as 1 in scale of resistances. Iron offers nearly six times the resistance of copper, and is graded 5·95. Heat increases the resistance of metals to the extent of about 0·2 of 1 per cent. for each degree Fahrenheit rise in temperature.

Electricians have a formula which sets forth Ohm's law. This is that the current (sometimes called quantity) of electricity is the result obtained by dividing electromotive force by resistance; thus, $\frac{E}{R} = C$.

The unit of electromotive force is called a *volt*, in commemoration of Volta, the inventor of the voltaic pile. It is very nearly represented by the electromotive force, or energy, or intensity of a Daniell cell. The unit of resistance is called an *ohm*, after Ohm, who laid down the law. A wire of pure copper 6,046·5 feet in length and ¼ of an inch in diameter has a resistance of one ohm. The unit of current or quality is called a *weber*, or *veber*, after Weber, another investigator in the line.

A veber of current represents the energy set free by the combustion of 11 grains of carbon, or 11 grains, about, of coal, or 1 grain of hydrogen, with a development of 6 units of heat in 0,338 seconds. That amount of free or sensible heat is set free in the circuit. Thus, one volt of electromotive force forces one veber of electric current through a circuit of one ohm resistance, requiring to do so 4,673 foot pounds of energy, with a development of 6 units of heat in the circuit in 0,338 seconds. The heat set free is the exact measure of the force used.

If we pass this veber of current through a solution of copper sulphate, the electric equivalent amount of metallic copper will be deposited, namely, 31·75 grains in the same time. Now, if we increase electromotive force by adding another cell to the circuit, making electromotive force 2, and so regulate resistance that it remains one ohm, a current of 2 vebers passes in the same time, thus: $\frac{2\,E}{1\,R} = 2\,C$.

Now, we find that twice as much zinc is consumed in *each* cell, or four times as much in the circuit, or its equivalent in energy is used in depositing only twice as much copper. We have in the circuit four times as much heat, which is the measure of the energy expended. Chemical decomposition is the measure of current, while heat is the measure of electromotive force multiplied by current. Increase electromotive force to 3, keep resistance 1, and we have a current of 3, and nine times the energy expended, resulting in nine times the heat.

It is now to be seen that by increasing definitely the amount of electromotive force, and at the same time keeping resistance as low as possible, we may use a definite amount of energy and distribute it as heat throughout the circuit in proportion to the special resistance of its parts, and utilize it as mechanical power. The object of increasing E at the expense of C is that we may save in weight of copper constituting the conductors. We get the energy distributed throughout the circuit, though but the square root of it is shown in chemical action when measured by the amount of copper or other metal deposited in a single depositing cell.

If we magnetize a core of soft, uncarbonized iron within a coil of copper wire by bringing it into the magnetic field of an electro or a permanent magnet, at the instant of stoppage of motion a current of electricity will start in the coil in one direction; that is, the molecules composing the circuit will turn in one direction, and then the action ceases. Remove the core and coil, a reversed current starts and continues as long as motion lasts in removing them from the field. If we revolve this arrangement between the poles of a magnet, thus alternately magnetizing and demagnetizing the core, we will get a succession of discharges of magnetism through the copper coil utilized as electricity. While the core is acquiring magnetism, there is no current in the coil, as there is no magnetic resistance to motion which requires force to overcome. As soon as it begins to lose magnetism an electric current is induced in the coil, which we may cause to do work by proper mechanical appliances.

We will find that the coil and core are heated, and the amount of heat is the measure of the mechanical force used, less that due to friction of the journals carrying the arrangement. If the coil completes the electric circuit within itself, so that there is no external resistance, then the total heat will be developed therein. If the circuit is made com-

* A paper read before the American Institute of Mining Engineers, at the Wilkes-Barre meeting, May, 1877.

6

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plete by a conductor, then the heat will be divided between the coil and conductor in proportion to their respective resistances. If this conductor be the coils of an electro-motor, the heat due to it can be utilized as work, less loss by conversion.

We have now the general requirement laid down, so will proceed to plan and construct a theoretical machine to suit the requirements of 1,000 horse-power, to be transmitted, if possible, through a rod of copper thirty miles in length and three inches in diameter. As resistance of wire of same diameter is in direct proportion to its length, and as we have seen that 6,040·5 feet of copper wire, ¼ inch in diameter, has a resistance of 1 ohm, so 30 miles, or 158,400 feet of ¼ inch wire, has 26 ohms resistance. But as it also decreases in proportion to the square of the diameters, we figure in the 3 inch rod a resistance of ·18 ohm, if of pure copper, at a temperature of 60° Fahr.

The energy of 1,000 horse-power is measured as 33,000,000 foot pounds per minute, and that of one veber current equals 4,673 foot pounds in 6,338 seconds, or 44·24 foot pounds per minute. So it will require 746,000 vebers current, or their equivalent in energy, to utilize 1,000 horse-power as electricity for dynamic purposes.

We may therefore use electromotive force of 1,000 volts, resistance of 1·34 ohms, and a current of 746 vebers; thus, $\frac{1{,}000\ E}{1{\cdot}34\ R} = 746$ C. In other words, the dynamic equivalent of 746,000 vebers may be had by multiplying the electromotive force 1,000 by the current 746.

It has been found that a discharge of the magnetism of a soft iron core induces a current in the coil surrounding it possessing electromotive force of one volt for about each twenty-five feet of coil. The quantity or current comes from the strength of the magnetism and number of discharges. For 1,000 volts electromotive force we will take 25,000 feet in length of copper wire or strips, weighing 1·2 pounds per foot length, or in all 30,000 pounds. This will have a resistance of ·66 ohm. It should be wound upon a core of iron weighing 10,000 pounds. This core and coil, constituting what is called an armature, must be revolved between the poles of an electro-magnet having such an attraction for the armature as to call for the expenditure of 1,000 horse-power in revolving it. Such a magnet will weigh, probably, 60,000 pounds, and have a like weight of copper in its coils. It should be excited or magnetized by a smaller armature revolved between the poles of a smaller magnet, with an expenditure of, say, 100 horse power. This is necessary, because, if the coil of the magnet is part of the main circuit, the resistance will be much increased.

The electro-motor receiving the current of electricity must have at least the same length of copper in its coils; and as the resistance of the coils (when the machine in motion is exerting its greatest power) is double that which they have at rest, and as it is necessary from our other fixed resistances to make the resistance of the machine ·50 ohm, we make the weight of copper coils per foot 3·17 pounds, a total of 79,200 pounds, with a weight of iron about 70,000 pounds.

The cost of this apparatus will be as follows:

Exciting magnet and armature	$3,500
Large magnet, 60,000 lb. iron, including work thereon, 10c. per lb.	6,000
60,000 lb. copper, 30c. per lb.	18,000
Armature: 10,000 lb. iron, and work thereon, 10c. per lb.	1,000
3,000 lb. copper, 30c. per lb.	9,000
Brass bearings, brushes, etc.	2,500
Total for machine	$40,000
Conductor: 158,400 feet copper rod at 27½ lb. per foot, 4,356,000 lb., 30c.	$1,306,800
Ground plates and connections	5,000
Insulation, etc., indefinite, say	100,000
Total for conductor	$1,411,800
Motor: Iron and work, 70,000 lb., 10c.	$7,000
Copper, 79,000 lb., 30c.	23,700
Brass, brushes, etc.	2,500
Total for motor	$33,200

The energy of 1,000 horse-power expended on the machine generating the electric current is distributed throughout the circuit in proportion to the special resistances of several parts. The armature, having a resistance of ·66 ohm, absorbs 66·184 or 462·5 horse-power; the conductor 18·154 or 134·3 horse-power; the motor 50·154 or 373·2 horse-power. This last amount is all that can be utilized with this arrangement, even if there is no loss. We may make our electric machine and the motor larger, or place two of them, making the resistances of them one half as much, but not with any increase of utilizable power, as the resistance of the conductor remains the same.

Let us consider a resistance of ·33 ohm for machine, ·18 ohm for conductor, and ·25 ohm for motor, and we have 33·76 or 434 horse-power for machine, 18·76 or 237 horse-power for conductor, and 25·76 or 329 horse-power for motor. This is less available power than before. The resistance of the earth returning the current we may count as nothing. Under no circumstances can we utilize the full power expended.

If we decrease the resistance of the machine to ·33 ohm, and increase that of the motor to ·83, keeping total resistance the same, we will gain. Then the machine will absorb 33·134 or 246·2 horse power; the conductor 18·134 or 143·3 horse-power; and the motor 619·5 horse-power. With a larger conductor or shorter distance, this proportion may be increased.

There are various sources of loss, especially with electricity of such electromotive force and tension. I have no doubt that at least 50 per cent. of the energy expended on a magneto-electric or dynamo-electric machine at a waterfall may be used at a distance by an electro-magnetic motor as mechanical power.

The amount of heat developed throughout the entire circuit will be equivalent to that from the combustion of 200 lb. of coal per hour, or 42·746 heat units per minute. The proportion due to the armature, having resistance of ·33 ohm, is sufficient to raise its temperature one degree Centigrade per minute. Of course, then, some arrangement for cooling by water must be applied.

What the effect of a discharge of a portion even of this current, with its high tension, through the body of a man would be, I leave you to imagine. Probably it would be worse for that man than it was for the one who was kicked by the Kentucky mule; "they swept up the pieces" in that case, as the veracious reporter states.

TRANSMITTING POWER BY ELECTRICITY.

The Société du Val d'Osne has an electro-plating establishment in Paris, where a process of coppering cast iron is carried on. The source of electricity is a Gramme machine, ordinarily run by a special engine at considerable expense and trouble, as it was situated at considerable distance from the main motor. M. Cadiat suggested the use of two Gramme machines, one to be connected to the driving shaft of the works, and to produce a current which should set machine No. 2 in motion, and this in turn might drive the machine which supplied current for the baths. Motive power was thus transmitted over a distance about 400 feet by means of a single copper wire. The system, says M. Cadiat, in *La Nature*, has worked perfectly and uniformly for two months. The velocity can be easily regulated by interposing resistance in the circuit. If, in the circuit from machine No. 2 to the electro-plating machine, a copper wire 6·4 feet long and 0·06 inch in diameter be inserted, the velocity falls from 750 to 40 turns per minute; with an iron wire 4·8 feet long and 0·32 inch in diameter, the velocity is reduced to 100 turns. As for the power required, the author states that the starting or stoppage of the system is not recognizable by the engineer who controls the driving engine of about 10 horse power, from which power is also taken for a variety of tools. July 78

UTILISING NIAGARA.—Some months ago the *Buffalo Commercial* described a series of experiments made in this city with the view of demonstrating the practicability of using the immense water-power at Niagara Falls for transmitting power to this city through the agency of compressed air. The experiments were sufficiently successful to convince several of our enterprising citizens that the scheme was entirely feasible. A company has since been formed, of which Senator Pierce is president, considerable capital has been paid in, and practical operations have been begun. The principal part of the machinery will be near the water's edge, below the falls near that delightful spot called the Bridal Veil. The rest will be on the bank immediately above. The great air receptacles, three of which will be 70 feet long by 6 feet in diameter, will be below the bank, near the water; while the receiving reservoirs will be on the bank. The cylinders will be constructed of boiler iron in the most substantial manner. The perpendicular fall from the feeding basin above to the air receptacles below is 214 feet. The engineer's figures show that 200,000 lb. of iron will be required, and it is estimated that power enough will be generated to raise about 350,000 gallons of water 150 feet every minute. These results have been obtained by careful scientific tests, so that there is little doubt but they are nearly correct. July 78

IN reference to the statement that Sir William Armstrong has employed electricity, generated by water power, a mile and a half distant, to light his picture gallery, and that he proposes to use the same force to turn machinery about his house, Mr. D. R. Jones sends us a copy of a letter sent by him to the *Australasian*, October 25, 1870, in which, referring to the phenomena of dynamic electricity, he states that it is evident that motion may be transformed into electricity, and *vice versâ*. He suggests that we may have here "the means of utilising the motions of the air and of water, which, for want of means of transmission, have been hitherto allowed to run to waste. Various methods of converting, transmitting, and utilising force will readily suggest themselves as a combination of these well-known facts. While we have such superabundant constant supplies of force it is not right that the stores of Nature should be ransacked." 78

THE TELEMACHON. — By his electric telemachon, Mr. William Wallace, electrical manufacturer, of Ansonia, Conn., U.S., is enabled to transmit power from the Naugatuck River to his factory, a quarter of a mile off, with a loss of some 20 per cent. of the current. The telemachon consists of a dynamo-electric machine, for transforming mechanical power into electricity, and an electric motor, which reverses this operation, and turns the current into power. It is this apparatus that Edison alludes to in his account of his [illegible]nts with the electric light. As it exists at present, [illegible]. Wallace's dynamo-machine only feeds eight separate [illegible]ctric lights, each being reputed to equal 4,000 [illegible]dles. Nov 78

7

The Siemens Scheme for Transmitting Power by Electricity Criticised.

THE scheme for transmitting power from natural waterfalls by electricity, as propounded by Dr. Siemens in his celebrated Glasgow lecture, is rather severely criticised by a writer (Mr. J. T. Sprague) in the *English Mechanic*. We extract from Mr. Sprague's article the summing up. Dec 15/78

Mr. Siemens says, correctly, that "the conductor itself (which includes also the generating machine) retains a certain amount proportional to that transmitted. That is to say, the engine must expend 1000 horse-power to transmit 400." This assumes, too, perfect conditions, no loss in the transformations of energy, no leakage on the road. Hence this figure would probably be doubled in actual operations. It is needless to go into the 100-fold figures, as the proportionate loss remains the same.

Further on Mr. Siemens refers to his proposal to transmit "1000 horse-power a distance of 30 miles through a conductor 3 inches in diameter. The electrical resistance of this conductor would be ·18 of a unit, and, supposing that the total resistance in circuit was made 2·5 units, which, as I before stated, gives a favorable working condition, it follows that

$$\frac{\cdot 18}{2\cdot 5} \times 1{,}000 = 72 \text{ horse-power.}$$

would be expended in heating the conductor. This would represent about 15 lb. of coal per hour—a quantity quite insufficient to raise a mass of 1900 tons of copper, with a surface of 132,000 square feet, to a sensibly-heated condition."

This refers to the potential heat of coal, supposing it were all transferred to the copper. But it is desirable to consider what would become of the machine developing the power. We have :—

Total resistance	= 2·5
Conductor ·18, machine 1	= 1·18
Resistance of useful work	1·32

Now, assuming that we are to develop 1000 horse-power in this 1·32 resistance, we have :—

Useful work 1·32	= 1000 h.-p.
Heat in conductor ·18	= 136·36
Heat in machine 1	= 757·57
Horse-power expended	1893·93

Here, again, we leave out of consideration all loss in conversion and leakage, and this would probably double the amount.

It appears, then, that having a free gift from nature in a waterfall 30 miles away, to utilize it as 1000 horse-power we must provide :—

1. Dynamic converters, capable of developing 1000 horse-power.

2. 1900 tons of copper rod, properly insulated.

3. A dynamo-electric apparatus capable of generating a current representing at starting 2000 horse-power.

4. Means of cooling that machine, and dissipating rapidly a constant energy equal to 758 horse-power.

It becomes a very serious question whether it would not be desirable to look that gift-horse (power) in the mouth. Without going into figures it really seems that it would be cheaper to buy steam or gas engines, and pay for coal to do the work on the spot.

8

Transmission of Power at Rock Island Arsenal. Feb 22/79

The experimental line of water power machinery with cable transmission, devised by Col. D. W. Flagler, for the Rock Island Arsenal, is said to work admirably. The full plans of Col. Flagler embrace 40 65-inch turbine wheels, working on two separate shafts, 20 wheels to a shaft. But now only four of these turbines are in place; the shaft is 9 inches in diameter, and 100 feet long. On the shore end of the shaft there is a driving pulley 15 feet in diameter, which receives a wire rope three fourths of an inch in diameter, which ascends to a tower and continues on to the shops. There are six spans of transmission, each span 400 feet in length, making the distance from the dam to the south row of shops 2,400 feet, almost a half mile. The ends of these spans are station towers of trestle work, each 40 feet high, these stations consisting of receiving and driving pulleys, each 15 feet in diameter. On one of the towers the cable turns at right angles by means of bevel gears. The four turbine wheels now being tested yield 240 horse power; and there was not a hitch in the whole length of the cable and machinery. This force will be used this winter for the shops. The great dams, the water power canal, and the minor parts of the work, have cost about $1,000,000. The pen stock is entirely of iron; and the turbines are so placed on the shaft that the stoppage of one by driftwood or otherwise will cause no derangement of the others.

TRANSMISSION OF POWER BY ELECTRICITY.—Profs. Houston and Thomson have experimentally shewn at the Franklin Institute that powerful electric currents can be conducted by very fine wires. They sent the current generated by one dynamo-electric machine through a wire ·004 inch in diameter to a second machine, which, working reversely, gave off considerable power. Apr. 79

Endless Ropes for Rapid Transit.

Mr. Haussknecht, the inventor of the absurd rapid transit plan which we noticed in our last number (page 102), sends us a letter in which he expresses his utter disgust at what he calls our "absurd editorial." He says: "My circular presents two practical, separate plans, and describes their mode or manner of operation, which must not be mixed up like an Irish stew, showing that the editor does not understand them," etc.

To this we remark that our account is no more mixed up than the inventor's own circular, from which it appears that he wants to use compressed air to raise the cars to the top of the inclines of "25 feet fall to the mile, by which they will attain a speed of about 20 miles per hour by the law of gravity," . . . "utilizing the force of speed, it will run up a part of the hight it has come down, rear car striking against truck platform to stop. The conductor presses his foot on rope lever, opens lower valve, admitting compressed air into cylinder, driving piston connected with four-wheeled truck, car riding thereon, upwards on inclined rails, delivering car automatically to the next section; the conductor pulls the rope, shuts the valve, the used air escapes, permits the truck to descend, in readiness to receive succeeding car, when he is on his way to next station; time consumed, say one quarter of a minute."

The circular further states: "The endless rope system is automatically to connect with the inclined plane system, but is intended for steep grades, which no ordinary locomotive can ascend. . . . Also of much larger transporting capacity than the unfortunate New York rapid transit system. The structure is very similar to the inclined plane system, but having stationary wheels for the continuously travelling ropes to rest on. The power is supplied by gearings at the ends, and the compressed air travelling to the various sections, enters a rotary fan drum, setting the large driving wheels with ropes in operation. The conductor grapples the rope to start, or releases his grapple to stop. It must be understood that the cars going down hill balance those coming up."

Mr. Haussknecht says in his letter that he predicted the failure of the Greenwich street plan, because "no engine can pull the rope with four-wheeled carriers when journals are overheated, because the wheels of said carriers were too many and too small for speed." This may be true, but this is not the reason why the system of endless ropes was abandoned in Greenwich street. Even if the road had been constructed after a method which Mr. Haussknecht may consider perfection it would have been the same thing; it is a fact that wherever the rope system has been adopted and retained circumstances were peculiarly favorable for the same, and the grade could not otherwise be overcome except at great cost and loss of time.

Mr. Haussknecht further says in his letter: "Does the editor know that endless rope systems for railroads have been in successful operation for many years by Elberfeld in Prussia, in Germany, France, Switzerland, Belgium, Pennsylvania, California, and even a short walk from New York, in Hoboken up Bergen Point, and of some 30°, about 482 feet high, carrying up cars, passengers, and horses safely on a platform truck."

To this the editor answers that he not only knows all this, but has travelled on most of the roads named, and many others besides. He went up and down the Elberfeld incline in 1847; it is not an endless rope, but the trains are attached to the ends of the same wire rope, the down train balancing the up train, while in many cases the stationary engine has little or no work to do, the locomotive of the two trains being often sufficient to move them. He has travelled on the famous Belgium incline, descending the valley of the Meuse near Liege; nor is there an endless rope here, the trains being hoisted up by a rope winding on huge drums, while the descending trains move by gravity alone and have their momentum regulated by a separate car attached to the rear and provided with special brake arrangements. It is the same with some inclines of lesser importance in France and Switzerland; in regard to Pennsylvania, the inclines which used to be in operation thirty years ago near Philadelphia, where the trains were hoisted up by stationary engines, have all been abandoned. It was the same near Albany, where the trains for Schenectady were hoisted up an incline to the summit of the table-land west of Albany; this also has been done away with and a gradual incline constructed north of the city. The system has been retained for several inclines at and near Mauch Chunk on the Lehigh river; also for the ascent of the Moosic mountain near Carbondale, and near the Lackawanna river at Honesdale; and this for the simple reason that the trains on these roads are not drawn by locomotives at all, but move by gravity on a series of inclines. The topographical condition of the region being mountainous makes it easy to construct any kind of grades along the slopes of the mountains 1,000 and 2,000 feet high; but to recommend such a system in a city which is comparatively level, is absurd. The different inclined planes in Cincinnati ought to be mentioned in this connection; they are similar to that in Hoboken, but three times as high; nor is there an endless rope here, but the up truck balances the down truck, each being attached to the end of one wire rope, moved by a stationary engine on the top of the hill.

All these roads have been visited and studied by the editor, and he will only add that during a trip he made last summer over most all the railroads penetrating the interior of the Rocky Mountains in Colorado, he was struck with the ingenuity displayed by engineering the most difficult grades, ascending hights of 3,000 or 4,000 feet, without having recourse to ropes, endless or otherwise; not a single stationary train-hoisting engine was to be seen. Thus at Black Hawk the ascent is made by a series of switch-backs; and at the famous Veta Pass the road winds upward along the sides and around the mountains until Alamosa is reached, situated near the frontier of New Mexico, at the head-waters of the Colorado, about 10,000 feet high.

Experience has taught that the great problem of modern engineering is to avoid the very system recommended by Mr. Haussknecht, and for this reason we cannot comply with his request to publish his circular in full, so as to invite discussion. It has already been given more attention in our columns than perhaps the whole affair is worth, because it is a matter pretty well disposed of by all engineers who possess sufficient information on the subject, while we are perfectly satisfied that very few would have considered it worthy of as much notice as we have already given it.

Transmission of Power by Chains.

Of all the attempts to use chains for the transmission of power, the Ewart detachable drive chain has been the most successful. One form is represented in Fig. 1; there are many other forms, but we have not space to represent them here. They are all covered by pat-

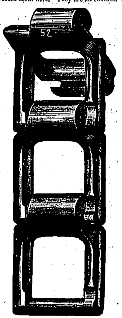


Fig. 1.

June 79

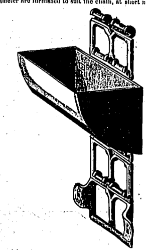
ents, which are owned by the Ewart Manufacturing Co., who manufacture them of the very best quality of malleable iron, and subject every link to inspection. The links are put together to make any length desired, and before shipping are tested in full lengths with a machine especially designed for the purpose.

The particular advantage claimed for this chain, is that it is not affected by the action of the weather, heat, cold, rain, chemicals, nor when running in water, as is the case with leather belting, which, under such circumstances, is soon destroyed. Another advantage is that it cannot slip, therefore it is of undoubted value in cases where positive and exact motion is necessary, and in vertical or inclined transmissions, and it may run so loosely on the wheels that a link may be readily taken out and replaced without removing the chain. It is largely used with malleable iron buckets in elevating phosphates, chemicals, and ores; for these uses it may be tinned or galvanized to prevent rust. It may be, and is, used on various machines, among which are harvesters, mowers, reapers, binders, headers, corn shellers, corn planters, windmills, middlings purifiers, threshers, cotton gins, governors, portable forges, pumps, water motors, drills, trimmers, live rolls, carriers and conveyers of all kinds; ice, grain, offal, shot, water, and tan-bark elevators; for traction engines, transmission of power in all classes of machinery, and in numerous other cases too numerous to mention, of which we will only describe a few, showing the importance of the application of Ewart's chain belt.

One is the straw carrier, of which a section is represented in Fig. 2; two chains, one at each side, are connected by cross bars, which move the straw forward on an upward inclined plane as rapidly as necessary, and pile it up beyond the most elevated end of the incline. Extensive farmers and dealers in fodder will at once see the advantage in cases where large quantities of straw have to be rapidly disposed of. Another application of far more importance is in saw mills, especially in regions where they are operated on a very extensive scale—for instance, in the timber regions of Michigan, Wisconsin, and Minnesota, we should say that the employment of this chain belt is indispensable. Besides securing the positive motion referred to, as well for the movement of the saw as for the carrying of the lumber while being worked; even for feeding light stuff to the saws feed chains are used to secure a regular parallel motion, and a smooth, even saw-cut. Then, for conveying the sawdust away, the chains are applied to elevator boxes. The dust coming from the saws, the finest parts of which are used for firing the steam boilers, passes through the grated floor on the lower chain, through which it is sifted; all the coarse pieces and bark that do not go through this sifting process are carried to the end and delivered into a receptacle, from which they are dumped into carts, while the fine sawdust sifted through falls on an inclined or perpendicular elevator, carrying it to an iron trough over the boiler; the trough is regularly fed by means of a V-shaped spout, provided with a slide to regulate the supply, according to the wants. These troughs are provided with a sheet-iron damper and counter-weight, so that when the chain, dragging through the trough, delivers sufficient dust into the spout to overbalance a counterpoise, the damper drops and delivers its load into the fire, closing again, so that the draft may not be obstructed by the slides or the top. The engineer, who regulates the supply, causes the surplus dust to be delivered outside; in this way firemen and shovellers are entirely dispensed with.

These sawdust carriers are made of wood, of such a size as to fit one large link of the chain; the best size is 2 feet wide over all, or 20 inches in the clear. The chain links and boxes are connected together by a screw-bolt and nut, as seen in the engraving. Lumbermen of the Northwest have not been tardy in endorsing these contrivances and introducing them extensively, and acknowledging their superior merits.

A large stock of links of different styles and sizes is carried by the manufacturers, and orders receive prompt attention. Wheels of nearly any desired diameter are furnished to suit the chain, at short notice.



Inquiries should be accompanied by a statement of speed desired to be run and purpose to which they are to be applied.

Mr. E. T. Copeland, of 30 Cortlandt street, New York, gives special attention to this article, and has applied it extensively as a substitute for belts and gearing. Through his agency it has found many new uses. Upon request sample links will be sent to any address, without charge or expense.

Facts Pertaining to the Manufacture and Uses of Wire and Wire Rope, and Telodynamic Transmission.

No. III.

THE transmission of power by endless belts of wire rope is one of the most important applications of such ropes in modern industry. It is often much more economical to transmit from its source the power required for manufacturing than to transport the raw materials to, and the manufactured products from such source. For example, a good water-power may exist on one side of a steep range of hills, while a railway or canal traverses the valley lying on the other side of the range. Now if the railway or canal be the channel through which the raw material to supply the manufactory must come, and through which the manufactured products must reach the market, it would probably be far cheaper to place the plant close to the railway or canal, and transmit the power from the source to the works than to carry the material and products to and from the factory.

Public attention was strongly directed to the method of transmission of power by wire rope at the Paris Exposition of 1867, where Mr. C. F. Hirn, of Mulhausen, Switzerland, exhibited a wire belt connecting a fifty-horse-power engine with a pump of great lifting power about a hundred yards distant. This exhibit, and the facts ascertained in relation to previous applications of the method of telodynamic transmission which were published in the report of the U. S. Commissioners, led to the adoption of the system in this country, where its employment is increasing. It has been found to be one of the most economical methods of transmitting power.

Instances were stated in the report above referred to of the transmission of power to points ranging from one to five miles from the prime motor.

Within certain practical limits the economy of the transmission will depend upon the following principles, which we find very clearly stated in the treatise quoted from in our former articles upon this subject:

"As mechanical power is measured by the product of *force* by the *velocity* with which it moves, so the one may be exchanged for the other, and a rope of one inch in diameter moving under a tension of 5000 pounds at the rate of 100 feet per minute conveys the same power only as one a quarter of an inch in diameter with a tension of 250 pounds moving at the rate of 2000 feet per minute.

"It is upon this principle that this system of transmission is based, viz.: *The transforming of power at its point of generation into velocity, and changing it back into force at its point of application.*"

Vertical grooved wheels of large size are used for the transmission at each end of the line. The grooves of the wheels are prepared with an elastic filling or packing upon which the rope runs, and which not only gives a good frictional bearing for the rope, but obstructs the wearing of the grooves. If the distance to which it is desired to carry the power be so great as to necessitate intermediate support for the belt between the transmitting pulleys, such support is supplied by intermediate pillars or piers carrying grooved idlers.

"A filling for the grooves now quite generally used and giving satisfactory results is made of sections of wood sawed from two-inch plank, the grain of the wood running lengthwise of the block; these are held in place by centre wedges, and when completely filled, the wheel is easily turned in place to a true circle. A small cushion of tarred rope is then run on the wheel for the wire ropes to track upon. This method of filling also protects the rope from wear upon the sides of the rim.

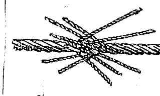


Fig. 1

"The wood may be of any of the tenacious varieties, of which hard maple is among the best. It should be well seasoned, and soaked in linseed-oil for about twenty-four hours before using, thereby rendering it weather-proof. This makes a much cheaper filling than rubber, and is one that can be '*home-made*' at any time.

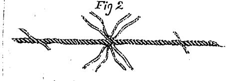
"As the deflection of the rope is slight, any inequalities in the bearing surface of the wheels tend to produce vibrations of considerable amplitude, so in placing the rubber filling care should be taken that it be done uniformly.

"The wheels should also be well balanced, as from their great velocity they act also as balance-wheels, the evil effect of irregularities in which it is useless to comment on here.

"The arms of the wheels should be of such form as to offer the least atmospheric resistance, which, owing to their rapid motion, is considerable."

This resistance with improperly constructed wheels may equal the loss by friction. Mr. Haigh has paid much attention to this feature, and has at his works patterns of wheels of all sizes up to ten feet in diameter, so constructed as to reduce this source of loss to a minimum.

Fig 2



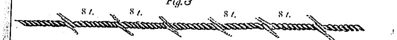
"The diameters of the wheels are measured from the outside of the filling, where the rope runs, and not from the edge of the rim. The hubs are made of sufficient dimensions to admit of boring to suit shafts of all sizes.

Care must be exercised in setting the wheels that they be in line, and that the shaft may be exactly at right angles with the line of transmission, that no vibrations from this source may occur."

As we remarked in a former article, Mr. Haigh manufactures by improved machinery wire rope of indefinite length without splicing. Nevertheless, in the use of wire rope some splicing can hardly be avoided. We therefore illustrate in the accompanying engravings the manner of procedure in making a splice, which with the description will enable any one of ordinary mechanical skill to perform the operation successfully:

"After having hauled the ropes taut and determined the length of one turn of the rope, by measuring along the rope the distance occupied by six strands; then,

Fig. 3



"*First.* Unlay from each end a length of rope equal to about twenty-five times the length of one turn, remove the hemp centres and place the ropes so that their opposite strands will interlock each other, as in Fig. 1.

"*Secondly.* Unlay a strand from one end, and following the unlay closely, lay into the score or groove left by it the opposite strand on the other end, until all but a length equal to about three turns of the strand is laid in as in Fig. 2; then cut off the one unwound to a length equal to three turns, and tie them temporarily.

"*Thirdly.* Unlay a strand from the opposite

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Distribution of Work to a Distance by Electricity. — Several experiments have lately been made in France in transmission of work by means of two Gramme machines, one made to produce electricity by mechanical work, the other to do the opposite and restore the work. Exact data of such an experiment at Sermaize (Marne) have been published by M. Tresca. There is a Gramme machine in the sugar works there, driven by a steam-engine at the rate of 1200 revolutions in a minute. This was connected by a copper wire or cable with a Gramme machine on a carriage at 400 metres distance, and another Gramme machine 250 metres further away; a commutator on the first carriage allowed of directing the current to work either machine as required. These secondary machines were caused to actuate drums with cables wound round them whereby ploughs of the double Brabant type were drawn a field. An effective force of 3 horse-power was thus obtained. The first Gramme actuated by the current made 1123 turns in the minute, the second 890. The current could also be applied to move the carriages on which the Gramme machines were conveyed

June 79

Ploughing by Electricity.—M. Tresca has succeeded in ploughing a field by electricity near Sermaize, in France. Three Gramme machines were employed; the first making 1,200 turns a minute, was driven by a steam engine of six horse-power. This current drove a second machine 400 metres off, at a speed of 1,120 turns per minute, or a third machine 980 metres distant, with a speed of 980 turns per minute, according as it was shunted. The two last machines, which were portable, propelled two ploughs, which were of the Brabant type, by means of two cables. The available power in the process was estimated at three horse-power, showing a loss of 50 %.

June 78

Wire Rope Transportation at the Reading Iron Works.

At the Reading Iron Works a system of wire rope transportation is being built, which is expected to do away with much expensive handling and carting, and will offer a good example of a system which is rapidly gaining ground in Europe, and has been repeatedly used with success both in Eastern and Western States, although not to that large extent which its advantages warrant. At the Reading Works there will be three lines of transportation, the first of which will be 1,000 feet in length. It will be used exclusively for conveying pipes manufactured in the establishment to a siding along the Reading Railroad, 90 feet in length, where the pipes will be loaded upon cars. The second line will be 800 feet in length, and will be used for the transportation of Anthracite coal, while the third line will be 300 feet in length, and will carry soft coal and pea coal to the rolling mill. The trestles vary from 20 to 45 feet in height. The first line is supplied with two terminal and eight intermediate trestles, the second line with two terminal and four intermediate trestles, and the third line with two terminal and one intermediate trestle.

The main line will be equipped with an endless steel rope, 1¼ inches in diameter, which will run over sheaves or large wheels located upon the trestles, the rope fitting firmly into grooves in the circumference of each wheel. Grooved trucks will be fastened upon the chain, from which will be suspended hangers to support whatever articles may be transported. As this line will be used for carrying pipes almost exclusively, two trucks will be arranged in such a manner as to carry the pipes suspended upon the hangers. When the trucks reach the railroad siding they will be run from the endless rope upon the siding by an ingenious contrivance. From the center of the track to the center of the wheel, the guage is the same as from the center of the rope to the center of the wheel. Upon the truck reaching the siding, the rope shoots at an angle, and the truck is run upon the railroad tracks with its freight. The moment the wheel strikes the rail the rope slips down and leaves the truck standing upon the rail. The truck is then disengaged from the rope and unloaded. While one line of loaded trucks is being conveyed from the pipe mill to the siding, a line of empty ones is being returned.

The operations of the other lines for carrying coal from the railroad sidings and dumping places to the pipe and rolling mills are of a similar character. The large sheaves or wheels, are 8 feet in diameter, and the small sheaves are 2 and 3 feet in diameter. The coal will be carried in buckets suspended from trucks fastened to chains. The power used in operating the endless ropes will be transmitted from a stationary engine by the line of shafting in the flue cutting department of the pipe mill. June 79

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a track, the planks being laid down in front and taken up behind. The outlay for timber and labour would probably have reached £500 at most, and much of this would have been cheerfully defrayed by exhibitors. The authorities placing their trust in the weather and taking no precautions against contingencies, the success of the whole undertaking has been imperilled. Is it not true that, lavish as the Royal Agricultural Society is in some respects, it draws its purse strings the moment a demand is made for an addition to a permanent and hard-worked staff, even when such an addition is imperatively required?

Let us hope for the best, and suppose that the weather will be all that can be desired between this and Monday and all next week. Let us assume that every stand will be filled, every implement in its place, and consider for a moment what the visitor will see, and what the exhibition will teach most prominently. The implement shows of the Royal Agricultural Society are completely unparalleled. In no other country than England is to be seen year after year such collections of machinery and tools used in tilling the soil, reaping harvests, thrashing grain, and preparing food for man and beast. On the continent of Europe there are held now and then shows which follow at a great distance the example set by England. In America there are what is known as "State fairs," in which agricultural machinery figures prominently. But these things all sink into insignificance before such a collection as that to be seen at Kilburn. It will be impossible to walk through the yard without being convinced that agricultural engineers of Great Britain, alike in the ingenuity which they display, the skill which they possess, the capital which they employ, and the energy which they manifest in continuously endeavouring to improve on their past work, form a body absolutely unrivalled, and of which the nation may well be proud. There is not a quarter of the world to which they have not penetrated; there is not a region which they have reached and left unbenefitted. They have increased the food production of the world to an incalculable extent; and no man dare say that they have done all or nearly all that they can accomplish. To the progress of improvement there is apparently no limit; and that progress moves with gigantic strides is shown by the fact that forty years ago the portable engine was unknown, steam ploughing a thing of the future. What barn work was like may be gathered from an examination of the contents of the Museum, or even of the illustrations of some of its occupants which we publish. Even within the last twenty years enormous advances have been made. Who can say but that in the year 1919 a museum may be found in a showyard of the Royal Agricultural Society, in which much that we now regard as perfect will be looked upon by the visitors much in the same spirit that Cambridge's portable engine, Aveling's traction engine of 1860, Fowler's original steam plough, and the reaping and mowing machines of Hussey, Crosskill, and Burgess are regarded now. It has been said that all things are possible to him who waits. Agricultural engineers have proved that to them all things are possible, notwithstanding that their last thought is to wait.

June 79

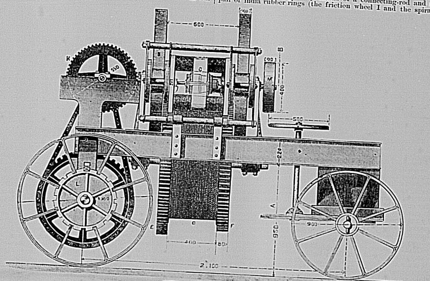
TRANSMISSION OF POWER TO A DISTANCE.

Although it is now at least seventy-seven years since Bramah proposed to transmit power to great distances by means of water under pressure, and although it is half a century since Mann proposed and described the means for transmitting power over still greater distances by means of compressed air, it cannot be said that either of these means of transmission have been employed to the extent that their proposers expected they would be, nor to the extent to which they might profitably have been used in many countries. Telodynamic transmission has been employed to a considerable extent; but in several cases works erected for this purpose have been abandoned, as, for instance, at Belgarde. The loss of power in transmission by these methods is probably less by the telodynamic than by the others, but although M. Hirn, who has taken so prominent a part in bringing this method before the world, has upon reliable data calculated that this loss would be but about ten per cent. for distances not greater than twelve miles, there are sufficient reasons for saying that two or three miles is the greatest distance to which the system is practically applicable. One of the strongest objections to it is the great cost of the way works, while those which may be raised against the employment outdoors of great lengths of wire rope moving at high velocity are hardly less cogent. Hydrodynamic transmission comes perhaps next in order of economy, but this quality decreases rapidly as the power to be transmitted increases. For comparatively small powers the system is applicable, because only small quantities of water, but under high pressures, are sufficient. For large powers, however, the system loses its economy. Large mains are needed, and for the very high pressures necessary to economy the required strength of parts would involve great outlay; maintenance would be costly, and especially so where much of the machinery driven was of a reciprocating character and intermittently employed. As at present designed, moreover, the most economical hydraulic motors cannot be employed to work at high speeds; while the enormous strain to which such machinery is subject sets a limit to the size as well as the speed which may be practically attempted.

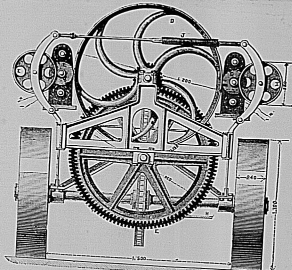
Pneumatic transmission really seems to offer greater advantages than either of the preceding. These were fully seen, and perhaps overrated at a time when experience in air compressing was very limited, and before the science of thermodynamics had acquired the shape in which it is now applicable to the uses of the engineer. It was not known that the loss of work in the form of heat during the process of compression and storage is sufficiently great to place a limit upon the application of compressed air as a transmitter, and that this loss would generally preclude its employment except in situations where the necessity for power is sufficiently

PLOUGHING BY ELECTRICITY.

The accompanying illustrations complete the article in our frame connected to the side frames. These machines are connected at the upper part by means of a connecting-rod and a pair of india rubber rings (the friction wheel I and the spiral



SIDE ELEVATION



TRANSVERSE SECTION ON LINE A.B.

last issue on this subject. The carriage is of wrought iron, mounted on four iron wheels, the two side pieces being of I section. The two Gramme machines G G are mounted on a hinged spring J not being found rigid enough were removed after the trial) which hold the pulleys on the end of the Gramme machine spindles against the pulleys D D. The small pulleys in the

ront pour les acides, ou l'on trouvera le moyen de les produire à plus bas prix, et en aussi grande quantité.

Déjà MM. Solvay, nous dit-on, essayent un procédé qui reposerait sur la substitution de la magnésie à la chaux ; dans la régénération de l'ammoniaque ils obtiendraient finalement un chlorure de magnésium au lieu de chlorure de calcium ; ils y trouveraient cet avantage prétendu que le chlorure de magnésium est facilement décomposé, par la chaleur sous l'influence de la vapeur d'eau, en acide chlorhydrique et en magnésie. Je crains bien pour ces messieurs des déceptions sous ce rapport, car cette décomposition n'est ni aussi simple qu'elle en a l'air, ni aussi facile ; les produits, en outre, peuvent laisser beaucoup à désirer. Assurément le problème n'est pas insoluble ; espérons que MM. Solvay et Cᵉ auront encore la main heureuse et qu'ils arriveront des premiers, c'est ce que je leur souhaite dans leur intérêt comme dans celui de toute l'industrie.

E.-P. ANDRÉ.

USINES ET ATELIERS

TRANSMISSIONS PAR COURROIES ET PAR CABLES

(Comptes-rendus de la Société des Ingénieurs civils).

M. Leloutre donne communication de son Mémoire sur les transmissions par courroies et par câbles.

« Les recherches expérimentales que j'ai l'honneur d'exposer ont été commencées il y a une douzaine d'années au sujet de quelques travaux importants que j'ai été chargé d'exécuter ; elles ont été complétées plus récemment pour établir des bases certaines pour la construction de transmissions par courroies et par cordes. »

Ce travail est partagé en quatre parties :

1°) *Recherches expérimentales sur l'allongement, l'élasticité et la résistance à la rupture des courroies en cuir et en caoutchouc, des sangles et des toiles.*

2°) *Recherches expérimentales sur le glissement des cordes et des courroies.*

3°) *Applications, et étude de transmissions exécutées. Analyse de quatre projets de transmission de* 40, 80, 150 *et* 750 *chevaux-vapeur.*

4°) *Renseignements pratiques et conclusions.*

§ I. — *Recherches expérimentales sur l'allongement, l'élasticité et la résistance à la rupture, des courroies en cuir et en caoutchouc, des sangles et des toiles.*

Au début de nos recherches sur les courroies de transmission je ne m'occupais que de la résistance à la rupture. Au bout de quelques essais, je m'aperçus que la détermination de la charge de rupture, des cuirs, des sangles ou des cordes n'est pas aussi simple qu'on veut le croire ; puis l'allongement et l'élasticité m'ont révélé quelques faits intéressants.

En opérant sur des échantillons de cuir de même qualité on peut trouver des coefficients de rupture fort différents, selon le temps que l'on met à provoquer la rupture.

Pour mettre en évidence l'influence du facteur *« temps »* que l'on néglige si volontiers dans bien des travaux, j'ai dû prendre, en commençant mes recherches, quelques précautions, et fixer mon opinion sur quelques détails relatifs aux méthodes d'expériences que je comptais suivre.

Voici comment les opérations ont été conduites :

Dans une même courroie ou une même peau, j'ai fait découper une bande de cuir de 5 à 6 centimètres de largeur. Cette bande de cuir était découpée en trois ou quatre lanières réservées pour les expériences diverses auxquelles je comptais les soumettre. J'étais ainsi sûr d'avoir plusieurs échantillons de cuir de même qualité.

Ces lanières d'environ 700 à 800 millimètres de largeur furent munies à leurs extrémités de crochets en fer ; l'un de ces crochets servit à les suspendre à un point fixe et, à l'autre, on appliquait des poids étalonnés que l'on augmentait graduellement jusqu'à la rupture ; on relevait simultanément tous les faits intéressants sur l'allongement et l'élasticité.

Sur chacune des lanières on traça sur la partie supérieure un trait transversal très-fin, considéré comme origine pour la mesure des longueurs, sous les charges successives auxquelles on les soumettait ; pour redresser les ondulations du cuir et pour tendre légèrement les lanières on les chargeait d'un poids de 2 kilogr. et au premier moment de l'application de cette charge on marquait rapidement un second trait, distant du premier de $500^{m}/^{m}$. Cette charge de 2 kilogr., augmentée du poids du crochet inférieur ou 2 kilogr. $+ c_r$, nous l'appellerons *charge de tension ;* puis on divisa l'intervalle compris entre ces deux traits en cinq parties égales de 100 millimètres.

Enfin on mesura la largeur et l'épaisseur des lanières en quatre ou cinq endroits différents, pour déterminer les sections transversales correspondantes. C'est le minimum de ces sections qui figure dans nos tableaux d'expérience. Ces dimensions ont été exprimées en 1/4 de millimètre, c'est-à-dire que les erreurs commises sont moindres que 1/8 de millimètre ; on évitait dans toutes ces mesures l'emploi de compas d'épaisseurs, de calibress afin d'éviter les erreurs qui auraient pu résulter d'une compression possible du cuir ; une discussion des erreurs probables nous permet d'affirmer que les résultats que nous discuterons sont approchés à moins de 2 %.

Ces dispositions prises, on soumettait les lanières à trois genres d'expériences :

1° Une des lanières fut soumise à des *charges rapidement croissantes* jusqu'à la rupture ; pour commencer on ajouta à la charge de tension, 2 kilogr. $+ c_r$, un poids de 5 kilogr. ; au bout de cinq minutes on constata l'allongement, puis on ajouta encore 5 kilogr. à la première charge de $5 + (2 + c_r)$, et au premier moment de l'application de ce poids de $10 + (2 + c_r)$ on mesura l'allongement, puis encore celui qui se manifestait au bout de cinq minutes de cette charge, après quoi on augmentait le poids de 5 kilogr. et ainsi de suite jusqu'à la rupture ; on

18

ELECTRO-TELEDYNAMICS.

BY PAGET HIGGS, LL.D., ASSOC. MEM. I.C.E.

(CONTINUED FROM PAGE 137).

Electrician Aug 14 1880

Some other points remain to be considered in the circuits employed for the transmission of power by electricity. One of these relates to the maximum heat effect, such as may be manifested in a calorimeter, obtainable on the exterior circuit, and representing the energy of the motor or driven machine. This maximum heat effect is obtained, as is well understood, when the resistance of the external circuit equals the internal resistance of the *effective* coils of the generator. When the resistances are so related, this maximum heat effect represents one-fourth of the work or energy of the generator. From this maximum the heat-work reclaimed can vary to $\pm$ zero, as the external resistance is varied 0 to ∞; and the total work will diminish, passing a value equal to half of the energy, or to the maximum efficiency of the work reclaimed, whilst the relative efficiency increases from 0 to 1.

When the electromotive force of the generating machine is not fixed, and under the condition that the mechanical power to be absorbed is the given quantity, the number of revolutions of the machine will increase as the total resistance (internal and external) is increased. Whilst the external resistance increases, the thermic efficiency will vary in absolute value from 0 to that of the work expended, the relative efficiency varying from 0 to 1.

When the electromotive force of the generator is a given quantity E, the work reclaimed on the second machine or motor during a unit of time is, at the maximum, represented by $c\frac{E^2}{4S}$, when $e = \frac{E}{2}$, and where c is the reduction constant. The expenditure of work will be variable, and $= c\frac{E^2}{2S}$; or the relative efficiency will be ½.

When the power applied to the generator is a fixed quantity, and the electromotive force is variable, thus varying E and e, the work reclaimed by the second machine or motor, $c\frac{V}{S}e$, will approximate more nearly to the work expended at the generator, $c\frac{V}{S}E$, in proportion as $\frac{e}{E}$ approximates to unity.

For the value of $\frac{e}{E}$, or the relative efficiency, constant, the ~~works expended and~~ reclaimed obviously increase in absolute value as does the value of $E-e$. But as the amount of mechanical work varies, so does the absolute value of the thermic work, and the limits of the values of E and e are those set for one consideration of modes of construction by the heat the insulating covering of the machines will support without burning, a kind of limit that has no practical value, since the efficiency of the machine is practically limited by the amount of current that the commutator of the machine will allow to pass without too speedy destruction. The quantity of current in webers $\left(\frac{V}{S}\right)$ determines a total thermic work of $c\frac{V^2}{S}$ calories, of which the two machines take respectively $c\frac{V^2 r}{S^2}$ calories and $c\frac{V^2 R}{S^2}$ calories as motor and generator.

When the two machines are working at a relative efficiency of $\frac{e}{E}$, either should be capable of sustaining a velocity of armature, without heating beyond practical limits, that would produce in a wire circuit of the same resistance as the external circuit to be used in working, a thermic work $\left[\frac{1}{1-\frac{e}{E}}\right]^2$ times greater than the working limit set by the builder of the machine.

The engineer who has to transmit a certain amount of power a given distance will require to know how to select the machines best suited to his requirements; for he will, unless experienced as an electrician, scarcely adopt the alternative of constructing machines for his own use, if not prevented therefrom by patent rights and want of time. The first consideration will be that of the distance to be traversed by the connecting wire, which will require to be of as small diameter as may be consistent with the proper conduction of the current without loss by heating. This diameter and length will give the resistance ρ, which will again determine the best resistances R and r of the two machines (for more than two machines the best conditions have yet to be deduced). With $\frac{e}{E}$ given under the conditions of maximum in the preceding remarks, and with the value of V or $E-e$ deduced at sight from Ohm's law and the number of webers current required, all the data are complete, except those concerning the diameter and insulation of the line-wire. The determination of these last mentioned points is worthy to be separately considered.

(TO BE CONTINUED.)

TRANSPORT ÉLECTRIQUE

DU TRAVAIL MÉCANIQUE A DISTANCE

APPLICATIONS AU LABOURAGE, ETC., ETC.

SYSTÈME CHRÉTIEN ET FÉLIX

Le jour de l'Ascension, nous avons, en très-bonne compagnie scientifique, consacré nos loisirs fériés à entreprendre le petit voyage de Sermaize (Marne). Il s'agissait d'assister à des expériences de labour par l'électricité. Nous avons remarqué la présence de M. Tresca, membre de l'Institut et de la Société nationale d'agriculture, sous-directeur du Conservatoire des arts et métiers. La rencontre de M. Tresca est toujours de bon augure; il inspire aux inventeurs peu sérieux une considération mêlée d'une terreur justifiée par la raison qu'en mécanique cet éminent ingénieur connaît tout, mesure tout avec la compétence et la précision que l'on sait, sans qu'il soit possible de lui donner le change sur aucun point. Nous avons vu : M. Dureteste, inspecteur général des ponts et chaussées; M. Cabanellas; M. Begbeyder, ingénieur des mines; M. Galichet, ancien député, agriculteur; M. de Felcourt, président du Comice agricole de Vitry-le-Français, délégué de la Société des agriculteurs de France; M. Napoli, ingénieur chimiste et inspecteur au chemin de fer de l'Est, collaborateur de M. Marcel Deprez dans la construction des enregistreurs électriques de ce géomètre appliqués au wagon d'expériences dont M. l'ingénieur en chef Regray a doté la compagnie de l'Est; M. Richard, ingénieur des mines; M. Dumont, ingénieur; M. Hersent, entrepreneur des travaux publics; M. Tassin, etc. Le journal *la Lumière électrique*, le journal de l'*Agriculture*, le journal des *Travaux publics*, s'étaient fait représenter. Enfin, un grand nombre d'agriculteurs et de propriétaires de la région assistaient aux expériences. Quelques jours avant, M. Duphémieux, préfet de la Marne, et M. le général Clinchant, commandant en chef du 6e corps d'armée, étaient venus examiner avec intérêt les applications électriques de Sermaize.

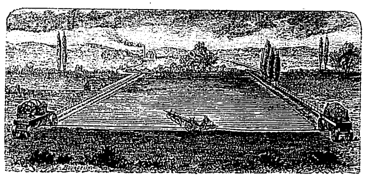
MM. Chrétien et Félix, ingénieurs très-avantageusement connus dans le monde industriel, ont, sans doute, comme cela est arrivé à bien des gens pratiques, arrêté leur pensée sur les conditions toutes spéciales qui caractérisent notre industrie du sucre : à une activité fiévreuse de quelques mois, succède, dans l'usine, une inaction absolue de tout le reste de l'année : il en résulte, qu'une puissance motrice toujours considérable, représentant un capital d'une grande valeur, se trouve immobilisée pendant tout ce temps, ce qui ne dispense pas d'un entretien minutieux et ce qui, à coup sûr, s'écarte beaucoup d'une bonne utilisation industrielle.

Il était donc d'autant plus logique de tenter la mise en culture du domaine par la force motrice de l'usine, qu'il est reconnu aujourd'hui, par la pratique de l'Angleterre, des États-Unis etc., même de l'Algérie, que la culture mécanique, partout où elle est possible, est économique, et augmente les récoltes dans la proportion d'au moins 30 p. 100.

19

Les labours mécaniques qui, jusqu'à présent, ont donné les meilleurs résultats comportent l'emploi de machines routières à vapeur actionnant des tambours sur lesquels s'enroule un câble d'acier qui remorque une charrue à socs multiples. Cependant ces appareils sont d'un prix élevé, leur conduite et leur entretien sont coûteux et exigent des soins spéciaux. Le poids est très-considérable et la manœuvre difficile dans les champs par temps de pluie; enfin, en dehors du combustible, le système nécessite un grand approvisionnement d'eau souvent fort incommode, et dispendieux au point qu'en réalité, les gens techniques estiment que cette eau arrive à coûter aussi cher que du charbon. Avec l'électricité, ces exigences disparaissent, les charriots complets pèsent environ deux tonnes au lieu de dix-huit, peuvent passer par tous les chemins, se manœuvrent avec une grande facilité, toujours à l'électricité; plus d'approvisionnement à transporter, ni charbon ni eau. On détermine la traction en tournant un simple conjoncteur métallique qui ferme le courant sur le moteur électrique; le sillon terminé, une autre touche de commutateur ouvre le circuit et envoie le courant au second charriot, rendant ainsi impossibles les avaries consécutives d'un malentendu non sans exemples qui a pour effet de mettre simultanément en action les deux locomobiles.

Les planches qui accompagnent cet article montrent clairement l'ensemble et les parties intéressantes du dispositif. Les données de l'expérience à laquelle nous avons assisté étaient les suivantes : deux machines Gramme ordinaires à lumière, dites du type A, étaient actionnées par le moteur de l'usine exportant leur électricité par un conducteur de cuivre de 3 m/m et faisant tourner, à 400 et 620 mètres de là, deux autres machines Gramme identiques. Ces machines, placées sur leur chariot respectif, aux deux extrémités du rectangle de



Labour électrique, vue d'ensemble.

terrain mis en labour et successivement animées par le courant, tiraient à elles, avec une vitesse de 40 à 50 mètres par minute, une charrue Brabant double, traçant des sillons larges de 30 centimètres et profonds de 20. La longueur des sillons était de 220 mètres, les deux charriots étant reliés par une longueur de 250 mètres de fil conducteur. En supposant la moyenne du travail du sillon d'aller égale à celle du sillon de retour, on peut regarder les travaux des machines comme proportionnels à l'inverse des temps, et, la durée du retour étant d'un cinquième moindre que celle d'aller, il en résulterait que le rendement en travail des machines Gramme, distantes électriquement de 650 mètres, serait les 80 p. 100 de celui des machines distantes de 400 mètres.

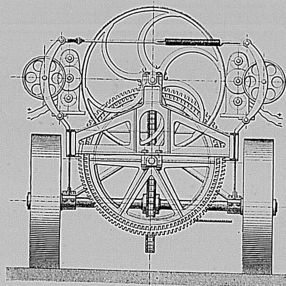
Avec les mêmes machines et du fil de 10 m/m carré de section, on a exporté le travail de l'usine à une distance de 2 kilomètres.

D'après les mesures dynamométriques prises par MM. Chrétien et Félix, tant à l'usine que sur le terrain, la moitié de la puissance empruntée à l'usine serait en moyenne transmise à la charrue, et nous avons estimé à environ trois chevaux de 75 kilogrammètres par seconde le travail moyen absorbé par le labour exécuté sous nos yeux. — Les ingénieurs de l'usine auraient trouvé plusieurs rendements supérieurs à 50 p. 100, mais il y a lieu de remarquer que les mesures dynamométriques étaient prises au frein de Prony, méthode qui procède par voie de substitution et ne comporte généralement pas une extrême précision. D'après les données théoriques actuellement admises (Travaux de MM. Mascart, Maxwell, etc.) et quelques expériences anglaises faites sur des machines Siémens, le rendement maximum ne peut dépasser 50 p. 100, rendement qui doit correspondre au point où la machine électro-motrice est animée d'une vitesse égale à la moitié de la vitesse de la machine électrique mécaniquement actionnée. Nous avons cependant des réserves à faire

20

sur ces points théoriques, nous les exposerons ultérieurement. D'ailleurs, pour le cas actuel, M. Tresca, rendant compte à la Société nationale d'agriculture de l'examen que cette Société l'avait prié de faire des applications de Sermaize, a dit qu'il allait expérimenter aux Arts et Métiers le rendement de ces machines Gramme du type A; nous allons donc bientôt être positivement fixés.

Quoi qu'il en soit, un rendement de 50, de 30, même de 25 p. 100, serait encore très-beau industriellement, si l'on réfléchit aux pertes énormes qui sont imposées par les transmissions usuelles et par la plupart des organes mécaniques avant d'arriver au travail effectif proprement dit qui est la raison d'être de ces organes. Il faut remarquer aussi que la force motrice prise à l'usine y est produite dans les conditions les plus économiques, par des machines fixes puissantes, qui peuvent facilement ne dépenser qu'un kilogramme de combustible par heure et par cheval, au lieu des consommations de locomobiles variables de 6 à 15 kilogrammes de houille. On réalise encore l'économie sur le personnel et l'économie de tout l'approvisionnement d'eau sur le terrain, dont il faut organiser et payer si cher le transport. Je ne parle pas de la mobilité absolue que le transport



Chariot électrique.

électrique du travail réalise d'emblée au point d'arrivée, quel qu'il soit.

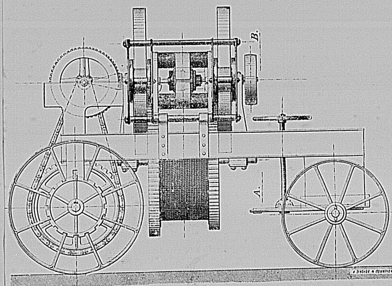
Les machines employées sont, comme nous l'avons dit, des machines usuelles à lumière, et il n'est pas douteux que des appareils spécialement combinés et construits ne soient appelés à se prêter beaucoup mieux encore à cet emploi.

On sait, en effet, que, dans les machines génératrices d'électricité par induction, le constructeur, par le seul changement des sections induites, est maître de la force électromotrice développée dans chacune des modifications relatives de positions de l'inducteur et de l'induit; la résistance intérieure se trouve alors modifiée dans le même sens, mais il en résulte néanmoins que la résistance extérieure non exploitée peut perdre beaucoup de son importance nuisible sur le travail extérieur utilement exploité, et nous ne doutons pas qu'il ne soit relativement facile d'établir de puissantes machines Gramme qui permettront l'utilisation d'un travail moteur à de très-grandes distances avec un bon rendement et en n'employant, comme circuit extérieur de transport de l'électricité que du fil métallique d'une section restreinte. Quand nous parlons d'une section relativement restreinte même avec les plus grandes portées qui pourront s'imposer dans l'application, nous ne risquons pas de causer de méprise, nous sommes seulement animé de cette conviction

21

que l'on doit tirer du principe tous les avantages qu'il comporte : car, dès aujourd'hui, avec les machines actuelles, on peut compenser par les dimensions du fil une augmentation quelconque de distance, puisque le conducteur extérieur n'a qu'un rôle passif en rapport avec sa conductibilité électrique effective, laquelle, en outre de la longueur, dépend de la conductibilité spécifique du métal et des dimensions transversales (section totale pour les circulations dites de quantité, et fonction analogue au périmètre extérieur total pour l'électricité de haute tension et certaines conditions de discontinuité dans la production).

MM. Chrétien et Félix ont combiné une série d'appareils mécaniques pour toutes les opérations de grande et moyenne culture exécutées en Angleterre au moyen de locomobiles : labourage, battage, hersage, sarclage, ensemencement. Ils ont établi des cabestans et des grues électriques d'un emploi très-commode. Ainsi, à Sermaize, pendant la fin de la dernière saison, une élinde, commandée électriquement de l'usine, prenait les betteraves dans les bateaux et les chargeait sur les wagons. Cet appareil a ainsi déchargé 4000 tonnes de matière première, réalisant, d'après le calcul du Directeur, une économie de 40 p. 100 sur la main-d'œuvre et permettant de s'affranchir d'un personnel spécial de débardeurs sur lequel on ne peut pas toujours compter.



Chariot électrique.

En résumé, nous qui ne sommes pas un converti des derniers jours, mais qui avons cru au transport du travail mécanique par l'électricité dès l'apparition des premières machines électriques réversibles, alors que ces machines étaient bien loin de l'état de perfection qu'elles ont atteint en dix ans, nous voyons avec une véritable satisfaction ces premières applications exécutées au grand jour, d'une façon pratique, sans complications inutiles, avec des dispositifs mécaniques assez bien entendus pour qu'il paraisse difficile d'admettre qu'on puisse les simplifier davantage.

Ces résultats font le plus grand honneur à MM. Chrétien et Félix, et les vastes horizons qui s'ouvrent ne leur ont pas échappé. Les applications peuvent être innombrables et d'une importance majeure.

Les économistes nous disent qu'il est urgent d'augmenter nos récoltes nationales et de diminuer les frais de mise en œuvre malgré l'insuffisance de plus en plus grande du travail manuel. Combien n'y a-t-il pas, en France et ailleurs, de puissances hydrauliques inutilisées faute de moyens économiques pour en transporter l'application à proximité des communications existantes?

La voie semble donc immense pour l'agriculture, et au même titre, pour un grand nombre d'industries.

GESSÉ.

Transmission of Power by Electricity.—Profs. Houston and Thomson have experimentally shown, at the Franklin Institute, that powerful electric currents can be conducted by very fine wires. They sent the current generated by one dynamo-electric machine through a wire .001 inch in diameter to a second machine, which, working reversely, gave off considerable power.

Min. & Sc. Press
Dec. 12 / 79

[illegible] 1879
Boston Journal of Chemistry

Ploughing by Electricity.—At a recent meeting of the Paris Academy of Sciences, M. Tresca gave an account of some experiments in ploughing by electricity which he witnessed at Sermaise, in the Marne. A Gramme machine, making 1200 revolutions per minute, and driven by a steam-engine, was connected to a second Gramme at a distance of 440 yards, and caused the latter to revolve at the rate of 1140 revolutions to the minute, the electricity produced by the first machine being thus converted into work. The second machine was connected to a third at a distance of 219 yards, and these two worked cables attached to a double Brabant plough. According to M. Tresca, the experiment was very successful, the work accomplished representing the equivalent of three horse-power, while one half of the motive power obtained from the steam-engine was really transferred to a distance of more than 1000 yards from the furnace.

LE LABOURAGE PAR L'ÉLECTRICITÉ

C'est déjà une expérience ancienne que celle qui consiste à réunir deux machines magnéto-électriques, à mettre en mouvement l'une de ces machines, pour produire un courant électrique et avec ce courant faire marcher en sens contraire l'autre machine, transformer ainsi un travail mécanique en électricité, puis, celle-ci transformée à son tour en travail mécanique. Le principe du transport de la force motrice à distance était trouvé; mais, jusqu'à présent, les éléments de précision manquaient, et, exception faite de quelques expériences entreprises par la Compagnie Paris-Lyon-Méditerranée, la distribution du travail à distance au moyen de l'électricité était restée dans la limite restreinte d'essais de laboratoire et n'avait pas encore reçu une application vraiment pratique.

Aujourd'hui la transmission de la force motrice sur un long parcours, par un ingénieux emploi de l'électricité paraît être un fait acquis. Des expériences concluantes de labourage par l'électricité ont eu lieu le 23 mai à la sucrerie de Sermaize (Marne), et M. Tresca, membre de l'Institut, a bien voulu faire connaître le résultat heureux de ces expériences.

Voici dans quelles conditions les essais de labourage par l'électricité ont été dirigés.

Dans un des bâtiments de la sucrerie de Sermaize, un moteur à vapeur mettait en mouvement une machine magnéto-électrique de Gramme faisant 1.200 tours à la minute. Le courant développé était conduit par un fil de cuivre formé de neuf brins de 1 millimètre de diamètre, offrant ensemble une section de 7 millimètres carrés, à une distance de 400 mètres, sur un chariot où il pouvait d'ailleurs être dévié par un commutateur qui le dirigeait alors à 250 mètres plus loin, sur un autre chariot, en tout semblable au premier. Sur l'un ou l'autre de ces chariots et à volonté, le courant faisait fonctionner deux machines Gramme dont l'arbre entrait aussitôt en mouvement, et ce mouvement, convenablement ralenti par des organes intermédiaires, déterminait la rotation d'un tambour de 1 mètre de diamètre, sur lequel s'enroulait un petit câble de la grosseur de 12 millimètres, entraînant une de ces charrues dites *brabant* double, qui labourait ainsi un sillon de 220 mètres de longueur, à une profondeur de 18 centimètres, en moins de 5 minutes.

M. Tresca, à qui nous empruntons les détails qui précèdent, ajoute :

« La terre était résistante, et, bien qu'elle eût reçu un premier labour, qui l'avait ameublie, je ne pense pas que le même sillon, de 18 centimètres de profondeur, eût été produit, dans les appareils Fowler, avec moins de trois chevaux-vapeur. La résistance à la traction était la même dans les deux sens, et l'on peut déjà se rendre compte de la déperdition suivant la distance en remarquant que la vitesse du tirage, qui était de 0m,88 lorsque le fluide agissait sur le tambour du premier chariot, se trouvait réduite à 0,70 lorsque la longueur du circuit se trouvait augmentée, pour atteindre le second chariot, de deux fois 250 mètres. Au reste, l'arbre des machines Gramme actionnées par le courant, qui tournait à raison de onze cent vingt-trois tours par minute dans le premier cas, se réduisait à huit cent quatre-vingt-dix dans le second.

« Ces machines pouvaient respectivement déterminer, en outre, l'avancement même du chariot qui les portait, la disposition générale imitant en cela le procédé de labourage à vapeur dans le système à double machine routière, cheminant sur les bords opposés d'une pièce de terre. »

Quelle est exactement le rendement de ce mode de transmission de la force motrice?

Quelle est la relation entre le travail dépensé et le travail réellement produit?

Dans l'état actuel des expériences, il nous paraîtrait bien téméraire de présenter des chiffres, quels qu'ils soient.

Sans doute, la transformation de l'électricité en travail mécanique, problème souvent cherché et dont la solution peut avoir des conséquences et produire, comme le dit si justement notre éminent confrère, M. J.-A. Barral, une véritable révolution économique, est une idée féconde qui laisse le champ libre à toutes les conceptions et à toutes les espérances. Mais, avant d'affirmer que cette application nouvelle du fluide électrique peut rendre à l'agriculture et à l'industrie des services réellement pratiques, il [illegible] attendre les essais nouveaux que M. Tresca doit faire dans bref délai au Conservatoire des arts et métiers.

E. Venelle.

Am Machinist July 1879

(8) C. A., Brooklyn, N. Y., writes: I have heard a great deal about the transmission of power by wire rope, and I now write to you for information. I have a water wheel located in a mill which is now in use, and I also have a large building situated about 1,000 feet from the mill, which I would like to adapt to manufacturing purposes which will require power. What I wish to know is, If it is practicable to transmit power from the mill to the large building, and also if I could use wire rope as the means to transmit the power? A. It is practicable to transmit power by wire rope, not only the distance that you speak of, but a great deal farther, and is coming into use more every year. There is an instance in the neighborhood of Frankfort-on-the-Main, in Germany, where the power of 100 H.P. turbine is conveyed for a distance of 3,200 feet, by means of a rope transmission, to a cotton factory located in the proper place for such a building. Wheels, 13½ ft. diameter, making 114 revolutions per minute, are used; size of rope ⅝ of an inch diameter. There are eight intermediate stations or places where wheels are located at distances of 400 feet apart, it being found in practice that for any distance over 400 feet an intermediate wheel, or wheels, should be used—thereby making two sections, by which the speed is much more steady. In the above instance a nearer site for a building could not be found, and this was the only way that the power could be made available for that purpose.

Engineer July 18 1879

4686. TRANSMITTING ELECTRICITY TO GREAT DISTANCES, *E. U. Parod.*—*Dated 19th November*, 1878. 8*d.* Engineer July 18 1879

This consists in the substitution for the telegraphic cables or wires of a condenser acting as a reservoir of electricity, and extending from one end of the territory to the other. This reservoir is charged at one of its extremities, or at any intermediate point between the extremities, by any suitable generator of electricity, actuated by any of the natural sources of motive power which abound in mountainous districts, such as rapids and waterfalls, and delivers the electricity with which it is charged at as many points as may be required along its whole length, for the purpose of supplying or actuating any machines or apparatus to which it is connected.

Eine neue Anwendung der Electricität.

Im Herbste des verflossenen Jahres hatte Herr Edison mit einem ihn besuchenden Reporter der "N. Y. Tribune" ein harmloses Gespräch gepflogen, in welchem auch von Transmission von Triebkraft mittels Electricität die Rede war. Nachdem sich die grosse Aufregung gelegt hatte, welche durch Edison's Behauptung entstanden war, ein electrisches Licht herzustellen, so theilbar und billig, dass es selbst das Gas im Haushalte verdränge, also zu einer Zeit, wo Mr. Edison die Ungeduld des Publicums, das Wunder von ihm erwartete, nicht sofort befriediget hatte, da erschienen besonders in deutschen Blättern Kritiken über die Unterredungen, welche Edison mit den Berichterstattern über die Transmission von Triebkraft mittels Electricität gehalten hatte, die mit spitziger Feder geschrieben worden waren und die auch in technische Blätter England's übergingen.

Mr. Edison hat auf diese Angriffe mit seinem "lautsprechenden Telephon" geantwortet, und bezüglich seines Versprechens des electrischen Lichtes wird er auch sein Wort vollständig einlösen, nur muss man bei einer *solchen* Erfindung dem Erfinder Zeit lassen.

Was aber nun jene harmlose Besprechung der Transmission von Triebkraft mittels Electricität und jene durchaus verwerfende Kritik dieser Idee betrifft, *wer* hätte es wohl ahnen können, dass zwischen Diesen doch etwas praktisch Ausführbares und Nutzenschaffendes liegen könne? —

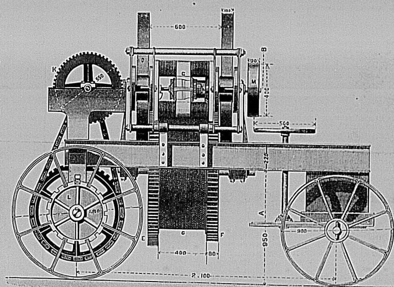
Und doch hat sich *solches* nunmehr herausgestellt, und zwei französische Ingenieure Namens Crétien und Félix überraschen uns mit der Anwendung von Triebkraft mittels electrischer Transmission zum — *Pflügen!* So hören wir, dass die Genannten vor Kurzem zu Sermaize, Departement Marne, Frankreich, mit einem von ihnen construirten Apparate gelungene Versuche mit einem neuen Systeme von Boden-Cultur angestellt haben.

Das Pflügen mittels mechanischer Kraft, wie es gegenwärtig in England, in Russland und in den Ver. Staaten vorkommt, ist von dem Gebrauche einer locomobilen Dampf-Maschine abhängig, welche neben dem zu pflügenden Lande aufgestellt ist und Trommeln in Gang setzt, über welche ein endloses stählernes Tau läuft, das dazu dient, den Pflug hin und her über das Feld zu ziehen. Diese Maschinen stehen aber in hohem Preise; sie sind theuer zu handhaben und zu unterhalten. Eigens muss man dabei darauf sehen, dass sie auch gut arbeiten, da sie in den Feldern oft eine abweichende Behandlung bedürfen, besonders bei regnerischem Wetter. Und schliesslich bedürfen sie auch noch eine beträchtliche Menge Wasser. Freilich ist die Arbeit, die durch sie verrichtet wird, auch besser gethan, und das tiefere Aufpflügen des Bodens, was nur durch mechanische Kraft vollbracht werden kann, steigert die Nahrungkraft der Oberfläche der Ackerkrume, so dass die Ernte um wenigstens 30 Prozent grösser wird.

Aber trotz all' dieser Vortheile hat das Dampfpflügen in Frankreich nur sehr wenig Eingang gefunden. Daran war die überwiegende Anzahl der Kleinbegüterten und die eben aufgezählten Kosten und Umständlichkeiten schuld, welche mit ihm verknüpft sind.

Zum Zwecke einer grösseren und allgemeineren Einführung mechanischer Kraft auf dem Lande haben nun die obengenannten Ingenieure ein Arrangement entworfen, bei welchem die Triebkraft von irgend einer festen Stellung aus angewendet werden kann, um die Arbeit auf mehreren angrenzenden Landgütern mittels Electricität, als Transmissionsagens einzuführen. Sie haben zu diesem Behufe die Gramme-dynamo-electrische Maschine zur Erzeugung der nöthigen Electricität adoptirt und ähnliche Maschinen als das electrodynamische Mittel zur Wiederumwandlung der Electricität, die durch Kabel auf irgend eine beliebige Distanz fortgeleitet wird, in Triebkraft.

Zwei Formen solcher Maschinen sind bereits hergestellt und, wie schon oben erwähnt, durch Experimente erprobt. Eine derselben ist zum Entladen der Runkelrüben aus Booten, die andere zum Pflügen bestimmt.



Cretien & Felix's Elektrische Pflugemaschine. Fig. 1.

Die erstere stand den ganzen Winter über in Thätigkeit und ihre Anwendung stellte der Handarbeit gegenüber eine Ersparniss von 40 Prozent heraus. Abgesehen davon, dass die Rüben viel schneller entladen wurden (ein Ding von Wichtigkeit in der Rübenzucker-Fabrikation), so geschah dies auch ohne alle Beihilfe von Arbeitern, auf welche nicht immer ein sicherer Verlass besteht.

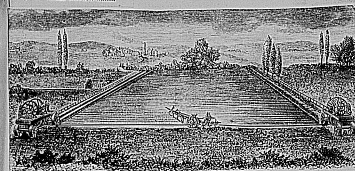
Letztere ist seit einiger Zeit auf einigen benachbarten Feldern im Betrieb und wurde mit balancirten Pflügen gepflügt, deren Haspelmaschinen wir illustriren.

Eine jede derselben besteht aus einem Wagengestelle von Schmiedeeisen, das auf vier eisernen Rädern ligt. Zwei Gramme-Maschinen, G G, stehen auf einem an die Seiten angemachten Ständer. Diese Maschinen sind an ihrem oberen Theile mittels einfacher Verbindungsstangen und ein paar Rubberingen miteinander verbunden, welche die Riemenscheiben an den Enden der Spindeln der Gramme-Maschinen gegen die Riemenscheiben, D D, halten (das Arrangement von Reibungsscheiben, I, und der Spiralfeder, J, hat man nach gemachtem Versuche aufgeben müssen, weil es selbst bei geringer Friktion nicht hinlänglich Steiheit gab). Die kleinen Riemenscheiben in der Gramme-Maschinen sind mit Gutta Percha überzogen. Die Aufziehtrommel, C, erhält ihre Bewegung von den Riemenscheiben, D D, vermittels der Drehlinge, E oder F, welche je nach Bedarf langsamere oder schnellere Bewegung ertheilen. Auf dem Ende der Spindel, welche die Riemenscheiben, D-D, trägt, ist ein schräger Drehling befestigt, welcher in das conische Rad, K, eingreift, auf dessen Welle ein Treib-Drehling ist, über den und das Rad, L, eine Bandkette läuft, wodurch die Bewegung auf dem Seitenbande für den Haspel erlangt wird.

Das Steuern des letzteren wird vermittels eines Handrades, an der Vorderseite ersichtlich, gethan. Wenn nun die Maschine in Thätigkeit gesetzt werden soll, so werden die beiden Hinterräder vermittels einer Setzschraube, die dann wieder gelöst werden kann, auf ihrer Achse fest geschraubt. Das Seil, H, ist, wie schon oben gesagt, von Stahl, hat ½ Zoll Durchmesser und eine Länge von 1.3 Meilen, so wenigstens, wie man sich desselben zu Sermaize bedient. Die electrischen Cables werden an Pfosten, wie beim Telegraphen, fortgeleitet. Sie bestehen aus Drähten von 0.04 Zoll Durchmesser und geben eine sectionale Fläche von ungefähr 0.33 Zoll.

Bei den vorgenommenen Experimenten wurden die Haspel in einer Entfernung von 664 Fuss aufgestellt und passirte der elektrische Strom vermittels Commutatoren abwechselungsweise das eine und dann das andere Paar von Maschinen, je nachdem der Pflug über das Feld hinüber und herüberging (siehe die beigegebene Abbildung). Eine Dampfmaschine, welche in der benachbarten Rübenzucker-Fabrik, ungefähr 1300 Fuss entfernt, aufgestellt war, setzte die dynamo-electrischen Maschinen, welche die Electricität lieferten, in Bewegung. Es waren etwa acht Pferdekraft nothwendig, um in leichtem Boden zwei Furchen auf einmal zu ziehen, welche jedoch in schwerem Boden nur für eine einzige Furche ausreichte. Die zum Pfluge transmittirte Kraft betrug drei bis vier Pferdekraft. Die Erfinder wollen jedoch eine Maschine herstellen, mit welcher sie im Stande sein werden, einen vierfurchigen Pflug zu benützen.

Die Gramme'schen Maschinen in der Fabrik hatten jede Minute 1600 Umdrehungen gemacht, an dem Haspel aber machten sie nur 800. Die Riemenscheiben, D, machten 133 Umdrehungen in der Minute und die Aufwindtrommel 14—27, je nachdem man sie langsamer oder schneller arbeiten liess, wobei die entsprechende Schnelligkeit des Pfluges 164—266 Fuss in der Minute betrug. Die Furchen waren 10.8 Zoll breit und 7 87 Zoll tief. Um zwei Furchen von ungefähr 24 Quadratyards herzustellen, bedurfte es nur Einer Minute. Ferner fand man aus, dass etwa 5 Prozent Arbeit der feststehenden Dampfmaschine auf das Feld übertragen wurde und dass die Wirksamkeit des electro-dynamischen Apparates von 30—60 Prozent je nach der Entfernung der Transmission betrug. Man nimmt an, dass diese Erfindung für Frankreich von grossem Nutzen werden wird, weil durch sie nicht nur viele Handarbeit erspart werden wird, sondern auch manche bisher unbenutzte Wasserkraft vortheilhaft (als Triebkraft für die Electricität erzeugenden Maschinen) verwendet werden kann.



Elektrische Pflügemaschine. Fig. 3.

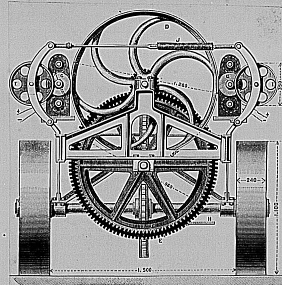


Fig. 2. Elektrische Pflügemaschine. Durchschnitt nach A—B, Fig. 1.

Sc. Am. [illegible] Aug 9 1879

TRANSMISSION OF POWER TO A DISTANCE.

ALTHOUGH it is now at least seventy-seven years since Brahmah proposed to transmit power to great distances by means of water under pressure, and although it is half a century since Mann proposed and described the means for transmitting power over still greater distances by means of compressed air, it cannot be said that either of these means of transmission has been employed to the extent that their proposers expected they would be, nor to the extent to which they might profitably have been used in many countries. Telodynamic transmission has been employed to a considerable extent; but in several cases works erected for this purpose have been abandoned, as for instance at Bellegarde. The loss of power in transmission by these methods is probably less by the telodynamic than by the others, but although M. Hirn, who has taken so prominent a part in bringing this method before the world, has upon reliable data calculated that this loss would be but about ten per cent. for distances not greater than twelve miles, there are sufficient reasons for saying that two or three miles is the greatest distance to which the system is practically applicable. One of the strongest objections to it is the great cost of the way works, while those which may be raised against the employment outdoors of great lengths of wire rope moving at high velocity are hardly less cogent. Hydrodynamic transmission comes perhaps next in order of economy, but this quality decreases rapidly as the power to be transmitted increases. For comparatively small powers the system is applicable, because only small quantities of water, but under high pressures, are sufficient. For large powers, however, the system loses its economy. Large mains are needed, and for the very high pressures necessary to economy, the required strength of parts would involve great outlay; maintenance would be costly, and especially so where much of the machinery driven was of a reciprocating character and intermittently employed. As at present designed, moreover, the most economical hydraulic motors cannot be employed to work at high speeds; while the enormous strain to which such machinery is subject sets a limit to the size as well as the speed which may be practically attempted.

Pneumatic transmission really seems to offer greater advantages than either of the preceding. These were fully seen and perhaps overrated at a time when experience in air compressing was very limited, and before the science of thermodynamics had acquired the shape in which it is now applicable to the uses of the engineer. It was not known that the loss of work in the form of heat during the process of compression and storage is sufficiently great to place a limit upon the application of compressed air as a transmitter, and that this loss would generally preclude its employment except in situations where the necessity for power is sufficiently urgent to make the question of cost of compressing power of minor importance. The latter objection, however, loses force when the compressing power can be obtained at little more than that of the necessary machinery for utilizing natural sources of power otherwise lost or wasted. A prominent illustration of this was the employment of air in the Mont Cenis tunnel, compressed by water power otherwise unused. In such a case as this, the great difference between the quantity of power expended in compressing the air, and that which can be realized by the best machinery worked by it, is of secondary importance, as the cost of the original power is nominal. In an article "On Water in Aid of Steam Power," in our impression for the 15th of October, 1875, we pointed out some of the places in our own islands whereat immense power is found concentrated at single spots, but which is wholly lost to man because it happens to exist at places where manufactures or industries cannot be advantageously established, though some of this power could be had for a mere nominal cost per horse. Much of this power, however, might be utilized if it could be transmitted to the places where it is required, and this transference, therefore, seems to be a question of sufficient importance to merit the careful consideration of engineers. In the article already referred to we showed that in Ireland alone there is running to the sea a quantity of water, the mechanically utilizable part of which would give 20,000 horse power at the lowest estimate. This enormous quantity of available energy is resident in five places, and for want of means of transmission to sites of employment, is wholly lost. There are many spots in Scotland, and a few in England, and very many abroad, where other large quantities of water pass on to the sea without being on their way made to act as the servants of man. Machines for compressing air, and that for reproducing the power which may be realized from that air transferred to a distance, have during the past few years been so much improved, that there seems sufficient reason to believe that such sources of power might be made to do duty in a variety of ways. The maximum distance to which air might be usefully transmitted would depend upon data not yet ascertained; but from what is already known, it seems that the loss of press- [illegible] from 5 to 6 per cent. per mile for a distance of from four to seven miles. The number of centers of population which could be supplied with power from one place would therefore not be great.

In many cases, however, a considerable number of villages and perhaps several towns might be supplied with power sufficient to accomplish the work of water supply, sewage pumping, etc., and in some cases to perform work in factories. Particularly, however, we would draw attention to the large quantity of force which might be utilized for agricultural purposes within a comparatively short radius of any center of water power. The whole of the work of cultivation and food preparation, including thrashing and some harvesting, might be thus effected. The method of transmission remains to be selected. We have dwelt most upon the use of compressed air, which has now been sufficiently tried to make it pretty well certain that of every 100 horse power at a waterfall, from 40 to 45 might be realized at a farm at, say, from one to three miles distant. In some cases, however, difficulties would be met with in laying pipes for the transference of the air compressed at the waterfall. The power realizable by means of the fixed air motor at the farm might also in some cases be with difficulty transferred to the implements in distant fields. In view of those cases, it may be suggested that the apparent success in the fields at Sermaize of the electro dynamic apparatus, which we illustrated in our impression for the 13th of June, gives some indication that electricity may come to the aid of the farmer in transmitting power. It seems that at a distance of about a mile, the work realizable by the electro-dynamic machinery is from about 40 to 50 per cent. of that done upon the dynamo-electric machine, which in our case would be situated at the waterfall. At present the practical experience with this apparatus is perhaps not sufficient to justify any very definite statements as to its ultimate value, but enough is certainly known to make it fully evident that vast amounts of power, now wholly lost, might be made to do farm work. The electrical apparatus offers the great advantage of facility of transference, and the cable from the falls once laid or carried upon posts might remain in good order and without need of attention for years, and in this it offers advantages which might not always belong to transmission by compressed air in pipes. There are cases where the electrical transmission of power to fields might be found to be economical even when the electricity had to be generated by steam power. A really excellent fixed engine might be placed in the center of a farming district, and in a position to secure a good supply of water and the delivery of fuel at a minimum cost. This engine might work dynamo-electric machines and supply electricity within certain distances at a cost which would not greatly exceed the expense of steam power by ordinary farm engines, when the expenses of repairs and of carting water and fuel to these are taken into consideration. Power so transmitted might without doubt be made to replace horses for plowing with economy. The facility with which power may be transmitted by electric cables, and the ease with which it may be controlled, suggests that it should have a wide application in the ways we have suggested, and particularly it should be made the means of carrying the power of unutilized waterfalls to the fields and barns of the farmer.—*The Engineer.*

La transmission et la distribution de l'énergie au moyen du courant électrique

M. Lippmann vient de publier dans le bulletin de l'*Association scientifique de France*, une note très intéressante sur les recherches qu'a faites M. C. W. Siemens, sur la transmission et la distribution de l'énergie au moyen du courant électrique.

D'après cette note, M. C. W. Siemens aurait jaugé, pendant l'automne de 1876, le débit de la cataracte du Niagara; il a estimé la force de cette chute à 17 millions de chevaux-vapeur. Pour produire la même force par la vapeur, il faudrait brûler 260 millions de tonnes de charbon par an, quantité à peu près égale à la production annuelle de houille par toute la Terre.

Si l'on veut utiliser cette immense force perdue représentée par la chute du Niagara comme aussi par les chutes d'eau si nombreuses dans les pays de montagnes, il faut pouvoir en transmettre l'énergie à de grandes distances. L'électricité convient mieux à cet effet que l'eau ou l'air comprimé. On peut employer la chute d'eau à faire tourner une ou plusieurs machines dynamo-électriques et transmettre le courant produit à travers un conducteur métallique. M. C. W. Siemens, dans un discours adressé en mars 1877 à l'*Iron and steel Institute*, avait estimé qu'on pourrait, à l'aide d'une barre de cuivre de 8 pouces de diamètre, transmettre à la distance de 30 milles une quantité d'énergie égale à 1,000 chevaux-vapeur ou bien capable de produire une lumière de 250,000 bougies. L'auteur trouve aujourd'hui que ces chiffres sont beaucoup trop faibles : la force qu'on pourrait transmettre serait de 3,000 à 4,000 chevaux, et la quantité de lumière qui peut remplacer un cheval-vapeur est plus grande avec nos moyens actuels qu'elle ne l'était alors.

On distribuerait l'énergie du courant en établissant des dérivations sur le circuit principal. Afin de régler ces dérivations, M. C. W. Siemens propose d'employer des appareils dont il donne le dessin. Le courant dérivé traverse une tige d'acier qui s'échauffe et se dilate plus ou moins. Cette dilatation a pour effet de déboucher successivement les résistances d'un rhéostat métallique interposé dans le circuit dérivé. Dans un autre appareil, on utilise la propriété du charbon, découverte en 1856 par M. du Moncel et appliquée depuis par M. Edison, de fournir une résistance électrique variable avec la pression. Le courant dérivé parcourt une série de disques de charbon empilés, disques pressés les uns contre les autres avec une force réglée par la dilatation d'un conducteur échauffé par le courant. La Correspondance [illegible] 1879 Scientifique

hroughout the matter without malice and as a journalist, believ-ng that he was doing his duty. He would ask only a few further uestions of Mr. Croll, and then let the defendant stand com-nitted for trial.

Mr. Croll said that the total cost of construction was £347,187, and that included the discount on the £100,000 10 per cent. pre-ference shares. Everything up to a certain period was charged o capital account. The profit was about £16,000 a year, but he ould not tell whether in that account had been charged the £4,000 a year for directors' fees.

The case was then adjourned until Friday for the depositions o be copied, and the defendant was admitted to bail in his own ecognizances in £500.

AN ELECTRIC RAILWAY.

Some particulars respecting the electric railway which has been in opera-tion at the Berlin Industrial Exhibition are given in the *Archiv für Post und Telegraphe*, from which it appears that this new exemplification of the application of electricity as a motive-power sprang from a question ad-dressed by Herr Westphal, a master builder of Cottbus, near Berlin, as to the possibility of utilising the force generated by coal burnt at that village by transmitting it to Berlin. The problem ultimately resolved itself into the question how far electric force could be employed as a motive-power on rails. The experiments which were instituted were successful, and led to the construction of the electric railway, as it has been seen in operation in the Berlin Exhibition. The arrangement is as follows:—There are two ines of rails laid down, which, in a narrow-gauge line, return into them-selves in a ring-shaped curve. The length is about 300 metres. In the middle is an insulated third line, consisting of an upright, continuous iron plate. The locomotive carries two rollers, with which it stands in connec-tion with the insulated middle line. The essential portion of the locomotive is formed by an electro-dynamical machine, one pole of which is connected with the middle line and the other with the pair of outer rails, through the outer wheels. Similarly the machine which produces the current stands in the machine-room in connection through one pole with the middle line, and through the other pole with the outer pair of rails. When, therefore, the dynamical machine in the locomotive is on the railway, the electric current produced in the machine soon runs through it and causes it to rotate and to impart its rotatory motion to the wheels of the locomotive, and the latter continues to move until the current is interrupted. Even an imperfect state of insulation on the part of the rails does not materially affect the action of the machine. When the locomotive is moving its conducting wires form much better conductors than the damp earth. If the current is interrupted, the damp ground is not a sufficient conductor to keep the dynamo-electrical action going. The magnetism of the machines produc-ng the current consequently disappears, and the result is that the subor-dinate stream through the earth is also interrupted. A great advantage is possessed by the transmission of electric force from the fact that the loco-motive, whether moving slowly or quickly, always works up to its full power—an effect which has hitherto been an unsolved problem in mechanics. When the machine that gives the power has to do much work, and so goes slowly, the counter-currents it produces are also correspondingly weak, and the current through the conductors thereby undergoes an increase in strength to a similar extent. By this means the electro-magnetism and, corresponding to this, the attractive power of the machine are increased. The dynamo-electric locomotive has the further advantage that it carries in itself the power which can be employed as a brake, inasmuch as it be-comes itself the primary or current-producing machine when it rotates more rapidly than the actual machine. In judging of the performances of the electro locomotive in the Berlin Exhibition it must be remembered that it was not constructed for the purpose to which it has been applied—that is, to propel the three elegant little passenger carriages which are attached to it. Each carriage holds from 18 to 20 persons, and all three are drawn in from one to two minutes round the circular railway of 300 metres in length. The locomotive was originally made for the purpose of drawing up coals out of a pit.

Electrician Sept 13 1879

BRITISH ASSOCIATION.

ELECTRICITY AS A MOTIVE POWER.*

(CONTINUED FROM PAGE 192.)

Electric transmission of power then becomes not only practical, but very economical both for short and for long distances, if we run both the enerator at the one end of the line, and the motor at the other sufficiently ast, and if we only require to transmit a sufficiently large quantity of ower.

But this latter requirement is the essence of all successful trades, viz., hat the per-centage of profits shall increase as the operations grow in agnitude.

We have been considering the transport of power derived more especially rom natural sources; but since we have seen that by the use of electricity, roperly employed, the waste of power in transmission can be reduced for ny distance to about thirty per cent. of the whole power absorbed at the enerator, it follows that the employment of steam engines of vast size at oints outside Sheffield would be by far the most economical mode of xtracting the energy out of coal. For it is at least four times as expensive o produce power with a small steam engine as with a large one; therefore,

* A Discourse delivered to the Working Men of Sheffield, August 23rd, 879, by Prof. W. E. Ayrton.

Iron Aug 30 1879

Although Saturday is usually regarded as a *dies non* in the working department, such was the abundance of important matter in the domain of physics, that some of the sections sat for a while and did good work. For the most part, however, the day was devoted to excursions and visits to works, which in all cases will be pleasantly remembered from the courtesy and hospitality experienced in every direction. Of the works visited we shall give an account next week, when we shall notice their special features. On Saturday evening the Mayor of Sheffield gave a dinner to the members of the Association, and which took place in the Cutlers' Hall, and at which about 350 gentlemen were present. On the same evening Professor Ayrton delivered a lecture in the Albert Hall to working men, on "Electricity as a Source of Motive Power." In his lecture, which we give *in extenso* on another page, Professor Ayrton showed that electricity was a motive power, just as steam and water are, and predicted that at some future time it would take the place of both these "old friends." The lecture was illustrated by a large number of experiments, some of them being very startling and brilliant. The platform and tables were covered with electric machines and other scientific appliances, and a large number of diagrams had been specially prepared and hung. To show that electricity could be used as a motive power, though generated at a distance, a number of wires attached to machines on the platform were connected with Messrs. Walker and Hall's works, in Howard Street, some distance from the Hall, and the electric current was conveyed from the works to the Hall. By this means a sewing machine was made to work, a small locomotive engine—which the lecturer called the "engine of the future"—was made to perform a circular journey, a lathe was turned, at which a workman did some turning; a circular saw was set in motion, and a quantity of wood sawn into thin strips; spoons were plated, water was boiled, and the screw of a ship was turned. Many other experiments were shown, and the conclusion the lecturer came to was that electricity would some day become the great motive power of the world, and would supersede gas for illuminating purposes. This lecture completed the entertainments for the week.

over

On Saturday evening Professor W. E. Ayrton delivered a lecture to working
men, which was crowded. The subject was "Electricity as a Motive-Power,"
and interesting illustrations were given, including machinery in motion, driven by power
derived from a distance.

Iron Aug 30 1879

The lecturer stated that in any generation of electricity there was a certain property called the
electro-motive force, which meant its tendency to send a current, and which was analogous with
the head of water in a reservoir, inasmuch as the product of the quantity of electricity flowing per
second, multiplied by this electro-motive force, measured the amount of energy furnished by the
generator per second, and which could be reproduced as motive power elsewhere if there were no
friction. The loss of energy due to electrical friction in the wires was equal to the square of the
current flowing per second multiplied by what was called the resistance of the wire—a number
depending on the length, the diameter of the wire, the material of which it was made, and the
temperature. The most efficient way to transfer energy electrically was to use a generator pro-
ducing a high electro-motive force, and a motor producing a return high electro-motive force, and
by so doing the waste of power in the transmission ought, he considered, to be able to be
diminished with the best existing dynamo-electric machines to about 30 per cent. It would be
impossible to increase indefinitely the speed of revolution of the cylinder of an induction machine,
since apart from mere mechanical friction the iron constituting the core of the revolving part had
to be magnetised and demagnetised very rapidly as it revolved. Now, there was a physical
limit to the speed with which this could be done, and in addition this rapid change of magnetism
heated the iron very much. But experiment showed that at the ordinary speed of revolution of
dynamo-electro machines—700 turns per minute—the electro-motive force was proportional
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it would be well for the transmission of power to attempt first, a considerable increase
of speed in the generator combined with so light a load on the motor, that its
speed would be also very high. When this began to fail as larger and larger amounts
of power were transmitted, then they might begin increasing the amount of wire on
the revolving coils of each; but this, of course, had the objection that the loss of power from a
given current would then become somewhat larger. As they had seen that by the use of electricity
properly employed, the waste of power in transmission could be reduced for any distance to about
30 per cent. of the whole power absorbed at the generator, it followed that the employment of
steam-engines of vast size at points outside Sheffield would be by far the most economical mode of
extracting the energy out of coal. For it was at least four times as expensive to produce power
with a small steam-engine as with a large one; therefore, including the waste of power in electric
transmission, the cost of production of power in small workshops would be little more than one-
third as dear as if small steam-engines were used, and similarly the waste of power in any large
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the employment of electricity he was advocating a total change in our mode of producing and
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answer this question they must consider what would be the probable minimum annual gain by the
proposed change in Sheffield alone. In making this calculation they must remember that not only
could electricity produce motive power, but also heat and light, and electric heating and lighting
had this great advantage that no chimneys were required. For example, with the electric current
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Various calculations had been made as to the relative cost of lighting by burning coal to produce
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so far as to say that it might be made 133 times as cheap. And certainly that there was a great
saving in expense in electric lighting was seen from the actual result obtained at the Albert Hall,
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where the science of putting a brilliant light high up had been allowed to ride over the precedent
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illumination anything differing from an ordinary iron lamp post. But there could be little doubt
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room they must have something with a globe on it, like an oil lamp; nor was it necessary for him
to remind them that by whitewashing the walls—yes, by whitewashing even the very machines
themselves—in some of the Paris factories, the supposed strong shadows cast by the electric light
had been less than the strong shadows cast by another bright light, one that we not only put up
with, but one that from the force of habit we were tolerably contented with, viz., the sun. At
present he was concerned with the pounds, shillings and pence question, which had more than
usual weight in these days of slack trade. Assuming that the cost of gas for lighting the large
buildings, factories, and the streets of Sheffield could be halved, also that where it was used for
heating purposes the expense could also be halved, by substituting electric currents generated by
very large steam-engines at certain points, and by turbines driven by falling water out of the town;
then they would save per year about £45,000. Supposing, also, that the cost of producing motive
power could in the same way also be halved, this represented an annual saving of something like

£60,000. In reality, he believed this last economy would be larger, since not only could power be produced so much more economically than by small steam-engines or even by a large engine, when a large proportion of its power was, as now, wasted in driving the shafting alone in their factories; but, in addition, much hand work could be economically replaced by machine work. And, lastly, supposing the consumption of coal in Sheffield for heating their metals and for heating their houses could also be halved, then there was another saving of about £300,000 a year; or, altogether, the annual saving that might be produced in this town alone, by substituting electricity for coal would be something like the large sum of £400,000. Last year, two French engineers, MM. Chretien and Felix, at Sermaize (Marne), actually ploughed fields by electricity, the electric current being produced by two dynamo-electric machines of a form invented by M. Gramme. These machines were usually worked with a steam-engine at some convenient place three or four hundred yards away in an adjoining road, and the electro-motors were also two Gramme machines, one on each side of the field, with their coils revolving of course backwards. Through one of these the electric current was sent alternately, so that motion was given to one or other of two large windlasses, one on each of the waggons containing the electro-motors. In this way the plough, which could be used going in either direction, was first pulled across the field making a furrow, and then back again, making another parallel furrow. If electricity were produced in large quantities at certain centres, then one difficulty that would of course be met with would be that of distributing it properly, since, just as in the case of water or gas, if a large branch pipe in a main be suddenly opened then the supply going on to the other branch pipes in the same main would be diminished, a result causing serious inconvenience in the case of electric lighting. But just as automatic governors had been devised for water and gas, to keep the supply constant, so automatic "electric current regulators" had been devised by M. Hospitalier and by Dr. Siemens, to keep the current constant. One of those invented by Dr. Siemens was on the table before him, and the general principle of its construction was easily understood. As the current passed through the regulator it heated a very thin ribbon of steel, which consequently expanded. The effect of this expansion was to introduce coils of wire into the circuit, the extra resistance of which diminished the strength of the current. Consequently the stronger the current the more was it automatically resisted, and the weaker it became the less was it resisted, and so it remained practically constant at any desired strength for which the regulator was previously adjusted. In conclusion the lecturer said there was a time when "Not only in the villages around old Sheffield," so said the historian of Hallamshire, "were the file makers' shops or the smithy to be seen, with the apprentices at work; but even on the hill side in the open country, at the end of the barn would be the cutler's shed, whilst in the valley below, by the river, was the grinding stone ready to sharpen the tools that had been manufactured." And why not now? Why should not that mountain air that had given the workmen of Hallamshire in past times their sinew, their independence, blow over their grindstone now? Why should not division of labour be carried to its end, and power brought to them instead of them to the power? Let them hope then that in the next century electricity might undo whatever harm steam during the last century might have done, and that the future workman of Sheffield would, instead of breathing the necessarily impure air of crowded factories, find himself again at the hill side, but with electric energy laid on at his command.

34

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ELECTRICITY AS A MOTIVE POWER.

At a recent meeting of the British Association, Professor W. E. Ayrton delivered a lecture on "Electricity as a Motive Power," and interesting illustrations were given, including machinery in motion, driven by power derived from a distance.

The lecturer stated that in any generation of electricity there was a certain property called the electro-motive force, which meant its tendency to send a current, and which was analogous with the head of water in a reservoir, inasmuch as the product of the quantity of electricity flowing per second, multiplied by this electro-motive force, measured the amount of energy furnished by the generator per second, and which could be reproduced as a motive power elsewhere if there were no friction. The loss of energy due to electrical friction in the wires was equal to the square of the current flowing per second multiplied by what was called the resistance of the wire—a number depending on the length, the diameter of the wire, the material of which it was made, and the temperature. The most efficient way to transfer energy electrically was to use a generator producing a high electro-motive force, and a motor producing a return high electro-motive force, and by so doing the waste of power in the transmission ought, he considered, to be able to be diminished with the best existing dynamo-electric machines to about 30 per cent. It would be impossible to increase indefinitely the speed of revolution of the cylinder of an induction machine, since, apart from mere mechanical friction, the iron constituting the core of the revolving part had to be magnetized and demagnetized very rapidly as it revolved. Now, there was a physical limit to the speed with which this could be done, and, in addition, this rapid change of magnetism heated the iron very much. But experiment showed that at the ordinary speed of revolution of dynamo-electro machines—700 turns per minute—the electro-motive force was proportional to the speed. They were, therefore, very far yet from the limit of speed. Consequently it would be well for the transmission of power to attempt first a considerable increase of speed in the generator combined with so light a load on the motor, that its speed would be also very high. When this began to fail as larger and larger amounts of power were transmitted, then they might begin increasing the amount of wire on the revolving coils of each; but this, of course, had the objection that the loss of power from a given current would then become somewhat larger. As they had seen that by the use of electricity properly employed the waste of power in transmission could be reduced for any distance to about thirty per cent. of the whole power absorbed at the generator, it followed that the employment of steam engines of vast size at points outside Sheffield would be by far the most economical mode of extracting the energy out of coal; for it was at least four times as expensive to produce power with a small steam engine as with a large one; therefore, including the waste of power in electric transmission, the cost of production of power in small workshops would be little more than one-third as dear as if small steam engines were used, and similarly the waste of power in any large mill or factory in its transmission from the large steam engine at its base to all the floors and machines on each floor would be very much diminished. But they would say that in advocating the employment of electricity he was advocating a total change in our mode of producing and transmitting power. Was the probable gain worth the expense of the necessary change? To answer this question they must consider what would be the probable minimum annual gain by the proposed change in Sheffield alone. In making this calculation they must remember that not only could electricity produce motive power, but also heat and light, and electric heating and lighting had this great advantage that no chimneys were required. For example, with the electric current sent to that hall from Messrs. Walker & Hall's works, he could heat a long coil of iron wire white hot, so that when put into a vessel of water, the water in a short time would begin to boil. Various calculations had been made as to the relative cost of lighting by burning coal to produce gas, or by burning coal to work dynamo machines for producing electric currents and it seemed to be pretty certain that if a large amount of light be required in one place, the electric light was at least twenty times as cheap as coal. Sir William Thomson, the eminent electrician, went so far as to say that it might be made 133 times as cheap. And certainly that there was a great saving in expense in electric lighting was seen from the actual result obtained at the Albert Hall, London, which was an example, and perhaps the only example, in connection with electric lighting, where the science of putting a brilliant light high up had been allowed to ride over the precedent of putting a number of feeble glimmers all over a building. The actual cost, including labor of men, allowance for wear and tear of machinery, etc., was only one third of that of the former inferior gas lights; and thus a saving of about 30s. an hour had been affected. Lighting streets by electricity had not been so successful economically, for the simple reason that instead of giving a large bright light, at a considerable heighth, reflected downwards, as in the Albert Hall, London, English conservatism had prevented the authorities from grasping the possibility of using for street illumination anything differing from an ordinary iron lamp-post. But there could be little doubt that if a few large electric lights, high up, were used for street illumination, the same sort of result as has been obtained at the Albert Hall would be arrived at. The cost of using gas in Sheffield for lighting large halls, such as the one they were in, factories, and the streets, could be halved if electric currents, generated by water engines, worked by hill streams, as well as by very large steam engines, were substituted for gas. It was not necessary for him to tell them how he proposed to employ the electric light to illuminate private rooms, if only he could get people to throw away the notion that to light a room they must have something with a globe on it, like an oil lamp; nor was it necessary for him to remind them that by whitewashing the walls—yes, by whitewashing even the very machines themselves—in some of the Paris factories, the supposed strong shadows cast by the electric light had been less than the strong shadows cast by another bright light, one that we not only put up with, but one that from the force of habit we were tolerably contented with, namely, the sun. At present he was concerned with the pounds, shillings, and pence question, which had more than usual weight in these days of slack trade. Assuming that the cost of gas for lighting the large buildings, factories, and the streets of Sheffield could be halved, also that where it was used for heating purposes the expense could also be halved by substituting electric currents generated by very large steam engines at certain points, and by turbines driven by falling water out of the town; [...] would save per year about £45,000. Supposing also that the cost of producing motive power could [...] same way also be halved, this represented an annual saving of something like £60,000. In reality, he believed this last economy would be larger, since not only could power be produced so much more economically than by small steam engines, or even by large engine, when a large proportion of its power was, as now, wasted in driving the shafting along their factories; but, in addition, much hand work could be economically replaced by machine work. And, lastly, supposing the consumption of coal in Sheffield for heating their metals and for heating their houses could also be halved, then there was another saving of about £300,000 a year; or, altogether, the annual saving that might be produced in this town alone, by substituting electricity for coal, would be something like the large sum of £40[...]000.

Last year, two French engineers, MM. Chreti[...] and Felix, at Sermaize (Marne), actually plow[ed] fields by electricity, the electric current being produced by two dynamo-electric machines of a form invented by M. Gramme. These machines were usually worked with a steam engine at some convenient place three or four hundred yards away in an adjoining road, and the electro-motors were also Gramme machines, one on each side of the field, with their coils revolving of course backward. Through one of these the electric current was sent alternately, so that motion was given to one or other of two large windlasses, one on each of the wagons containing the electro-motors. In this way the plow, which could be used going in either direction, was first pulled across the field, making a furrow, and then back again, making another parallel furrow. If electricity were produced in large quantities at certain centres, then one difficulty that would of course be met with would be that of distributing

THE ENGINEER.

FEBRUARY 6, 1880.

ELECTRICITY A FORM OF FORCE.

This was the main text of Mr. W. H. Preece's inaugural address to the Society of Telegraph Engineers, which we briefly noticed in our last number as having been delivered. If Mr. Preece had deliberately selected a subject for his presidential address that should best serve as a "bone of contention," he could not have chosen a better topic. We should not be surprised to learn that, seeing the dearth of controversy existing at the present moment, the happy inspiration flashed through his mind to give an inaugural address containing the greatest possible number of ideas directly antagonistic to received teaching. The language in which the address is couched is a good example of our best and most lucid scientific exposition. There is no mistaking the meaning; no mere verbiage hides the conclusion which is deduced; there it stands clear and distinct. But the question will arise—Are these conclusions real, or are they put forward as a means to an end? If Mr. Preece has used them to serve a purpose, he will of course gain from the work of the critics labouring to demolish his airy structure. Although we may infer from internal evidence that the author is joking, we must, until better informed, take the statements of the president of a learned society as *bona fide* expressions of his deliberate opinion. It is not our intention to discuss the questions touched upon in the address *seriatim*, though the whole teems with controversial matter. Mr. Preece was careful, and we think wisely so, to introduce his conclusions as resting entirely "on the imaginative power of the mind." Prof. Tyndall has much to answer for, but we doubt if he would not prefer his disciples to test the results of the imagination by experiment when possible, or at all events to make sure that such results are logical.

"My purpose," says Mr. Preece, "is to contend that electricity is not a form of matter, but a form of force, and that all its effects are evident to us in one or other of the several forms of energy characterised by the motion of molecules or of mass." An argument brought forward in support of this contention is "that when a wire conveys a current of electricity it is warmed, as the strength of the current is increased it is heated, and eventually rendered incandescent. The ultimate form which every electric current takes is heat. The wire of every telegraph is warmed in proportion to the currents it transmits. Joule showed that when this heat is produced by a current generated in a battery by chemical force, its amount, is exactly equivalent to that which would have been evolved by the direct combination of the atoms. The conducting power of all bodies is affected by heat, and some even, like selenium, by light. Hence, as we know that in the case of heat and light conduction is molecular vibration, we reasonably conclude that it is the same with electricity." The test of every theory is, according to the author himself, that it "must agree with every observed fact." How does this assumption relating to the heated wire agree with fact? In order to have an electric current we must have an electric circuit, and no matter at what part of the circuit a galvanometer is inserted, the needle gives the same deflection under the same conditions. If in the circuit we have an incandescent wire, the galvanometrical deflection on both sides of the wire is the same. Now, between these two points there is the glowing wire. Something causes the heat, and the question remains what is this something? The quantity of electricity passing on the one side is the same as on the other. Clearly then, Mr. Preece's form of force being the same on the one side as the other, produces light without any loss. This means the possibility of perpetual motion. There is no doubt about the fact. Two voltameters, one on either side of the incandescent wire, show equal volumes of water decomposed in equal times. According to this theory, however, we use our mode of force, and keep it too. The explanation generally given as to what causes the incandescence is extremely simple, it is a pity that it should be found to diverge so far from experimental facts. We do not deny, argue the supporters of the theory, that the current is the same in all parts of the circuit, but the current is much smaller after the insertion of the wire that becomes incandescent, than it was previous to such insertion, and the difference between the two currents is the electricity used to give the light. This argument really makes matters worse, inasmuch as now the theorists pretend to use a current which never exists. The difference between the observed currents is not due to the cause above mentioned. When the wire to become incandescent is brought into the circuit, there is, so to speak, a retardation in the production of the current. The introduction of this new resistance diminishes the quantity of current in a given time, and surely that which does not exist cannot give us light. We shall try and make this quite clear, for it is owing to the ignorance of these fundamental and experimental truths that so much nonsense is written and spoken. Suppose we have a powerful battery, the terminals of which are connected through two voltameters, or galvanometers by means of copper wire. The current will decompose a certain amount of water in each voltameter in a given time, or deflect the galvanometer needle so many degrees. After the action has continued, say, an hour, weigh the zincs of the battery—having carefully noted the weight at the commencement of the experiment—we find the loss of weight to be, say, 1 lb. Now, insert at some point between the galvanometers a piece of platinum wire, the needles immediately drop several degrees, and we get a brilliant light. At the expiration of an hour, weigh the zincs again, and it will be found that less than 1 lb. has been consumed. In other words, the lessened needle deflection was caused by the lessened production, and not by the consumption of the current to produce light.

We come to a point in this address where it seems that boldness has given place to rashness, or the statements of the late Clerk-Maxwell would hardly have been criticised. The late Professor was a giant, against whom it was dangerous to contend; and his carefully studied conclusions require much stronger evidence than has been advanced by Mr. Preece before they will be overthrown. The latter states:—"Clerk-Maxwell, in his classical work on electricity, has used a somewhat curious argument to show that electricity is not, like heat, a form of energy. He says that energy is produced by the multiplication of 'electricity' and 'potential,' and that it is impossible that electricity and energy should be quantities of the same category; for 'electricity' is only one of the factors of energy, the other factor being 'potential.' But," says Mr. Preece, "this does not militate in any way against the force of the argument, for in nature we can no more do so (*sic*) than we can separate heat and temperature. Energy usually appears as the product of two factors, and it is the equivalent of the work done. Thus potential energy is the product of mass and gravitation acting through a distance. Kinetic energy is the product of mass and the half-square of velocity. . . . The energy of heat is made up of heat and temperature, and the energy of electricity is the product of electricity and potential. Hence it is that electricity, *per se*, may be said to be a form of force, while all its effects, as known to us, are forms of energy. Force alone cannot produce energy; it must be force and something else. Force is the power of producing energy, and it must have something on which to produce it. Hence, matter is always present; and thus though heat, light, and electricity are forms of motion, they are in reality properties of matter from which they are inseparable. They are evident to us through the play of molecules of matter, and thus are properly called molecular forces." Now, although there is no lack of material for criticism here, we prefer to call attention to a statement of Clerk-Maxwell, forming part of the text to that commented on by Mr. Preece. "We have proved that "it—electricity—cannot be created or annihilated, so that if the total quantity of electricity within a closed surface is increased or diminished, the increase or diminution must have passed in or out through the closed surface." This is true of matter; it is not true of heat—it is not true of energy if we admit the immediate action of bodies at a distance. It will be seen from this that Mr. Preece has used his analogies only so far as they seemed to fit his theory. To return to the above extract, it would seem that Clerk-Maxwell and Mr. Preece must be talking about two different things. May we not follow the plan proposed by Mr. Preece, and see the result to which an imaginative mind will lead us? Taking for our example the incandescent wire in the circuit, as previously explained, we can imagine electricity plus something in a high state of activity at the one pole of the battery, whilst at the other pole we have the same quantity of electricity without the something additional. In other words, this active component of electrical energy has been lost during its passage through the wire. This component which has thus been lost is generally termed potential. Electricity is there, but potential is gone. Reasoning analogically, the action is somewhat similar to that of water going from a higher to a lower level, and during its passage turning the wheel of a water-mill. The same quantity of water passes on the one side of the mill-wheel as on the other, no water has been lost, but yet work has been done. The similarity between the action of water and the action of electricity in these cases is so marked that it leads us to say electricity is not a force, but something carrying a force.

We do not say that electricity is not a mode of motion, but we do say, and that most emphatically, that neither Mr. Preece nor any other electrician has as yet proved electricity to be a mode of motion. It seems to us that a similar process of reasoning will enable us as satisfactorily to show that electricity is not a "form of force" and that it is a "form of matter."

Feb 1880

Kent's Autographic Transmitting Dynamometer.

Am. Machinist

The accompanying engraving represents a dynamometer used at the Stevens' Institute at Hoboken, during the recent experiments with machines for producing electric lights.

These experiments with their results have been published in a government report of the Light House Board, by Prof. Henry Morton, from which we print the following extract:

The power employed in driving the machine was taken by the use of a transmitting dynamometer, designed by Mr. William Kent, a graduate of the Institute, and built in the workshops of the Institute by the graduating class of 1879. This is in fact a modification of the dynamometer invented by Mr. Samuel Batchelder, of Boston, nearly forty years ago. The modification consists in providing a method of making an automatic record, and of indicating more minute variations of the power transmitted. The accompanying cut represents the dynamometer without the recording attachment, and as it was used in the experiments. The construction of this apparatus and its mode of operation are as follows:

It consists, as shown, of two stout cast-iron frames, held together by bolts in bearings, in the top of which frames run two shafts, each carrying a pulley at its outer end and a bevel-gear wheel of 45° at its inner end. One of these shafts is the driving-shaft, connected by belt to the engine or other prime mover; the other is the driven shaft, connected by belt to the machine driven. The power is transmitted from one shaft to the other through two other bevel-wheels of 45° gearing with the first, the shaft common to them and on which they run freely being at right angles to the axis of the two shafts first mentioned and carrying at one extremity a heavy pendulum.

The bevel-wheels being connected, as shown, and the power being applied to the driving-wheel, the two intermediate wheels with their common shaft have a tendency to revolve around the driving-axis, which tendency is a measure of the force transmitted, and is resisted by the moment of the weight of the pendulum. In the Batchelder dynamometer the four bevel-wheels and their shafts are used, but the shaft connecting the intermediate wheels is always held in a horizontal position, and its tendency to revolve is resisted by weights and a sliding poise applied to an extension of one end of it, which is graduated like a scale-beam. In using the Batchelder dynamometer the operator requires to keep the beam constantly balanced, by shifting the poise on the scale-beam or the weights in the scale-pan hung at its outer end, to correspond with the variations of the power transmitted, and a record of the power is obtained by noting the weight on the scale-beam at each instant, and the corresponding number of revolutions of the driving-shaft. The horse-power is obtained by multiplying weight in pounds of weighting poise on the scale-beam by the distance in feet of its point of suspension from the driving axes, by the number of revolutions per minute, by 3.1416, and dividing by 33,000.

In the improved dynamometer the horizontal scale-beam with its weights and sliding poise has been dispensed with, and the swinging pendulum substituted. The tendency of the shaft carrying the two intermediate bevel-wheels, the prolongation of which shaft, is the pendulum arm, to revolve around the driving-axis, is measured by the weight of the pendulum and its arm multiplied by the distance of their center of gravity from the driving-axis and by the sine of the angle which the pendulum arm makes with the vertical. When the pendulum hangs in a vertical position the force transmitted is zero, errors due to friction excepted, and when it is horizontal, the sine of the angle being equal to unity, the force is the maximum the apparatus is capable of recording. The weight of pendulum and its position on the arm being constant, the only variables to be considered in measuring the horse-power transmitted are the number of revolutions per minute and the sine of the angle of the inclination of the arm. These variables may be caused to automatically record themselves on a sheet of cross section paper by any one of a number of devices.

The dynamometer used in these experiments has a capacity for measuring 20 horse-power; a method is provided of measuring very small powers, which consists in lessening the moment of the pendulum and arm; first by shifting the sliding weight nearer the driving-axis; second, if still lighter moment is desired, by removing the weight from the arm entirely; or, third, if even still greater delicacy is desired, by counterbalancing the weight of the arm by adding weight to its upper end, above the upper intermediate bevel-wheel.

During the experiments one person attended to the running of the engine, dynamometer, and machine, while another recorded the number of revolutions of the dynamometer and the inclination of the weighted pendulum; the latter was read from a graduated arc fastened to the pendulum in such a manner as to be in the same plane with its axis; this arc, by the deflection of the pendulum, swung by a pointer attached to a cross-bolt at back of machine, and thus indicated the degrees of inclination of the pendulum. The friction of the dynamometer was obtained by loading its delivery shaft with a weight which produced the same pressure on the bearings as was brought on them when it was transmitting power to the light machines, and then noting the deflection of the pendulum to overcome the friction produced.

In the earlier experiments the readings of the dynamometer were recorded every fifteen minutes, and in the later ones every five minutes.

Photometric measurements were also made simultaneously with the reading of the dynamometer, and occasionally one or two between successive readings of the dynamometer.

THE SOCIETY OF TELEGRAPH ENGINEERS.

THURSDAY, JUNE 3, 1880.

THE DYNAMO-ELECTRIC CURRENT IN ITS APPLICATION TO METALLURGY, TO HORTICULTURE, AND TO THE TRANSMISSION OF POWER.

Electrician June 12 1880

By Dr. C. W. Siemens, D.C.L., LL.D., F.R.S.

Dr. Siemens commenced by referring to his inaugural address in 1878, in which he called attention to the use of electricity in transmitting power and in electro-metallurgy. He then proceeded to describe three somewhat novel applications of the dynamo-electric machine, viz., as a means of effecting the fusion of refractory materials in considerable quantities in an electric furnace; in certain effects in horticulture; and as a means of mechanical propulsion.

The paper was rendered the more interesting as experimental results were shown, as well as described and illustrated by diagrams.

Dr. Siemens showed that the electric arc is not only capable of producing very intense degrees of heat in a focus or extremely contracted space, but also such larger effects of intense heat, with moderate expenditure of energy, as will render it useful for effecting the fusion of platinum, iridium, steel, or iron, or for such reactions or decompositions as require for their accomplishment an intense degree of heat, coupled with freedom from disturbing influences such as are inseparable from a furnace worked by the combustion of carbonaceous material.

Dr. Siemens exhibited his furnace, and demonstrated its utility by melting steel. The apparatus employed to effect this electro-fusion consisted of an ordinary crucible of plumbago, placed in a metallic casing, the intervening space being filled up with some bad conductor of heat. A hole is pierced through the bottom of the crucible for the admission of the conductor connected to the positive pole. The cover of the crucible is also pierced to receive the negative pole. The negative pole is connected by a strip of copper to one end of the beam of a balance, the other end being attached to a hollow cylinder of iron, free to move vertically within a solenoid coil of wire. By means of a sliding weight the balance can be adjusted, to balance the magnetic force with which the hollow iron cylinder is drawn into the coil. The variation in the resistance of the arc is counteracted by the action of the solenoid. This automatic adjustment of the arc is of great importance to the attainment of advantageous results in the process of electric fusion. Without it the resistance of the arc would rapidly diminish, and heat would be developed in the dynamo-machine to the prejudice of the furnace. The sudden sinking or change in electrical resistance of the material undergoing fusion would, on the other hand, cause sudden increase in the resistance of the arc, with a probability of its extinction, if the automatic action were wanting. It is important that the material to be fused should constitute the positive pole of the battery. Here heat is principally developed, and fusion takes place before the crucible itself is heated to so high a temperature. Dr. Siemens gave some interesting quantitative explanations. He said the dynamo-electric machine, consuming 4·25 horse-power, or 3·17 ergtens per second, will send a current of 40·5 webers through 1 unit electrical resistance; replacing the resistance by an arc maintained by the balance-weight constantly at 37·8 volts electromotive force, the same current will flow.

Neglecting the connecting wires, there will be developed in the arc an energy of

$$1{,}531{\cdot}2 \times 10^7 \text{ ergs. per second} =$$
$$9{,}187{\cdot}2 \times 10^8 \text{ ergs. per minute} =$$
$$1{,}378{\cdot}1 \times 10^{10} \text{ ergs. per 15 minutes} =$$
$$32{\cdot}8 + 10^4 \text{ gram water degree units of heat.}$$

Assuming steel to have the same specific heat as iron, viz., at $t°$ =

$${\cdot}1040 \times 0{\cdot}0001441,$$

and that the melting point of steel is 1800° C., then 420·5 units of heat will be expended in raising the steel to this temperature; and assuming the latent heat of fusion at 29·5 units (silver is 21, and zinc 28), there are roughly 450 units required to melt a gram of steel, and 225,000 to melt half a kilogram, that is about ⅔ of the heat generated in the crucible, and ⅓ of the horse-power actually expended. A good expansive condensing steam engine converts the heat energy residing in coal into mechanical energy, with a loss of about eighty per cent., or, in other words, ⅕ only of the 7,000 units residing in a gram of ordinary coal is represented as work in the engine. The useful effect attainable in the electric furnace is therefore $\frac{1}{3} \times \frac{1}{5} = \frac{1}{15}$ of the heat energy residing in the fuel consumed under the boiler of the engine.

To melt a gram of steel in the electric furnace takes, therefore, $450 + 15 = 6{,}750$ units, which is within a fraction the heat energy residing within a gram of ordinary coal. It results from this calculation that, by means of the dynamo-electric machine worked by a steam engine, one pound of coal is capable of melting one pound of mild steel. In melting steel in the ordinary air furnace, as practised at Sheffield, three tons of best Durham coke are consumed; to melt a ton of mild steel in crucibles, and in working with the regenerative gas furnace, one ton of coal effects the fusion of one ton of steel in crucibles, whilst to produce steel in large masses on the open hearth of this furnace, 12 cwts. of coal suffice to produce one ton of steel. The electric furnace may be therefore considered as being more economical than the ordinary air furnace, and would, barring some incidental losses not included in the calculation, be as regards economy of fuel nearly equal to the regenerative gas furnace. It has, however, the following advantages in its favour:—1st. That the degree of temperature attainable is theoretically unlimited. 2nd. That fusion is effected in a perfectly neutral atmosphere. 3rd. That the operation can be carried on in a laboratory without much preparation, and under the eye of the operator. 4th. That the limit of heat practically attainable with the use of ordinary refractory materials is very high, because the fusing material is at a higher temperature in the electric furnace than the crucible, whereas in ordinary fusion the temperature of the crucible exceeds that of the material fused within it. Without wishing to pretend that the electric furnace here represented is in a condition to supersede other furnaces for ordinary purposes, the advantages above indicated will make it a useful agent, I believe, for carrying on chemical reactions of various kinds at temperatures and under conditions which it has hitherto been impossible to secure.

(TO BE CONTINUED.)

4090. ELECTRO-MAGNETIC ENGINES, A. M. Clark.—Dated 18th November, 1879.—(A communication.) 6d. Engineer July 16 1880
This consists in an electro-magnetic motor of the use of one or more commutators upon a driving shaft or upon an independent shaft geared with said driving shaft, in combination with one or more driving wheels carrying each a series of electro-magnets.

COTTON BELTING.

Engineer Oct 15

A variety of materials have been tried to replace leather as a material for driving belts, but most of them are inferior in some respect, and cotton belts have not till quite recently been manufactured in such a manner as to justify their general adoption. Some of these have, however, lately been brought into the market, called Scandinavian belts, which appear to answer their purpose admirably well. They are simply a cotton fabric, which is lighter, more elastic, and more durable than leather, and, therefore, particularly adapted for high speeds. For most purposes, and especially for heavier belting of this kind, a coating of wood tar is found an advantage, while for small bands, such as are used for spinning machinery, the unprepared raw cotton belt is used. The cost of manufacture of these belts is very small as compared with leather, and by the peculiar method of weaving them, they do not fray out at the edge or break after being worn at the edge by running against a belt fork. The woven belts have, however, their disadvantages; they stretch and shrink more than leather belts; but once taken up sufficiently, they run more smoothly than leather, since they have but one joint and are perfectly uniform. When they get damp, they have the disadvantage of shrinking slightly. On their tensile strength Mr. Kirkaldy has made some experiments, and found that a cotton belt 3½ in. wide broke under a load of 4187 lb., while a leather belt of good quality, 4 in. wide, was broken with 2100 lb. It is nevertheless advisable to use wider belts when replacing leather by cotton, since they are best used of ordinary thickness; this is, however, also in accordance with good practice in leather belting, thick belts having been found not to answer as well as thin wide belts, or at least requiring disproportionately large belt pulleys. In connexion with this subject, we may mention the American cotton belting, manufactured by Mr. M. Gandy, of Ansdell-street, Wapping, and which was largely employed at the Düsseldorf Exhibition, where it attracted considerable attention.

ELECTRICITY AS POWER.

BY FRANCIS R. UPTON, ESQ. Science July 2 1881

In the early history of electrical science, many forms of engines were made, by which the power of electricity could be shown. Each was as wonderful as the other to the unthinking observer; for, without apparent combustion of fuel, work was done. We find, among the largest of these engines, one used in St. Petersburg, to drive a small boat, and one in this country to propel a train.

The United States Congress voted a sum of money to Prof. Page to carry on his experiments and he built a very efficient motor. After many experiments, though it was found that any amount of power could be obtained, yet the expense was so great as to make it of no practical value. In a small machine, the consumption of zinc might not be noticed, while in a large machine it would be found to burn exactly as the work was taken. Now that the doctrine of energy is clearly understood, the folly of the attempt can easily be seen. In a battery the fires are fed with an expensive metal. The energy developed by the zinc, thus used, was given to it artificially when it was reduced from the ore. In order to obtain a convenient fuel, both the coal and zinc ore must be mined, and the latter reduced, absorbing in the reduction a very small per cent. of the energy of the coal used in the process. Thus batteries for furnishing power consume a fuel at least fifty times more expensive than coal.

Besides the cost of fuel, the atmosphere, so to speak, in which the zinc burns, must be furnished to it artificially in the shape of acids or solutions. Though this has nothing to do with the theoretical cost, yet in practice, it is found to be the largest item of expense. It resembles furnishing a boiler with air made by a chemical process, so far as the economy of combustion is concerned. Yet the convenience and reliability of a battery to burn zinc has, where very small amounts of power are required, allowed of its use commercially, since steam is extremely difficult to manage in fractions of a horse power.

To-day the practice has been entirely reversed from what the first experimenters expected to realize. For electricity is now entirely made by means of steam engines to drive large motors. The last few years have brought the means of generating and using electrical currents to such a high state of perfection that power may be with economy transferred by them.

The loss in transferring is double; if a machine converts fifty per cent. of the power it receives from a staem engine, only fifty per cent. of that can be utilized, that is, twenty-five per cent of the original; thus wasting seventy-five parts out of each hundred of energy. A sixty per cent. machine can render effective thirty-six per cent.; an eighty per cent. machine can turn into useful work sixty-four per cent., and so on. This wasting of power in the transmission is more than counterbalanced in a great many cases by its delivery at the point where needed; for example, from a waterfall to a field for ploughing and threshing, as has been done in France; or from the shore to the water for the purpose of driving a torpedo boat, as has been done in this country.

Lately experiments have been made to show the application of electricity to railroads. Mr. Siemens, in Berlin, and Mr. Edison, at Menlo Park, are experimenting with electrical railroads. Mr. Edison uses the rails as conductors of electricity, the current going in one and returning in the other. The wheels are insulated, so that, by means of brushes on them, the electricity may be brought to the moter, which is on a carriage. The moter is simply one of Mr. Edison's generating machines, laid on its side, and connected by suitable mechanism to the axle of the driving wheels. On an experimental track of one-half mile length, a speed of twenty to thirty miles an hour has easily been reached, in spite of heavy grades and sharp curves.

For elevated and underground railroads, this method has many advantages; it does away with all the smoke and noise from the puffing of the locomotive, and substitutes for the many locomotives a few stationary engines scattered along the route. Mr. Edison feels very confident of success, since his troubles so far have all been in transferring the power from the armature to the driving wheels. He thinks that if the armature is only reliable, experiment will lead to proper mechanical devices for transferring the power from the quick-running armature to the slower driving wheels.

The road will be very useful in mountainous regions, since the engine is quite light and can be carried by trestle work and light earth work, over any country. The engine and boilers are not in this case put on wheels and required to push themselves over grades and around curves, but are placed in the valley below. Perhaps in many cases they may be done away with and water used to drive the generators.

For beach roads, in grand exhibitions, as feeders to main lines, and in many ways it is easy to see that use may be made of a properly constructed road. The gentle fluid, which has so quietly, for many years been the swift messenger of man, is now showing that it is also able to be a strong and lusty servant, and carry any load that it may be asked to take.

The Engineering & Mining Journal. Aug 27th 1881.

Transmission of Power by Electricity in Mining.—The first instance on record of the application of electricity for the transmission of power is reported from France. M. Mathet has submitted the details to the Société de l'Industrie Minérale. The St. Claude shaft at Blanzy was sunk to the depth of 500 meters (1640 feet), for the purpose of searching for a faulted portion of the coal seams, and a heading was run from it across the strata. When this heading had reached a length of 400 meters (1312 feet), the ventilation became so poor that the temperature at the face rose to 95° Fahr., and the miners could work only for a few hours. After some ineffectual attempts to improve the ventilation by simple means, it was decided to put in a fan 2·03 feet in diameter, and run it by power transmitted by electricity. An 8 to 10 horse-power portable engine was put up above ground, and with it a Gramme dynamo-electric machine was run at a speed of 1200 revolutions per minute. The electric current thus generated was conducted by a cable, consisting of seven 0·044-inch copper wires, to a second Gramme machine coupled directly with the fan, and placed in the heading near the shaft. Running at 700 to 800, it required 2½ horse-power, the useful effect being at least 60 per cent. The temperature at the face was only lowered five degrees, but the men could work in 8-hour shifts. The return current was conducted from the underground machine by an iron wire cable. The cost of the whole plant is stated to have been only one third of what a machine for delivering compressed air to the heading would have required.

ELECTRO-TELEDYNAMICS.

BY PAGET HIGGS, LL.D., ASSOC. MEM. I.C.E.

Electrician Aug 7 1880

Teledynamics, or the science of transmission of power to a distance, has been confined in meaning to the conveyance of power by belting, or by ropes and pulleys. The transmissions of power by tubes of water, or of air, have neither, as far as I know, received specific titles. Whilst using the general term teledynamics in its commonly accepted and limited sense, I propose to name that correlative science in which electricity appears as the transmitting medium, as in the title of this paper; and, consistently, to term the science of hydraulic means of power-transmission, hydro-teledynamics; and that in which air is employed, pneuma-teledynamics. These titles would convey the desired meanings, and prevent unnecessary repetition.

The employment of compressed air as a means of transmitting motive power has, in the last decade, received so great an advance as to become a chief tool in tunnel construction, and an important aid in mining and quarrying. The system, with its numerous defects, proves the want of power-transmission possessing greater facilities than the merely mechanical teledynamic method. Notwithstanding the loss of power through the heat manifested in the air during compression, to which must be added the loss by cold manifested during the expansion of the air, as well as the incidental losses due to effects of extraneous temperature, this system is being much extended in its application. The power transmitted by air is, to put it electrically, of low tension; the velocity of the current is affected in high degree by the walls of the pipe, and the engines, generative and motor, are bulky. For some of these reasons, the efficiency or the ratio of power received to that transmitted is low, rarely more than 30 per cent., and in practice averaging 25 per cent.

Hydraulic transmission has been limited in its application. Probably this has occurred from the great pressure in the pipes conveying the power, varying from 100 to 700lb. a square inch, from the difficulty of maintaining the pipes intact under this pressure, but chiefly from the slowness and indocile nature of the power received. For cranes and elevators hydraulic power has been and is transferred and accumulated with great economy; its generation at high tension is, however, expensive in first cost of plant.

To the third means of transmitting power by the intervention of electricity but desultory attention has been given, and very little is publicly known on the subject, whilst as a mechanical method both in adaptation and efficiency it can leave only small margin for complaint. It may, therefore, be not inadvisable to study more closely the advantages that electricity gives over water and air as transmission media.

In 1878 I presented to the Institution of Civil Engineers a paper, which was afterwards incorporated, with an account of other experiments, into book* form, descriptive of a series of measurements of power received and transmitted. I then showed that the efficiency of power received to that transmitted was one-half, provided regard was had to the maximum power obtainable from the second or receiving machine. This proviso, although stated, was given with insufficient definiteness, and the related ratios of efficiency were disregarded, making it appear as though 50 per cent. were the maximum relative efficiency. That this is not the case will presently be made clear.

In the system of transmission referred to similar dynamo-electric machines were employed, one being connected to a steam or water motor, from which power was initially derived to generate electricity in this the transmitting machine. The electricity so obtained was conducted by a cable of copper wire to a second or receiving machine, from which power was taken and observed on a dynamometer. This is the primitive arrangement for the machines in transmission by electricity, the electrical circuit comprising the exciting magnets and the revolving armature and the conducting wire in direct connection. Such an arrangement, although admitting of considerable facility for mathematical investigation is emphatically not the practically best, neither in the machines themselves, nor in their connection to the line-wire and related dimensions. The mathematical representation is, however, of the utmost simplicity under this system, and serves as a step in the study of complex and more efficient methods, such as the use of shunt magnet circuits on the Wheatstone principle, subjects of subsequent consideration.

It is now common knowledge that the revolving coils of the second machine generate a current, the electromotive force of which is of contrary sign to that of the current from the first machine. In this, the first machine represents a battery, the second a decomposing cell, and, for the electrical conditions of the circuit, we have, as current, the quotient of the difference of the electromotive forces by the sum of the resistances, or $\frac{E - e}{R + r + \rho}$, where E is the primary electromotive force, e the secondary, and R and r the resistances corresponding to the generators, ρ being that of the connecting wires. From Wheatstone's first elucidation of this formulated expression of polarisation phenomena to the present time innumerable investigators have considered the corresponding mechanical or heat values of the electrical conditions of any part of such circuit. It would remain only to see how these apply to the subject in hand; but that it is convenient to give one definite representation of such a deduction.

In an electric circuit comprised of the resistances R, R_1, R_2, &c., there may exist the electromotive forces $\pm E, \pm E_1, \pm E_2$, &c., and Q may be taken to represent the resultant current produced. The work of the electromotive forces will be represented by $\pm E\,Q$, $\pm E_1\,Q$, $\pm E_2\,Q$, &c., and the thermic value of the current passing in each of the resistances will be $Q^2 R$, $Q^2 R_1$, $Q^2 R_2$, &c. The sum of the terms of the latter series will be strictly equal to that of the former, although corresponding terms may differ greatly. To correspond with the earlier representation, three terms of the series may be taken to correspond to R, r, and ρ, and in the last portion of the circuit or in the conductor the electromotive force of the third term may be assumed to be nil. There then occurs the equation (substituting e for E_1)

$$Q\,E - Q\,e = Q^2(R + r + \rho), \text{ or}$$
$$Q\,E = Q\,e + Q^2(R + r + \rho);$$

or, putting for $(E - e)$ the letter V and for $(R + r + \rho)$ the letter S,

$$Q\,E = \frac{V}{S}E + \frac{V}{S}e + \frac{V^2}{S} \quad . \; . \; . \; . \; . \; . \quad (1).$$

The first term is the total work of the source, the second the work of the motor, the third the thermic work lost in heating the wires. These expressions may be taken as in absolute units, and assigned their proper co-efficients for reduction to the ordinary units of work, tension, current, resistance, and heat.

If $e = 0$, the thermic or lost work is at a maximum; if $e = E$, the thermic work disappears. The variable value of e is a true representation of the state of the second machine or the motor which is at rest when $e = 0$. Between these two limits there is an algebraic maximum, when $e = \frac{E}{2}$, and when there is an equal distribution between thermic work and the motor's work. As the variable e exceeds $\frac{E}{2}$, the motor's work diminishes in absolute value, but increases in value relatively to the work expended, to the limit $e = E$. This absolute value of work reclaimed is obviously determined, in relation to the work expended, by the ratio $\frac{e}{E}$, and its relation to its maximum is $= 4\frac{e}{E}\left(1 - \frac{e}{E}\right)$.

Thus, if the electromotive force of the generator be a fixed quantity, the relative efficiency cannot be increased beyond $\frac{1}{2}$ without diminishing the absolute value of the work reclaimed; for any fixed relative efficiency the work reclaimed can be increased to any given value, provided the generator's electromotive force can also be increased, as when absorbing a fixed mechanical power. Only under this condition can the work reclaimed, at the theoretical limit, equal the work expended.

These two cases, apparently incompatible, are not really so, and the inconsistency disappears on a close study of the question, which is not generally well understood. Its solution, as here given, unerringly points out to the constructor the principle to be followed in building machines for the transmission of power.

(TO BE CONTINUED.)

* "The Electric Transmission of Power." [E. and F. N. Spon.]

ELECTRICITY AS A MOTIVE POWER.

Telegraphic June 15 1880

The following letter, concerning certain experiments on the application of electricity as a motive power, appeared in a late number of the *Times*:—

"About this time last year I sent you a short account of some experiments by Mr. C. Felix, of Sermaize (Marne). This gentleman has continued his experiments, and at the Regional Agricultural Show now being held in this town, his apparatus has been shown at work. It consists of the ordinary 'Gramme' machine, worked by a semi-portable engine, furnished by Boulet and Co., Faubourg Poissonnière, Paris. Two coils of wire convey the power to a smaller Gramme fixed on a framework of wood, movable on four wheels. This acts as an intermediate motion, and has two broad-face pulleys, one on each side, 20-inch and 14-inch diameter; these run at a speed, if required, of 800 a minute, the latter driving a 6 horse-power thrashing machine at a considerable distance from the main power. The 20-inch pulley might be used for driving any other machine if required.

"The ploughing apparatus, which is at work at the same time, in the field adjoining, consists of a similar Gramme machine, fixed in a very solid framework of wrought iron, about 6ft. long by 5ft. wide, standing on wheels, 3ft. 6in. diameter, in front, and 4ft. 6in. behind. Shafts and a locking gear are also attached. There are two of these at work for ploughing, as in Fowler's double tackle.

"The Gramme has two pulleys, as I before stated, one on each side. These, by friction rollers, work the drum of the ploughing tackle, round which the steel wire rope is coiled, the drum being in the centre of the carriage, the wire escaping from the lower part near the ground, and guided in its course by two flat rollers.

"The plough is one of Howard's double-furrow, supplied by Mr. Pilter, Paris, and fitted for the purpose.

"The power is conveyed in an instant from the main power in the showyard by a coil of wire on wooden reels, long enough to reach several fields off.

"The plough worked clean and regularly about seven or eight inches deep. The ground was very hard and uneven, as this part of France is suffering very much from want of rain. One man is required to each machine, and one man to the plough, three in all. The ploughing was not very straight, for, as the people crowded about the plough and on the ropes, the driver could not see where he was going. Directly the plough reached the end of its course, it was lowered and returned, the machine being thrown out of gear and reversed with the greatest ease.

"The machines are also advanced or retired without the least difficulty. When this is done, the friction rollers are detached, and the power conveyed to a chain and notched wheel, which move the machine rapidly forward as the ploughing work progresses.

"The manager, Mr. Ducret, states it would be just as easy to work a three or four furrow plough as this double, but the holdings being small in this country it is not necessary.

"Mr. Felix, who is here superintending his invention, has a large sugar factory at Sermaize, and there may be seen his various machines worked by electricity, as we indeed see in this showyard.

"The officials connected with the show and many others were present, and the greatest interest was manifested in the trials. Electricity as a motive power is only in its infancy, but who can help feeling sanguine as to its future?

"J. S. Cocksedge, of Stowmarket.

"Bar-le-Duc, France, May 22."

New Instances of Magnetic Attraction.—By M. Ader, in *Comptes Rendus*, 1880, p. 864. When making his researches on magnetic quality of wood, paper, and other light bodies, the author made pith balls 5 mm. in diameter, and found that the permanent magnet of Jamin (which supports 100 kilos.), with two small armatures, having a space between of 2 mm., attracted the suspended pith from a distance of 3 or 4 mm. And when once the ball had adhered to it, only rough shaking of the magnet was sufficient to release the ball from its position. The magnet alone sufficed to attract the pith, but in all experiments attraction was much stronger when to the poles of the magnet were added the said soft iron armatures, in close proximity to one another.

ELECTRICAL HEAT AND POWER.

34 Sc. Am Suppl Aug 14 1880

There seems to be little or no doubt that the time is not far distant when we shall be enabled to utilize the mysterious forces of electricity for heat as well as for light, and for mechanical propulsion as well as for metallic deposition. It is not possible to foretell the exact period when these things will be accounted among the accomplished facts, but it appears to be likely that the time is not far distant. The more we learn of electricity, the more its capabilities increase, and we no sooner make it our servant in one capacity than we are led to speculate upon its possible utility in others. A lecture delivered the other evening by Dr. C. W. Siemens is replete with facts and suggestions of this nature. Dr. Siemens, in the first place, has tested the electric arc as a means of fusing metals with the most complete success. He has melted one gramme of steel in this way with units of electric power amounting to within a fraction of the heat energy residing within a gramme of ordinary coal; that is to say, by means of a dynamo-electric machine, worked by a steam engine, one pound of coal is rendered capable of melting one pound of mild steel. At Sheffield, in the ordinary air furnace, three tons of best Durham coke are consumed in melting one ton of mild steel in crucibles. Further than this, the fusion by electricity attains heat which is practically unlimited; is effected in a perfectly neutral atmosphere; can be readily conducted; the fusing material is within, and of a higher temperature than the crucible—contrary to the results of ordinary fusion. Dr. Siemens has also ascertained that the electric light has the effect of causing plants, vegetables, etc., to grow to a finer development than sunlight, and, he is so convinced on this head that he is specially applying the light at his country residence. With respect to the application of the dynamo-electric current to mechanical propulsion, Dr. Siemens quotes the example of a narrow-gauge railway, laid down in a circle nine hundred yards in circumference, at Berlin, by his brother, Dr. Werner Siemens. Upon this railway a train of three or four carriages has been run by means of a dynamo-electric machine so fixed as to give the necessary motion. The two rails being placed on wooden sleepers were sufficiently insulated to serve for electric conductors, the driving axle being also insulated, so that a current passing through one rail could pass into the driving wheel, thence through the second rail to the station, where both rails were connected with another dynamo-electric machine which was driven by an engine. This little railway worked most successfully, the trains running from fifteen to twenty miles an hour. Its operations have suggested a similar line on a larger scale within the city of Berlin, and Dr. Siemens thinks we shall shortly have electric tramways on roads, as well as in connection with mines. In adits or tunnels the entire freedom from smoke of the electro-motor would be greatly in its favor—in no case more so than on the underground sections of the London railways. So forcibly does this advantage appear that Dr. Siemens states the administration of the St. Gothard tunnel seriously contemplate the use of electricity for running trains through that gigantic undertaking. Should this really be done a great step forward would be made, and we should be so much the nearer the realization of that long-foretold era when all the principal operations of mechanics will be performed by electricity.—*Ironmonger.*

Vol. XII.—No. 10 Manufacturer OCTOBER, 1880. & Builder TWELFTH YEAR.

Pneumatic Clocks.

The accompanying illustration gives a representation of a street clock operated on the pneumatic principle, a convenient system which has been largely adopted in Paris and other cities of continental Europe. Compressed air in this plan is made use of to operate all the clocks of a city or district simultaneously, precisely as electricity is similarly employed. The parts of the pneumatic clock system are, the central clock, the receiving clocks, and the tubes and intermediate mechanism for conveying compressed air to the receiving clocks. At the central station a reservoir of compressed air is provided, containing about 25 cubic feet at about five atmospheres pressure. From this reservoir the compressed air is conducted to a second reservoir, in which its pressure is regulated at seven-tenths ($^7/_{10}$) of an atmosphere. Every minute the distributing reservoir is placed in communication with the distributing tubes by the action of the mechanism of the central or distributing clock. The central station is provided with several of these clocks, so that if one should become disordered another can be set in operation within a few seconds. A distributing tube connects with the several mains which convey the compressed air into the various districts where pneumatic clocks are provided. The mains are of wrought iron, $1^1/_{16}$ inches in diameter, and are connected with lead tubes three-5ths of an inch in diameter, for conveying the air into the houses where necessary. With a pressure of seven-10ths of an atmosphere, it is found that any required number of clocks can be operated at a distance of from one to two miles from the central station.

The action of the receiving clocks is about as follows: A small bellows, resembling that used in pneumatic call-bells, is in communication with the tubes conducting the compressed air from the central office. Every minute the pressure of the air raises the bellows, and a rod attached to the upper bellows-head actuates a lever which engages with a wheel provided with 60 teeth, which is rigidly secured to the minute-hand arbor. The wheel rotates the distance of one tooth every minute, and a weighted pawl on the other side of the dial checks this movement. The hour-hand is rotated by means of the usual dial wheels. By means of a second bellows the clock may be arranged to strike. The ordinary spring and weight clocks can be easily transformed into pneumatic receiving clocks.

The mechanism of the receiving clock is alike in all cases, and is entirely independent of the size of the dial or the location of the clock. It is asserted that many of the principal hotels, railway depots, public buildings, courts and the like in Paris, are provided with clocks operated on the principle above described. One of the most useful applications of the system is that shown in connection with a street clock. A number of these pillar clocks, of very ornamental appearance, and illuminated at night, are said to have been erected in that city.

We are informed that it is the intention of a company that has lately been organized, to introduce pneumatic clocks into American cities.

PNEUMATIC CLOCK IN PARIS.

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~~Aug 28 1880~~

ELECTRO-MOTORS.

7

THEIR POWER AND RETURN.

J. Hospitalier.

The transmission of force from a distance, electric ploughing, the electric railroad, etc., have made electric motors and the conditions of maximum work and maximum return, quite the order of the day. In a previous article on the available force in batteries, we have determined, for the most usual forms, the quantity of energy that could be furnished by a certain number of elements in an external circuit of proper resistance, supposing no polarization and without variation of the internal resistance.

Is this maximum of available work entirely convertible into effective work? It is not, and we will show how this maximum should be reduced when a given electric energy is to be transformed into mechanical force.

Let us suppose, for instance, in numbers, which always strike the attention more than formulas, that we have a source of electricity of 100 volts, with an internal resistance of 1 ohm. It would be easy to realize the conditions by employing an electro-dynamic machine, separately excited, or 100 very large Bunsen cups, arranged for tension in 2 parallel series of 50 each. Putting into the circuit an external resistance equal to the internal, and supposing no polarization to exist and no change in the internal resistance, we obtain as elements for the electric circulation:

E.—Electro motive force	=	100 volts.
r.—Internal resistance	=	1 ohm.
R.—Exterior resistance	=	1 ohm.
(r + R)—Total resistance	=	2 ohms.

$$\text{Q.—Quantity } \frac{E}{r+R} = \frac{100}{1+1} = 50 \text{ webers.}$$

In these conditions we know that we have in the external circuit the maximum of available work, as deduced from the formula of Joule:

$$W = 10\, Q^2 R \text{ meg-ergs} \qquad (a)$$

$$\text{or } W = \frac{Q^2 R}{9.81} \text{ kilogram-meters} \qquad (b)$$

In the case before us we have:

$$W = 10 \times 50^2 \times 1 = 25{,}000 \text{ meg-ergs} \quad (1)$$

What can we do with this available electric work? If we make it traverse an inert wire it will heat it. All the electric energy will be transformed into heat, and in this wire will be developed a certain number of calorics C, per second:

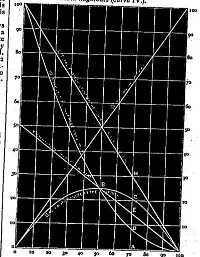
$$C = \frac{Q^2 R}{9.81} \times \frac{1}{A}. \qquad (c)$$

A being the mechanical equivalent of heat 424.

Let us substitute for the inert resistance of a wire, an electro-motor of equal resistance with the wire, say 1 ohm in this particular case. Let us suppose this motor to be one of Gramme's magneto-electric machines, and that the resistance of the armature is equal to 1 ohm. If we put a break on the armature to prevent it turning under the influence of the passing current, we will not have any of the original conditions changed; the wire of the armature will be heated by the current, and a number of calorics C will be produced equal to that developed in the wire. Now let us make the armature turn under the action of the electric current. The rotary motion of this armature will develop a certain electro-motive force E', inverse to that emanating from the source of electricity E, varying with the speed of the motor. It results in a diminution of the current, and can be expressed at each instant by the formula:

$$Q^1 = \frac{E - E'}{r + R}. \quad (d)$$

Hence the rotation of the motor diminishes the intensity of the current (and consequently the work of the motor) if a machine is employed as a source of electricity, or the consumption of zinc, if you employ a battery. The diagram shows how the different elements vary when the speed of the motor varies from zero (where the work developed is null) to a velocity such that the opposing electro-motive force E, which it develops, becomes equal to the electro-motive force of the source. It is seen that the energy expended by the source of electricity diminishes from the time the motor begins to turn (curve I.); similarly, the intensity of the current (curve V.) diminishes to zero when E and E' become equal. Curve II. represents the work developed by the motor at different speeds. Let us suppose these speeds are proportional to the electro-motive forces—a hypothesis easily verified in a well constructed magneto-electric machine—then we see, by the diagram, an augmentation of the work produced, up to a point where the speed of the motor becomes 50. At this moment the work done is at a maximum, and represents but 50 per cent. of the work expended by the source of electricity. The energy converted into work (curve III.) is equal to what is unconverted (curve II.). If the speed augments beyond this point the work produced (curve II.) diminishes, but the return augments (curve IV.).



The work produced and the return are hence perfectly distinct things which are too often confounded. There is no impossibility in making the motor return 80 per cent. of the work expended by the source of electricity, on condition you do not make this source produce all the work which it can furnish. When, at the limit, the work produced becomes null, the return becomes equal to 1. The same conclusion is arrived at on comparing curves I. and II. It is thus seen that energy not converted into work, diminishes more rapidly than the total energy expended by the source of electricity. When the motor is at rest, the work is zero, all energy being transformed into heat. When $E' = \frac{E}{2}$, the diagram shows that the work is equal to the loss; curves II. and III. cut each other at B and the return is 50 per cent. Several consequences result from this. If you wish to obtain the *greatest* results from any given source of electricity, the electro-motor, turning at normal speed, must be so arranged as to develop a counter electro-motive force equal to the half of the original source. If the *best* results are wanted greater speed is required, by which a return in work is gained with a corresponding loss in the quantity of work produced.

Curves III. and IV. show why an electro-motor heats more when stopped than when turning at a certain speed; the intensity of the current is greater in the first case than

48

VELOCITY OF ELECTRICITY.

ELECTRICIAN, AUGUST 21, 1880

A correspondent, dating his letter from Marseilles, writes to request "a lucid answer with reference to the ratio between the speed of electricity and that of light." As it is probable that a statement in "Answers to Correspondents" to the effect that no such ratio exists, or, at least, that it is impossible to determine it, might be considered insufficiently lucid, we purpose devoting a little space under this heading to the explanation of the fact as here stated. Many young electricians, besides our correspondent, appear to be under the impression that electricity travels with an assignable and constant velocity, such as that of 288,000 miles per second, which was the speed observed by Professor Wheatstone in his celebrated experiments at King's College, from which, unfortunately, some very erroneous conclusions were deduced; and it cannot be too widely made known that, as Mr. Fleeming Jenkin observes, "the same quantity of electricity may, under different circumstances, be made to traverse the same distance with almost infinitely differently velocities," and that, in fact, there is no velocity proper or peculiar to electricity. And in these days it should be understood, also, that the results obtained in Wheatstone's experiments were not "conclusively in favour of the double fluid hypothesis as to the nature of electricity," and that they are equally compatible with the single fluid, or, indeed, with any other hypothesis that has yet been advanced in this relation.

The destinction to be made between the *velocity of electricity* and the *velocity with which a given quantity of electricity can be transmitted* requires, in the first place, to be insisted upon in order to arrive at a logical conception of the real questions involved. Now, it may at once be stated that what is meant by the term "velocity of electricity" has never yet been defined, and that the velocity with which a given quantity of electricity can be transmitted varies "directly as the inductive resistance and inversely as the conductive resistance of the circuit through which the transmission takes place."* Thus, taking, as is usual, inductive capacity (F) in farads, instead of its reciprocal "inductive resistance," the *time* (t) in which a condenser, when circuited, will lose any given fraction of its charge is

$$t = \mathrm{R \cdot F} \cdot k \ \textit{seconds};$$

R being here the resistance in ohms,† and k a constant which depends only upon the ratio between the final and initial charges. Quoting from the same authority: "if this ratio equal ·367, k is unity, and, if it equal $\frac{1}{2}$, k is ·693." Therefore any condenser will lose 633 thousandths of its charge in R F seconds, and any condenser will fall to half charge in R·F·× ·693 seconds. And although an experiment with an ordinary condenser represents a simplified case, whereas an experiment with an elongated condenser such as a submarine cable presents conditions of greater complexity, it is to be observed that all cases of electrical transmission necessarily involve a conductor or electrical resistance and inductive capacity or a condenser. Since velocity is measured by the length of the conductor divided by the time, it will be seen that data may be obtained for calculating the speed at which a given quantity of electricity may be transmitted under any given conditions. And if we adopt the convenient plan of measuring velocity by the product of the length of wire (L) in knots into the number of elementary signals that can be transmitted per second, the "given quantity of electricity" being here that which will produce a signal on the instrument employed, then, according to the data given by Messrs. Clark and Sabine,‡ the velocity of transmission, with the mirror instrument, would be

$$\mathrm{V} = \frac{43 \cdot 3 \times \mathrm{L}}{\mathrm{R\,F}};$$

the product RF being, as before, either ohms into farads or megohms into microfarads.

Prior to the year 1834, it was held that the "velocity of electricity" was so great as not, under any circumstances, to be measurable. And the first result of Wheatstone's experiments was to show that the duration of the discharge from a Leyden jar, when the latter was "short-circuited," was not so much as the millionth part of a second. In these experiments the image of an electric spark was received upon a mirror in rapid rotation; one spark passing at each rotation, when the mirror was in a position to render it conveniently visible. With a high velocity, the image of a spark having any measurable duration would appear elongated; the length becoming greater as the velocity was increased. Now, with the short-circuited jar no enlongation in the image of the spark could be perceived; but when the jar was discharged through a copper wire half a mile in length the elongation became very appreciable. This result was sufficient to show that the propagation of electricity is not instantaneous: other arrangements, referred to as follows in Nord's "Student's Text Book of Electricity," had to be made in order to determine the velocity of transmission. "A jar was discharged through a copper wire half a mile in length, interrupted both in the middle and at the two extremities so as to give three distinct sparks. The deviation of half a degree between the two extreme sparks would indicate a velocity of 576,000 miles in a second. This estimated velocity is on the supposition that the electricity passes from one end of the wire to the other; if, however, according to the *two-fluid* theory, the two electricities travel simultaneously from the two ends of the wire, the two external sparks will keep their relative positions; the middle one alone being deflected, and the velocity measured will be only one-half that in the former case, viz: 288,000 miles in a second. The following were the results actually obtained:—In all cases when the velocity of the mirror exceeded a certain limit the three sparks were elongated into three parallel lines, and the lengths became greater as the velocity of the mirror was increased. The greatest elongation observed was about 24°, indicating a duration of about the 24,000th part of a second.

Aug 13 1880

ENGINEERING.

54

GAS ENGINES.

To the Editor of Engineering.

Sir,—As an old subscriber to your paper, will you kindly allow me a few lines in answer to Mr. Linton's paper on the gas engine, which appeared in your paper of July 30th, and which will bear out very fully some of Mr. Linton's remarks.

I put down an 8 horse power Otto engine for a client in February, 1878, since which time it has run constantly with the exception of holidays. During that time the only repairs done or necessary to the engine have been having slides refaced twice, this costing with railway carriage from Manchester 23s. each, in all 46s. The engine is run sometimes at full power, sometimes at less, and I have found it admirably adapted for a variable load. The engine under various conditions runs steadily at 160 per minute. The average attendance I have found to be one-quarter of an hour per day, and with the system of lubrication employed no further attendance is necessary.

Having very clean gas in this town, I have not once required to remove the piston, and the slides only require to be cleaned once every month.

Regarding water supply—I have found it best to keep a little running into cistern all the day. I have found the engine requires 17 cubic feet of gas per horse power per hour, and from my experience think the depreciation allowed by Mr. Linton too high.

Mr. Linton will find that the oscillation he mentions can be overcome by putting in another gas bag between the meter and the engine, two bags I have found placed somewhat apart being better than one large one. When the pressure is increased, as during the night, this pulsation does not occur. The side light should also be taken from a separate pipe; if this is not possible, it should be taken at some distance from main connexion, as it is highly necessary that the side light should burn steadily.

I have since 1878 fitted up a number of these engines in the district, and since gas managers have overcome the prejudice against their use, get all encouragement from them.

In this letter I have not gone into figures, as your readers can judge as to relative value of steam and gas engines from Mr. Linton's paper, the allowance he has made for gas engine being in my opinion too high.

I shall be glad to give any of your numerous readers any other details they may wish, and remain

Yours faithfully,

John W. Logan.

Berwick-on-Tweed, August 9, 1880.

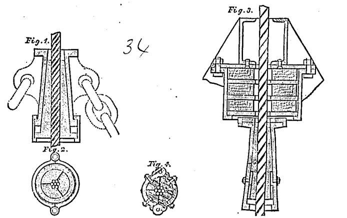
49

WIRE ROPE CONNECTIONS.

The connections commonly in use for securing wire rope to hoist cages consist in either bending the end of the rope into a loop, putting an iron ring into it, and lashing or clamping the end against the side of the rope, or the end of the rope passes through a conical sleeve, and a tapered wedge is then driven in between the wires of the rope, forcing the latter against the sides of the sleeve, and thus firmly uniting the two, or the wires in the end of the rope are turned back, the rope being passed through a conical sleeve, and the space run in with lead. All these methods are applicable where the end of a rope is to be fastened to a cage; but in all cases this end is destroyed, and the two cannot be separated—for repairs, for instance—without renewing the mode of connection after the previous end has been cut off. In cases where, as it is at present not uncommonly the case, a continuous rope is used partly for the purpose of balancing the weight of the rope, partly for working with the same rope from different stages, the modes of connection above referred to are not suitable, and some other means of making the connection have to be employed. The principal conditions which a coupling for this purpose has to fulfill are: first, to form a safe and firm connection, and, secondly, one which in no way injures the wire rope, since an injured place in the middle of a rope cannot well be repaired. It is, moreover, desirable that this coupling should be capable of being easily and rapidly put into or out of operation. A coupling which fulfills these requirements, and has for some time been in practical use in Rhenish Prussia, is shown by its inventor, Mr. F. Baumann, at the Dusseldorf Exhibition, and we understand that it is already applied to a considerable extent in the Rhenish and Westphalian mining districts.

This coupling is shown in its simplest form in Figs. 1 and 2, from which it will be seen that it consists of an outer conical casing fixed to the cross bar of the cage. Through this casing the rope passes, it being held in position by three or more conical pieces exactly fitting the casing externally, and the windings of the rope internally. The weight of the cage will naturally exert a pressure on the rope which increases with the load. These fitting pieces are cast in white metal or brass round the rope, and the coupling has stood some of the severest tests; having been tried in one case with a ¾ in. rope, consisting of thirty wires, 0·1 in. in diameter, well greased, and the cage loaded till the rope broke about 10 ft. above the coupling under a load of 7½ tons; the place where the coupling had gripped the rope could not, after the oil had been wiped off, be found, showing that the rope does not in any way suffer, and that no slip had taken place.

A hinged ring connecting the fitting pieces with the casing prevents the coupling from disengaging when the cage sets off at the bottom. An arrangement of this construction has been in use at the Friedrichsthal mines for over a year, and has been weekly shunted about several times, but has up to the present given every satisfaction.



BAUMANN'S WIRE ROPE CONNECTION FOR MINING CAGES.

To entirely avoid the necessity of care in adjusting this coupling, which is indispensable in the arrangement above described, and to obtain a still more rapid disconnection, Mr. Baumann has designed the arrangement shown in Figs. 3 and 4. The packing pieces here consist of four pieces with dovetailed slots, into which fit the heads of four bolts. The casing outside is made in two pieces hinged together, and this cannot be closed over the rope until the "lay" of the rope thoroughly fits into the grooves. An India-rubber buffer is added to avoid the sudden shock on the rope. In steel ropes, suitably arranged to carry an electric cable inside, communication can easily be established between the cage and the engine room. This system certainly possesses great advantages where a continuous rope is used, but even for a single rope, where disconnecting is occasionally necessary, it is a very handy arrangement.—*Engineering.*

~~Manufacturer~~ Builder Sept 1880

Motive Powers of the Future.

A suggestive paper was recently read before the Liverpool Engineering Society on the "Utilization of the Tides," by Mr. Oates, of Bradford. He was of opinion that although the coal supply of England would last for a long time to come, yet that ultimately the power of the tides would outrival all other sources of mechanical power. After pointing out that the ways of utilizing the tides were innumerable, and describing the construction of the tidal dam with suitable converters of the power, such as turbines in openings of the dam, working air-compressing or magneto-electric machines, he stated that the necessity for large conservators for storing the power between the tides would be the greatest difficulty in utilizing their power. A description of how this could be done, and the power rendered constant, was given. The means of conveying the power to a distance was then considered, air and water pressure and electricity being suggested. With regard to the latter, Mr. Oates believed that the "age of steam" had reached its zenith, and that the "age of electricity" had dawned; but should there be difficulty in conveying the power to a distance, he suggested that manufactories might be built adjacent to suitable tidal sites.

34

Electricity from River Currents.

An inventor of this city proposes to utilize the swift current of rivers by systems of anchored floats carrying current wheels connected with electro-dynamo-machines. The electricity thus generated might be conveyed to factories on the shores and set to work by means of electro-motors: or it might be used for lighting towns, or even for running trains on railways. 34 Scientific American Oct 1880

34

Adhesive for Rubber Belts.—A simple adhesive for rubber belts is made by sticking powdered chalk, which has been evenly sprinkled over, to the surface of the belt by cold tallow or boiled linseed oil. Mining Press Oct 16 1880

34

Wire Rope Transmission.—Among the recent improvements in the way of transmitting power for long distances, is the substitution of belts by endless wire ropes running at a high speed. Just where the belt becomes too long for economy there the rope steps in. In place of a flat-faced pulley a narrow sheave, with a deep, flaring groove, is used, the groove being filled out, or lined rather with leather, oakum, India rubber, or some other soft substance, to save the rope. The essential points are a large sheave, running at a considerable velocity, and a light rope. When the distance exceeds 400 ft., a double-grooved wheel is used, and a second endless rope transmits the power 400 ft. further, and so on. The loss by friction is said to be only 8% per mile. If it is required to transmit 300 horse power by means of a wire rope, the size of rope required will be one inch in diameter, running 4,020 ft. per minute over a wheel 14½ ft. in diameter, making 108 revolutions per minute. One is thus enabled, at a small expense, to transmit power in any direction.

Mining & Scientific Press Nov 13 1880

Adhäsionsfett für Lederriemen.

Die Treibriemen werden nach D. R.-P. 11462 mit Ricinusöl, dem man bis 10 Proc. Talg hinzusetzt, geschmiert, um sie geschmeidig zu machen und die Reibung derselben an den Scheiben zu vergrössern. 34

Chemiker Zeitung Nov 25 1880

Electrician Sept 4 1880 34

Mr. Bissinger, M.E., of Carlsruhe, gives the following results as obtained in his examinations of the several motors in regard to their relative cost per horse-power for each hour. It will be observed that the examination pertained principally to small motors. The relative cost per effective horse-power per hour is as follows:—100 h.-p. steam engine, 7·6; 2 h.-p. steam engine, 44·3; 2 h.-p. Lemann's caloric engine, 26·5; 2 h.-p. Hock's motor, 40·0; 2 h.-p. Otto gas engine, 26·4; 2

THE FUTURE OF AMERICAN COTTON MANUFACTURE.—THE POSSIBILITIES OF SOUTHERN WATER POWER. 34

Scientific American Nov 27 1880

In a communication from Atlanta, Ga., dated October 31, Mr. Henry N. Meigs writes as follows to the New York *Herald:*

There are now some 10,000,000 cotton spindles operated in the Union. In the year 1900, only nineteen years away, there will be 20,000,000 needed, because the increase of population and of exportation of American goods will demand them. The population, as ascertained by the recent census, is, in round numbers, 50,000,000. In 1870 it was 38,000,000—an increase of thirty-one and a half per cent. in ten years. The same rate of increase for the next two decades will make it 81,000,000. To sustain this estimate let me suggest that from 1790 to 1820 and for each succeeding period of thirty years the "Compendium United States Census" shows an average increase of over one hundred and forty per cent. This ratio applied to the 38,600,000 of 1870 gives us over 90,000,000 in 1900—thirty years later. So it appears that twenty years hence we may expect a population nearly double that of the present year as just ascertained. Even if this estimate of population fails the increased tendency of the people toward manufactures will compensate for the smaller number of the population. Will not two pounds of cotton goods be required from United States mills in 1900 for one pound now produced? If this is correct 20,000,000 of spindles will be required.

During the interval of nineteen years most of the spindles now in use will be worn out or otherwise destroyed. Let us say that 5,000,000 must be replaced and 10,000,000 more must be supplied—in all 15,000,000, with all their preparatory and following machinery—before the end of this century. Is this extravagant? I think not. One-half of the 7,000,000 at work in 1870 were operated by steam, the other half by water power. The *Financial Chronicle* reports the home consumption last year at 1,800,000 bales, averaging 481 pounds each. This is equivalent to over 865,000,000 pounds. If the ratio of 1870 has been maintained some 430,000,000 pounds have been manufactured by steam in 1879 and 1880. Is this economical? It pays, certainly; but does it pay as well as with water power? The requisite power for 1,000 spindles, with looms, has been variously estimated at fifteen to twenty-five horse power. As all speeds have been accelerated since the introduction of the American ring spindle, let us take (in medio) the ratio of twenty horse power. For 20,000,000 of spindles, with looms, this ratio demands 400,000 horse power.

The Utilizing of the Tides.

A Philadelphia engineer has invented, it is claimed, a machine by which the power of the tides can be utilized. Numerous plans have been proposed for the accomplishment of this most desirable end, but only under exceptional conditions have they been practical or economical. If the new device can harness the tide in its daily channel, so as to convert any considerable portion of the vast power into working force, the inventor will rank among the great benefactors of humanity. Emerson says somewhere: Hitch your wagon to a star. A device for utilizing mechanically the free tides, that sweep along our shores, would come next to that, since it would enable us, through converters and carriers of electricity, to hitch our wagons to the sun and moon.

An Enormous Rubber Belt.

The contract for supplying the rubber belting to be used by the largest elevator in the world, now being erected near Baltimore, has been awarded to the Gutta Percha and Rubber Manufacturing Company, N. Y. The elevator will require one hundred ... The main driving belt will be five feet wide, eight plies in thickness, two hundred and twelve feet long and will weigh over one and a half tons. This is by many hundred pounds the heaviest rubber belt ever made.

Engineering Mch 18 1881

TRANSMISSION OF HEAT AND POWER.

To the Editor of Engineering.

Sir,—I have thought it would be of interest to give you some particulars of experiments which have been carried out in the United States relative to the transmission of heat and power to a distance from the generator. I have searched amongst my papers for the experiments of the late Mr. Max Hjortsberg in vain, so that unfortunately I can only offer you at present a very brief description of what has been done, and which from an engineering point of view will be, I fear, very incomplete.

There are two systems which are receiving attention in the States, both of them being intended to be used for the supply of heat and small power to the inhabitants of cities, viz., steam and highly heated water.

Mr. Holly, the inventor of the high-pressure pumping system, was the first to experiment on a large scale as to the ability of carrying steam for considerable distances. About three years ago he put down a line of pipes in his native town of Lockport, New York, with comparative success. He has in several places put down plant for the same purpose, but the most successful one has been at Hartford, Connecticut, as I mentioned in my former letter. There Mr. Burdett Loomis, aided by his friends, determined to put down a plant differing from Holly's practice in several material points, and experience has shown that his judgment was correct. He carried steam through about a mile and a half of pipes, ranging from 6 in. to 2½ in. in diameter, under a boiler pressure of 70 lb., and he informs me that at the further end of the plant, the pressure is reduced only 2 lb., but unfortunately he does not give how much steam passed through the pipes at that point, so that this figure cannot be utilised for determining the loss in carrying the steam so great a distance. The covering he uses for the pipes is most effective, consisting of logs, bored and turned so as as to allow of a 2 in. air space between the pipe and the log. These logs are creosoted and driven one within the other tightly, so as to prevent any circulation of air. At intervals of 100 ft. expansion joints are provided, which are placed inside cast-iron manholes, also kept air-tight, the logs being driven into holes formed in the sides. The forms of the expansion joints, reducing valves, and traps are all novel, but I will not inflict a description of them upon you here. By this plan all the water of condensation is returned to the boilers by means of a pipe laid alongside the steam pipes, and covered in a similar manner, and into which the water of condensation from the various buildings is trapped. This gives the material saving not only of about 150 deg. of heat, but also of the water, which latter, in towns where it has to be purchased from water companies effects a considerable economy. He informs me that wherever his pipes are laid the inhabitants nearly all decide to take the heat supplied in preference to continuing their old systems of heating by hot air derived from cast-iron stoves, or by the old method of stoves and open fires. He further tells me that although only started last October, he is now heating over 6,000,000 cubic feet of room space, and driving about 150 horse power nominal in the shape of small engines where the cost of putting down boilers, together with the extra risk for insurance would prevent them from being used. There is very little doubt that before many years are passed every city of any size in the United States where it is cold enough to require heat in the winter will have some general system of heating.

The hot-water system spoken of has been claimed by the inventor, Mr. W. E. Prall, of New York, to be a superior means of doing what has hitherto been done by steam. He contends that water is a better medium for the storage and conveyance of heat than steam, and he claims as superior features the facts that pumps can be used to circulate the water at seasons of the year when very little heat is being taken from the mains, but that little requiring to be of a sufficient temperature for cooking, &c.

His plan is to heat water to a temperature of about 400 deg., and allow it to circulate through pipes which have communication with a circulating pump. He also provides a return pipe for the water of condensation. Mr. Max Hjortsberg after carrying out the series of experiments mentioned, came to the conclusion that in his opinion Prall's system was vastly superior for its intended purpose than any steam system. He laid down about a mile of piping conveying the water to buildings, where, after reducing the pressure, he used the steam generated for running the engine of a factory and the unconverted water for heating the rooms, stating to me that the loss at the end of the pipe furthest away from the generator was surprisingly small.

Mr. Prall is about to lay a plant in New York City, and I await the results with very considerable interest, and shall be happy from time to time, as they proceed with the work, to give you information respecting it. The question of measuring or metering the amount of heat and power supplied to customers is one still unsettled. Mr. Holly designed a steam meter, which consisted of some clockwork actuating a small screw shaft, the speed of this shaft being controlled by a link worked from a diaphragm which rose or fell with the pressure of the steam in the pipes giving a greater or lesser throw to a pawl working in a ratchet. This, however, could not have been successful from the fact that he did not charge by its reading, and has in most cases thrown them out. Mr. Prall claims that by means of a specially made water meter he can register the amount of water that is conveyed into a building before it passes the reducing valve, and by this means can measure accurately enough for charging.

The advantages of using these systems are numerous. The heat supplied for warming buildings is much healthier than that produced by ordinary means. The dirt and dust consequent on using open grates and stoves is avoided. The risk of fire is greatly reduced, and the cost of heating a given amount of space is very much smaller when supplied wholesale. For running small powers, especially in a country where gas is charged at exorbitant rates, it is invaluable, and these facts being appreciated by the people, there is generally very little difficulty found in obtaining custom.

Trusting that these few facts, which want of time prevents my putting in a more interesting shape, will be of some interest,

I remain, Sir, yours obediently,

Harry Olrick.

27, Leadenhall-street, London, E.C., March 3, 1881.

Boston Journal of Chemistry.

JAS. R. NICHOLS, M. D., *Editor.*
WM. J. ROLFE, A. M., *Associate Editor.* 3

BOSTON, MAY 1, 1881.

TRANSMISSION OF ELECTRICAL FORCE.

IT is claimed that by a new device mechanical energy can be transmitted from one distant point to another by means of electrical conductors, so that a descending stream anywhere can be utilized as a source of mechanical power in towns and cities ten or fifty miles distant. This invention is claimed by an Englishman, Dr. Hincks, now in this country, who has constructed the apparatus, and has formed in New York a company with a large capital, to put it in practical operation. The construction of small motors propelled by electricity has been accomplished for many years; ever since, in fact, the discovery of the electro-magnet and methods of changing polarity by automatic devices. The new motor claims to be very much more than a plaything; a power, in fact, which is capable of propelling heavy machinery and doing the work of steam in all its varied applications. We were promi-ed last winter a private *séance* in this city with this new wonder, but there was a hitch somewhere in the arrangements, and it was transported to New York without having been seen, so far as we can learn, by any one. The machine was constructed here, and it was stated that no unemployed steam-power could be found in the city of sufficient capacity to test it. Dr. Hincks claims that his machine is no untried device, it being at the present time at work in England and Wales, in the mining districts, doing heavy work in tunnels at a distance of ten miles from the mountain stream, which is the source of power.

If the important end has been accomplished of changing mechanical energy over into electrical force, and then transmitting the same long distances by means of a wire, and again changing it to mechanical energy, so as to drive machinery, certainly results are reached of the highest consequence in industrial progress. It is claimed that this is accomplished with a loss of only twenty-five per cent. of the original power; or, to state the matter a little clearer, a turbine wheel affording one hundred horse-power at a stream can have seventy-five per cent. of the same delivered to shafting ten miles distant, the only medium of communication being a copper wire $\frac{3}{16}$ of an inch in diameter. A ten horse-power water-wheel, located anywhere on a farm or estate, could have more than seven tenths of its power brought to the farm buildings and dwelling, and used for lighting, warming, pumping, and all other uses for which it might be wanted. The development and practical results of a plan so magnificent as this will be watched with interest by every one.

1881. Electrician. July. 16.

ELECTRICITY AT THE ROYAL AGRICULTURAL SHOW AT DERBY.

(BY OUR SPECIAL CORRESPONDENT AT DERBY.)

It may be thought, and truly so, that few applications of electricity have been made in apparatus connected with agriculture. Still, it is now getting on for two years since a dynamo-electric machine was tried as a motor to actuate ploughs at Sermaize. So far as that experiment is concerned, there is no indication of its having made any deep impression by any apparatus to be seen at Derby.

The miscellaneous exhibits and those indirectly rather than those directly used for agricultural purposes indicate, perhaps, that the rubicon has been passed, and in years to come electrical appliances will be no unique things at these shows.

A large meed of praise will always be due to the Royal Agricultural Society from the pioneers of electric light enterprise, inasmuch as it has been under the auspices and incentive of this society that the portable and semi-portable engines so largely used for electric light purposes have been brought to the point of perfection they have obtained. All the eminent makers of these engines are represented at Derby, and it would be an invidious task to attempt to decide whose build of engine was the best where all are so excellent. There are engines by CLAYTON and SHUTTLEWORTH, by HORNSBY and SONS, by MARSHALL, SONS, and Co., by RANSOMES, HEAD, and Co., by ROBEY and Co., by RUSTON, PROCTOR, and Co., and so on, any one of which may be depended upon for design and workmanship. The designs of the various makers differ in minor details, each of which are supposed to present something superior to that of rival makers; but it is well known that, taken as a whole, the engines run one another very closely in any competition in which they may be engaged. It may not be out of place here to say that Messrs. Ransomes are engaged on an engine specially designed for electric light purposes, and we believe that this engine will be shown at the Paris Exhibition.

Mr. Turner, of St. Albans, exhibits a gas engine, which has been successfully tried with the Swan lamp at Lord Salisbury's. This engine, with the expenditure of 1 h.-p., kept alight 12 of Swan's lamps, but not at their full brilliancy. On reducing the lights to 8, however, the full effect was obtained.

We noticed that Messrs. Western and Co., of the Chaddiston Works, Derby, had two Siemens dynamo machines with which to drive some of the wood-working machinery exhibited. As we saw the arrangement, the driving machine was placed to drive a four-cutter moulding and planing machine, and we understood that the power obtained from the dynamo machine was from 4 to 5 h.-p. Messrs. Deakin, Parker, and Co., of Sandon Works, Salford, Lancaster, exhibit a specially designed 10 h.-p. stationary engine for electric light purposes. This engine is fitted with a modified Hartnell governor. It could not be shown in motion owing to an accident received during the transit by rail.

Thus we see that builders of engines are considering the special requirements of the electric light, and hence we may expect still further improvements in details. As usual, a telegraph office is open in the show yard.

~~Times.~~ June 11. 1881.   Times. June 13. ~~1880.~~ (1881)

PNEUMATIC TRANSMISSION OF POWER.

BY PROF. HENRY ROBINSON, C.E., LONDON.

The review in the issue of THE SANITARY ENGINEER for January 1, of "Isaac Shone's Pneumatic Sewerage System," may advantageously be followed by a reference to other data than those mentioned in the article.

In considering the special application of compressed air in the Shone appliances, it must be remembered that the efficiency of this motor depends on three factors; namely, (1) the air compressor; (2) the tubes transmitting the air under pressure; (3) the appliance worked by the compressed air.

In a paper which we read before the Institution of Civil Engineers in 1877, on the "Transmission of Power to Distances," we went at some length into the consideration of the useful effect obtained from compressed air, and the result showed that, as regards the first factor, about 50 per cent. of power was lost in the compressor. In other words, that a steam engine exerting a power of ten horses, at a steam pressure of about 40 lbs. to the inch, would lose one-half of that power in compressing the air and would transmit one-half. We also pointed out that the loss in transmission through great lengths of pipe was but trifling, when the joints were tight and the pipe surfaces smooth. One case was given of the application of compressed air to underground haulage in a colliery. The air was taken down shafts upwards of 300 yards in depth and conveyed a distance of 1,600 yards underground, with a *gain* of 2 lbs. per inch pressure, at the time that the air engines were working at the extremity of the line of air pipes. The experience gained in the Mont Cenis and in the St. Gothard tunnels shows that compressed air can be conveyed great distances with but little loss, depending on the size of the pipe conveying the power, compared with the volume of air to be conveyed in a given time, the friction varying as the square of the velocity.

The results of some practical experiments with compressed air, which we gave in the paper referred to, may be usefully repeated in the annexed table.

Having thus considered the proportion of useful effect which may be obtained from compressed air, we come to the third factor, namely, "the appliance worked by the compressed air." Here we think the apparatus used by Mr. Shone and termed the "ejector," is not quite understood by some, who have failed to see that the loss of power due to friction in working a rotary engine, or other compressed air appliance, is saved in the ejector, inasmuch as the air passes direct on to the fluid surface in the receiver, and its elastic force is not diminished by friction in passing through contracted orifices to a cylinder to actuate a piston. The temperature of the sewage that the compressed air acts upon is doubtless sufficiently high to prevent the refrigerating action, due to the sudden expansion which occurs after the air has passed through the cylinder of an air engine at a high pressure.

To form an opinion as to whether the advantages which are claimed for the pneumatic system of Shone are likely to be realized, it is necessary to bear in mind the conclusions which are deducible from the foregoing remarks. These conclusions may be briefly summarized thus: Where compressed air is employed at a pressure of about 4 or 5 atmospheres, and where, at its point of utilization it can be brought *directly* to do its work without loss of power in applying itself, then the most favorable conditions exist for the economic use of it as a motor, and these conditions appear to exist in the "ejector." It would be interesting to consider the application of gas or water from the town mains to work an appliance of this kind, as we think in many cases the utilization of existing mains to supply the power necessary to compress the air, might be better than creating an independent source of power and laying entirely new mains. This question, however, does not admit of being worked out in the compass of a short communication like this.

Before concluding, we would refer to a paper which has just been read before the Institution of Mechanical Engineers, by M. Achard, of Geneva, on the "various modes of transmitting power to a distance." Those who have studied this question will be familiar with the admirable articles of M. Achard, which appeared from 1874 to 1879 in the *Annales des Mines*. In the paper recently read, M. Achard states that the efficiency of the St. Gothard compressors has been approximately from 78 to 80 per cent. This greater co-efficient (which is estimated, for no experiments of a complete nature appear to have been made) is claimed to be, owing to the injection of a very fine spray into the pump barrel of the compressor, whereby the water is brought into direct contact with the air to be cooled.

There is a wide field open for practical advancement in regard to the motors to which compressed air is applied, especially in the direction of avoiding the loss of power due to refrigeration by expansion, as well as the incomplete expansion in the motor.

The greatest progress in utilizing compressed air is exhibited in M. Mékarski's compressed air engine for tramways. The peculiar features of this appliance is that the air passes through a boiler with water at 248° Fahrenheit, before entering the cylinder of the engine. The air chambers on the locomotive are small and the air is stored in them at a high pressure. M. Achard states that in this engine the air goes through the boiler before passing the expander, so that if the temperature of the air in the boiler is 212°, and if the limiting pressure is 5 atmospheres, the gas which enters the engine will be a mixture of air and water vapor at 212°, and the pressure exerted will be due to a combination of 1 atmosphere, due to the vapor of water and 4 atmospheres due to the air.

PRACTICAL RESULTS OF EXPERIMENTS WITH COMPRESSED AIR.

PRESSURES.		Work required to produce 1 cubic foot. Compressing apparatus giving 66 per cent. efficiency.	Work done by 1 cubic foot of air at pressure given, expanding to atmospheric pressure.		PERCENTAGE REALIZED OF WORK EXPENDED.			
					Including both operations, viz: Compressing and Expanding.		Expanding only.	
Atmospheres above Atmospheric pressure.	Lbs. per square inch above atmospheric pressure.		Without addition of heat during expansion.	With addition of heat.	Without heat.	With heat.	Without heat.	With heat.
		Foot Lbs.	*Foot Lbs.*	*Foot Lbs.*				
2	29.4	4.401	1.366	2.156	30	44	45	66
3	44.1	10.458	3.048	4.648	29	44	44	66
4	58.8	17 577	4.962	7.812	28	44	42	66
5	73.5	26.451	7.028	11.756	27	44	41	66

ENGINEERING.

THE ELECTRICAL TRANSMISSION OF POWER.

M. CABANELLAS, who has given much consideration to the questions of production and distribution of energy by electricity, and who is the author of a system of automatic working of such a problem, has just communicated to the Academie des Sciences, of Paris, the theory in reference to the recent experiments made by M. Marcel Deprez, at Munich, on the electrical transmission of power, and to which reference has been made in these columns. M. Cabanellas' theory is as follows: "In the transmission of mechanical energy by means of two identical dynamo-electric machines, the ratio of the speeds does not express the value of the duty; the efficiency is equal to the product of the ratio of the speeds into the ratio of the fields."

Those who have had experience with dynamo-electric machines have remarked that for a given number of revolutions, per unit of time, of the generating machine, the maximum work is not obtained from the receiving machine when this is allowed to go at half the speed of the generating machine; but for a large number of types of machines the receiving machine should go at two-thirds the speed of the generator to obtain the maximum mechanical work. This fact, however, is in contradiction to a theory which is found in several scientific works, a theory which admits, explicitly or implicitly, the quality of the fields of the generator and receiver. But it must be granted by every one that from Lenz's law there follows the necessary reaction between the field and the moving current in each machine. The theory of M. Cabanellas takes exact account of all experimental results; his example shows how great this reaction may become with high speeds. M. Cabanellas' communication is moreover of great interest on account of the general method of reforming the electric elements which he applies to the particular case of the experiments of M. Marcel Deprez as to speeds, differences of potential, and current observed at Munich by the engineer who carried out the following experiments in accordance with the instructions of M. Marcel Deprez.* Now that very exact instruments for measuring currents and differences of potential are obtainable, the value observed by the easy method of M. Cabanellas for the total work given electrically to the generator has every reason for being much more exact than the value of the work obtained by interposing a transmission dynamometer between the mechanical source of power and the generating dynamo, since at a speed of 2200 revolutions per minute the error introduced in the traction, and thence in the work of one revolution, is multiplied thirty-six times in the determination of work per second. In this method M. Cabanellas has profited greatly by his former experiment on the increase of internal resistance of machines when running.

M. Cabanellas says:—In a series of studies on electrical machines, communicated to the Academie des Sciences, I have analysed the theoretical reasons which differentiate the reflex magnetic and electric elements of a machine according as this machine is worked mechanically to create electric currents, or is worked electrically to produce mechanical work. But No. 15 of vol. xcv. of the *Comptes Rendues* (October 9, 1882) has on page 633 a note from M. Marcel Deprez, the conclusions of which prove to me that in the interest of science and its applications it is indispensable to call attention to the results of the experiments of which I have spoken in a manner sufficiently concise for the figures to be followed. M. Marcel Deprez gives the results of an interesting experiment on the transmission of power to a great distance which he has made from Miesbach to Munich (fifty-seven kilometres of overhead telegraph line).

According to the note the receiving Gramme machine developed half a horse power measured on a brake at 1500 revolutions per minute, an identical Gramme generator at Miesbach running at 2200 revolutions. M. Marcel Deprez concludes, "That subtracting the passive resistances of every kind the ratio of the work reproduced at Munich to the work expended at Miesbach was as $\frac{1500}{2200}$ = more than 60 per cent." It was a departure from the above-quoted theory that caused M. Marcel Deprez in the preceding assertion to make an error which is very far from negligible, since I will show that from the results of this experiment the return instead of being about 60 per cent. was about 20 per cent., that is to say about one-third as much as the author of this experiment imagined. The above-mentioned note, besides the speeds of the machines and the work reproduced, gives only the resistances (in repose) of each of the two machines (470 ohms) and the total resistance (line wire and return) of the telegraphic circuit (950 ohms). There would not be in this the elements necessary for a numerical estimation, but I find the following series of figures in a recent publication which relates to the experiment at Munich, the *Bulletin de la Cie. Internationale des Telephones*: Power transmitted ½-horse power, resistance of each machine 460 ohms, resistance of line 1000 ohms, speed of generator 2100 revolutions, speed of receiver 1400 revolutions, difference of potential between the terminals of the generator 2400 volts, and between the terminals of the receiver 1600 volts, current 0.5 ampères. It will be seen that the two sources of information present in what they have in common an agreement sufficient to permit both to be taken as the base of an approximate calculation. It is reasonable to take without selection the figures of the most complete source which can be applied, although they are a little different from those of the experiment noted by M. Deprez. Let i=current, E the electromotive force of the generator, e that of the receiver, r the resistance of the generator when working, ρ that of the receiver, R that of the line, ϵ the difference of potential at the terminals of the generator, ϵ_1 the difference of potential at the terminals of the receiver, t the mechanical work reproduced per second (kilogramme-metre) t^1 the useless work of the receiver through rubbing of brushes and resistance of the air, g the acceleration of gravity. Neglecting at first the work done uselessly we have:

$$\epsilon_1 i = gt + i^2\rho \therefore \rho = \frac{\epsilon^1 i - gt}{i^2} = \frac{1600 \times 0.5 - 10 \times 37.5}{0.5^2}$$

$= 1700$ ohms, and $e = \epsilon_1 - i\rho = 1600 - 0.5 \times 1700 = \frac{gt}{i} = 750$ volts, but the resistance of the machine in repose is 460 ohms, and therefore the increase, for 1400 revolutions, is $1700 - 460 = 1240$ ohms. The increase for 2100 turns will be $\frac{1240 \times 2100}{1400}$ and hence for the generator $r = 460 + 1860 = 2320$ ohms, and $E = \epsilon + ri = 2400 + 2320 \times 0.5 = 3560$ volts, and therefore the return is

$$\frac{ei}{Ei} \text{ or } \frac{e}{E} = \frac{750}{3560} = 21.06 \text{ per cent.},$$

admitting that the current is not less at the receiver than at the generator, which would again lower the return. As verification

$$i = \frac{E-e}{r+R+\rho} = \frac{3560-750}{2320+1000+1700} = 0.55 \text{ ampères},$$

which would represent a loss of $\frac{1}{10}$ ampère or $\frac{1}{11}$ of the current in a total length of the wire of more than 100 kilometres. The positive and negative tensions vary gradually from a difference of 1200 to 800 volts with the potential of the earth. If it is wished to take account of the work t^1 reproduced uselessly in the receiver, the formula becomes

$$\epsilon_1 i = gt + gt^1 + i^2\rho_{t_1},\quad \rho_{t_1} = \frac{\epsilon^1 i - g(t+t_1)}{i^2} \qquad \epsilon_{t_1} = \epsilon_1 - i\rho_{t_1} = \frac{gt^1}{i},$$

and since

$$\rho_{t^1} = \rho_0 - \frac{gt^1}{i^2} \therefore \epsilon_{t^1} = \epsilon_1 - i\rho_0 = \epsilon_0,$$

which should be *à priori*. The useless work t^1 is easy to measure dynamically and even electrically by a method which I have communicated, and which has been inserted in the *Comptes Rendues*. In the absence of direct measurements we may estimate this useless consumption at one-tenth of the mechanical power reproduced by the receiver, *i.e.*, at 3.75 kilogramme-metres per second. The above formula gives us for $t = 37.5$ and t^1 3.75, $\rho = 1550$ ohms, $e = 750$ volts without any change, increase for 1400 turns = 1080,

$$r = 470 + \frac{1080 \times 2100}{1400} = 2090 \text{ ohms},$$

$$E = 2400 + 2090 \times 0.5 = 3445 \text{ volts},$$

$$\frac{e}{E} = \frac{750}{3445} = 21.77 \text{ per cent.}$$

Using the figures of M. Deprez's note or inert resistances it would be $i = \frac{3445-750}{1550+950+2090} = 0.58$ ampères. If in the numerator of ϵ_1 we take account of the difference of potential lost through derivation on the line we find 0.51 ampères. We have judged it interesting to pass through all the details of the reconstruction of the electric elements, for we might have at once applied the formula

$$\text{Return} = \frac{gt}{\epsilon i + \frac{N}{n}\left[\epsilon_1 i - g(t+t_1)\right] - a i^2 \frac{N-n}{n}}$$

which applies if the line is perfectly insulated.

N n are the speeds of the generator and receiver, a is the resistance of the machine in repose at the strength of current i. But the formula

$$\text{Return} = \frac{gt}{\epsilon I + \frac{N}{M}\left[\epsilon_1 I - g(t+t_1)\right] - a_1 I^2 \frac{N-M}{M}}$$

in which $\epsilon_{1\,1}$ is the difference of potential between the terminals of the machine worked at a speed M by a current I, the work got out by the brake being t_1 and the useless work t^1_1, a_1 being the resistance at rest under the strength of current I. The value of the current I at the generator being greater than i the value of the current at the receiver, approximately in this case where the line is imperfectly insulated the formula

$$\text{Return} = \frac{gt}{\epsilon I + I^2\left[\frac{N}{n}\left(\frac{\epsilon_1}{i}\right) - g\left(\frac{t+t^1}{i^2}\right) - a\frac{N-n}{n}\right]}$$

may be employed.

With the preceding approximate figures a calculation would give I = 0.65, which would reduce the return to less than 15 per cent. The kind of calculation which I have just made shows how useful and practical is the consideration of the increase of internal resistance of machines when working; also with what ease it allows a great error to be rectified and of finding the return which a measure of the power expended at Miesbach will give, a measurement which is particularly easy and exact if, as has been remarked, the generator is driven by a separate gas engine. In fact, when M. Deprez admits that the return is equal to the ratio of the speeds he implicitly admits the equality of the magnetic fields of the generator and receiver, whereas through the reflex actions of which I have spoken (electric current in movement inducing magnetism) the generating field was more intense than the magnetic field, which the same current would develop with the armature in repose or turning with an open circuit, and the field of the receiver was less intense than this field not influenced, so that according to the figures given the field of the receiver in this experiment would be three times less intense than the magnetic field of the generator.

* M. Cabanellas has since acquired proof of the authenticity of these figures.

Engineering, December 1882.

ELECTRICAL TRANSMISSION OF POWER.

The first practical application in Scotland of the electrical transmission of power to a distance in everyday use has just been made at the works of the Railway and Electric Appliances Company, Polmadie, Glasgow, by Mr. Rankin Kennedy, electrician and engineer, formerly of Paisley and Kilmarnock. By means of two dynamo-electric machines, designed and made by him at the Polmadie Works, a power of from four to five horses is transmitted from the line of shafting of the turning and fitting shop of the works to the department occupied by the carpenters and pattern makers on the opposite side of the yard of the works. Thus transmitted, the power is used by those workmen for driving the large saws used in cutting their wood, and it is completely under their control. In this example of the electrical transmission of power there are used two of Kennedy's dynamos. One of them—the generator which supplies the electricity—is placed on the floor of the turning shop of the works, and is driven by a belt from the line of shafting which drives all the machinery of the works. This generating machine runs all day, and from it two copper wires are led away to the carpenters' and pattern-makers' shop, where they are fixed and connected to the other dynamo, which, as in the former case, is also on the shop floor. This second dynamo is the motor which receives the electricity from the first, the shaft of the motor dynamo being caused to revolve at a speed of 600 revolutions per minute. A belt from the pulley on this shaft drives the saws when the current is turned by the switch handle.

MARCEL DESPREZ'S MUNICH EXPERIMENTS.

M. MARCEL DESPREZ has communicated to *L'Electricien* of December 1 a correction of the exaggerated deductions drawn from his Munich experiments, which in great part confirms the comments of M. Cabenallas, reproduced in our issue of the same date (page 517). M. du Moncel had announced in the *Temps* that M. Marcel Desprez had obtained an economical result at Munich of 60 per cent. of the power evolved at Miesbach. M. Desprez now explains that the figure of 60 per cent. refers only to the electric result, measured by the respective rates of motion of the generator at Miesbach and the receiving instrument at Munich; but that the margin of power actually available for industrial purposes varied between 25 per cent. in the first experiment, when the generator was making 1600 revolutions per minute, and 30 per cent. in the second experiment, at 2000 revolutions per minute.

Engineering Dec. 1883.

L'Electricien (Paris, October 15), publishes Captain Boulanger's second report to the Academy of Sciences on the Grenoble experiments, in which he treats of the electrical measurements and the distribution of the force transmitted. In an article commenting unfavourably upon M. Marcel Desprez's proceedings, it is pointed out that the only really scientifically tested observations as to the distribution of force, were made —not with power coming from Vizille, 8½ miles away, as was popularly supposed, but—with power generated by a machine at a short distance driven by a locomotive. Captain Boulanger is to present a third report, bringing the electrical figures into connexion with the dynamometrical results.

The same paper gives details (taken from the *Elektrotechnische Zeitschrift*) of the experiments in the electric lighting of trains, carried on upon the Vienna and Trieste Railway. The normal speed of the train selected is a little over 37 miles per hour, but between the stations of Gloggnitz and Mürzzuschlag, where it climbs the steep slopes of the Semmering, it is reduced to about 17 miles per hour, for the course of an hour and 40 minutes. This makes it exceedingly difficult to maintain an equable intensity in the light. The illumination is effected by a dynamo, driven by one of the axles, with which it is connected by bands. Before the machine is in motion, and during stoppages, the lighting is carried on by a current supplied by accumulators, which are recharged by the motion of the train itself, ready for the next interval in the action of the dynamo. Full details are given of the system, which is found to work well as long as the train travels on a level; but fails on the Semmering incline. Here the accumulators are unequal to furnish an adequate current, for which it would be necessary that they should each develop 18,000 kilogrammetres in the 100 minutes. On the contrary, a result of 18,000 kilogrammetres has only once been obtained from a single accumulator. These experiments, therefore, must still be considered as tentative.

58

60

61

obtained by Marcel Deprez in the electric transfer of power. The author describes these experiments at some length, quotes the favourable opinion expressed by M. Bert, and expresses the confidence that by this means Italy may derive great benefit from the utilisation of the mountain torrents descending from the Alps and the Apennines.

The second chapter discusses the general principles of electricity and magnetism, and is communicated by Prof. Ferrini, being, in fact, taken from his treatise, "Elettricita e Magnetismo." These principles are laid down in a number of detached paragraphs. We find here an account of the law of Coulomb, the experiments of Riess, Coulomb, and Hæcker, the definition of the magnetic field as furnished by Sir W. Thomson, the theorem of Volta, the laws of Ohm, Long, and Jacobi, and an explanation of the standards of electric measurements.

The electric light, and the various forms of lamps, are the subjects of an extensive section by A. Casanova. This author gives a history of the electric light from its first discovery down to the present day. He describes the arrangements for the arc light, for incandescence, or glow lamps, the means of producing the necessary electric currents, such as the hydro-electric, the secondary, and the thermo-electric batteries. He then treats of electric induction and the principles of magneto-electric machines, several of which are described and shown in illustrations. The style of the figures is, however, not equal to that which we generally find in French, English, and American treatises. A. Casanova then passes on to an account of the distribution of the electric light, the system of M. Marcel Deprez taking a prominent place.

Some of the especial uses of the electric light are next described, as in lighthouses and in military operations. Here the writer notices its employment by the French in disembarking on the coast of Tunis, and adds a reflection on the manner in which science is made to minister to the caprices of human ambition. The introduction of the electric light for civil and industrial purposes is duly considered, and strong hopes are expressed of its future utility. We can scarcely see the reason for introducing a figure of the "solar motor" in this connection. This novel source of mechanical power may come into practical use in Australia and Africa, and may of course serve to drive dynamos; but in no part of Europe is the sun light sufficiently free from interruption.

The succeeding chapter, on electricity applied to the transmission of signals—in other words, to electro-telegraphy and telephony—is from the pen of P. Meardi.

Erminio Ferraris gives a preliminary account of an arrangement for electrolytic purposes, as in electro-metallurgy, galvano-plastics, &c. This chapter is short, and might easily have been rendered more instructive.

Dr. A. Baratieri treats of electricity in reference to the animal economy. In this chapter we find mention of the electricity of the gymnotus, and of the original experiment of Galvani, but there is nothing which can be called suggestive.

Dr. P. Schivardi discusses electro-therapeutics—a much abused subject.

The concluding chapter contains practical instructions for the application of electricity to household uses, and is of a somewhat promiscuous character. It includes the installation of the electric light without a motor, by means of the Gardine battery; the arrangement of electric bells, indicators, telephones, electric motors, gilding and silvering, the Mucci voltameter for medicinal purposes, and the determination of the poles in the battery.

There is little in this treatise to which direct exception can be taken as inaccurate. But the various sections are very unequal in their merit, and errors of arrangement are not wanting. Thus, in the section on animal electricity, we find much that belongs to the general elements of electrical science, and such "piper's news" as that "the atmospheric air is a body," or that "our globe is formed of a quantity of points, such as mountains, pyramids, obelisks, trees, church-towers." Very true, doubtless, but having little especial bearing upon the electric manifestations in animals.

The electric transfer of mechanical power, though referred to in the introductory section, is not made the subject of a distinct chapter.

THE EFFICIENCY OF SECONDARY GENERATORS.

WE observe that we are not alone in criticising the recent report given by Dr. Hopkinson on the Gaulard-Gibbs system of electrical distribution. M. Jules Sarcia writes as follows in the last number of *La Lumiere Electrique:*

"In the calculations for percentage of efficiency we see two grave errors of a theoretical nature. The first is the violation of a well known arithmetical theorem; in the second, Dr. Hopkinson unduly applies Joule's law which, as is shown in all classical treatises, is not applicable to alternating currents.

Let us examine first the arithmetical error. We will designate by T the electric work furnished by the primary machine at the terminals; by t the electric work of the secondary generators, and by c the heat absorbed by the line. The individual return of the secondary generators is, by definition, the relation of the energy, t, which they give to that which they receive from the primary current. Now the energy which they receive is no other than that which is developed at the terminals of the primary machine, minus the caloric energy absorbed by the line, that is to say, $T - c$. The return is therefore expressed thus—

$$\frac{t}{T - c}$$

Now, Dr. Hopkinson does not proceed thus, he takes for the numerator of the fraction which expresses the rendering, the work of the secondary generators (9513 + 1875) augmented by the caloric work of the line (3630), that is to say, $t + c$, and for the denominator he takes, on the contrary, the work, T (16,710 watts) of the primary machine. The rendering thus defined would be equal to

$$\frac{t + c}{T},$$

which we may write

$$\frac{t + c}{T - c + c},$$

It is, therefore, the true expression of the rendering in which we have added the same number, c, to the numerator and denominator. Now, an elementary arithmetical theorem teaches that we increase the value of a fraction when we add the same number to the numerator and to the denominator.

The expression of Dr. Hopkinson is, therefore, always higher than the true rendering, and that in consequence of an error against the principles of arithmetic, the electric methods being accepted without discussion.

Let us see, now, how Dr. Hopkinson calculates the caloric work, c, absorbed by the line. For this he simply measures, by means of the electro-dynamometer, condemned at the beginning of his report, what we may call the intensity of the primary alternating current, he squares this intensity, and then applying Joule's law he multiplies by the resistance of the line, and finds 3,630 watts. Now, this mode of proceeding is inadmissible, since, as said above, it is impossible to draw any conclusion from the indications of the electro-dynamometer when it is applied to alternating currents. In order to be consistent with himself, Dr. Hopkinson ought to have applied to the line the method of M. Joubert.

We will point out, lastly, two important omissions.

duration. On this subject it is best to quote the certificate given by the Commission:—

"The dynamo machines were set in motion for the first time on Sept. 25th, at 7 p.m., and, according to the data of M. Datterer, the engineer appointed by the committee, the receiver placed at Munich revolved at the speed of 1,500 turns per minute, the brake, serving to measure the work, being loaded with 1·5 kilog.

"A series of accidents, due to the fact that the machines were constructed for laboratory experiments and not for practical work, arrested, after eight days, the progress which up to that time had been completely satisfactory. The circles surrounding the ring of one of them broke, consequently the wires of the ring of 0·4 mm. in diameter were damaged, and had to be insulated afresh. In the remote town of Miesbach these repairs were effected with great difficulty, and required, on the part of the assistants of M. Marcel Deprez, much patience and perseverance.

"On Oct. 9th and 10th, when the Commission of Investigation commenced its measurements, the greatest speed attained at Miesbach with the repaired machine was 1,600 revolutions per minute; the results were consequently much less favourable than they had been with the normal velocity of 2,000 revolutions per minute obtained at first.

"During a few moments only it was found possible to reach, during the measurements, the speed of 2,000 revolutions per minute, and quite at the beginning of the experiments one of the brushes of the machine became detached, which produced an extra current and destroyed the machine."

It will be seen from these extracts that the results were obtained under disadvantageous conditions.

They are not, moreover, perfectly exact, especially from the transmission dynamometer at Miesbach having been made for 15 horse-power, was ill adapted for the measurement of small forces.

The results were the following: work received 0·25 horse-power, electric return 38·9 per cent. The mechanical return was not measured, but it is estimated at about 30 per cent.

All this, doubtless, was but a beginning; but it differed so widely from the attempts previously made, that a great outcry was raised. There was a brisk, indeed a violent, discussion on the results, the procedures, and everything which seemed open to attack. However, as was said by M. Cornu in a report to the Institute, to which we shall have to return below:—"The very violence of the polemic which has arisen on this question suffices alone to show that the author, if he has not solved the problem, has at least approached it very closely."

It was impossible to stop on so open a road. Along with these public trials, laboratory experiments were also advancing, and M. Deprez succeeded in deciding on the construction of his permanent machines.

On account of particular circumstances, and of a special application which was projected at this time, it was not proposed to adapt the first machine to a distant transmission, but it was thought desirable to receive a quantity of work of practical importance.

A beginning was made with a single apparatus; prudence demanding that in novel regions we should advance only step by step. The machine was completed about the end of January, 1883; it was tried, at first, in the laboratory, and appeared to answer all expectations, but it was necessary to try it in a more practical manner, and on a real line.

A telegraphic line is not an easy thing to find. It is true one was urgently offered, but it was in Bavaria. As a sequel to the success of the first former experiment, the administration of Munich had urged upon M. Deprez to repeat it with the machines which he subsequently constructed.' He might have accepted this offer, but it implied going to a distance, leaving France, and carrying his performances abroad. This did not please the inventor. Among the French telegraphic lines there are some which the Administration often devotes to experiments. But these are more especially reserved for telegraphy. Besides, it must be said that the Administration had an exaggerated fear of high tensions, and was reluctant to see them upon its lines. M. Deprez addressed himself, therefore, to the Companie du Nord. The engineer of the telegraphic service, M. E. Sartiaux, with great kindness, found a line which it was possible to withdraw from the general service for a few days. The engineers of the depots, MM. Delebecque and Sauvage, found in their work rooms a corner and driving gear; the working service and its engineer, M. J. Sartiaux, took the experiment under their charge, and occupied themselves with the details. In a word, the company showed a good will, for which M. Deprez is exceedingly grateful.

(To be continued.)

Disastrous Fire from an Electric Spark.—A telegram to the *Times* from Philadelphia, on April 4th, states that the steamer *Rebecca Everingham* caught fire on the Chattahoochie River, some 40 miles below Columbus, Georgia, about daylight on the previous morning, her cargo of cotton having been ignited by an electric-light spark. She was run ashore within a few minutes. The passengers had been roused, but some of them had to escape in their night-clothes. Of 30 persons, about 14 were killed and several others injured. The boat and cargo were a total loss.

A TRANSMISSION DYNAMOMETER.*

By Profs. W. E. Ayrton and John Perry.

WE now come to a dynamometer of another character—viz., one for measuring the horse-power transmitted by a shaft to any machine. Much of the vagueness which exists as to the economy in electric lighting has arisen from there not having been any easy mode of measuring the power absorbed by the dynamo machine. In the very complete investigations of Mr. Schwendler, Dr. Hopkinson, and of others, transmission dynamometers were of course employed, but they were laboratory instruments. You do not find such transmission dynamometers fitted up, almost as a matter of course, in all cases between the engine and dynamo-electric machines; and one reason of this is because such transmission dynamometers are separate machines occupying space and liable to a considerable amount of oscillation when in use, requiring therefore the employment of a dash pot to damp the vibrations, &c. Feeling the inconvenience of all strap dynamometers, we have designed for the Guilds Laboratory at Finsbury a form of dynamometer which can be permanently attached to any shaft, and which will show at a glance the force being transmitted to any particular machine—not a dynamometer that is specially fitted up with a certain amount of trouble for some special investigation, but an apparatus that is always ready and always indicating, whether or not it is desired to make any use of its indications. And as there may be others like ourselves who feel the importance of having some such instrument, which shows at a glance to a manager of works the power absorbed by any machine, we have thought you might be interested in seeing the working drawing of the dynamometer now being constructed to transmit 10 horse-power.

B B', Fig. 1, is a loose pulley used to drive, by means of a strap, any machine, such as a dynamo-electric machine. F F' is a boss keyed on the shaft driven by the steam engine: this boss has four stout arms seen in Fig. 3, which are attached by four spiral springs to the rim of the loose pulley. If, then, the shaft be driven, and the motion of the loose pulley be resisted, by its having to drive, say, a dynamo-electric machine, the springs will be stretched, and the amount of such stretching, combined with the speed of rotation, will measure the power transmitted. So far we have been merely following General Morin. Now the question is, How are we to measure the stretching of the springs—that is, the twist the loose pulley and the keyed boss undergo relatively to one another? Such a twist of course produces a tangential motion which we desire to observe without stopping the machinery, and consequently without any system of unrolling paper and moving pencil, such as General Morin employed. We have sketched out various devices, in some of which the tangential motion was transformed into a radial motion, in others into an axial motion—that is, a motion along the shaft. For example, we employed the plan of attaching a cord to the rim of the loose pulley, and passing it over a little wheel on the arm of the keyed boss, its other end being attached to a little spiral spring which again was attached to the shaft. If, then, the loose pulley and keyed boss received a twist relatively to one another, the little spiral spring would obviously be more or less stretched according to the direction in which the twist was made. A bright bead then attached to any point on the radial portion of the cord would describe a larger or smaller visible circle as the shaft spun round, and the radius of such a circle would be a measure of the force transmitted. Another plan we employed was to carry this cord under a second little wheel on the shaft, and attach the end of the cord to a collar moving loosely along the shaft, the little spiral spring which previously was in the radial portion of the cord being now placed along the shaft, and having one of its ends attached to the collar, and the other to the shaft, so as to resist the motion of the collar produced by the pull of the cord. The force transmitted would then be measured by the position of this collar on the shaft. The method, however, shown in the diagram, of converting the tangential motion into a radial one, we consider preferable to the others just alluded to. H C is an arm, which, to combine considerable stiffness with lightness, is trussed in the plane of rotation as well as in a plane at right angles to this, as seen in the upper part of Fig. 3. This arm turns about C, a pivot on the rim of the loose pulley, and is moved by means of a link L L', attached at L by a pivot to the arm, and at L' by a pivot to the end of one spoke of the keyed boss, F F'. If now the loose pulley and the keyed boss receive an angular twist, the end, H, of the harm, to which a bright bead is attached, moves almost radially towards the shaft. The exact path of of the bead H is shown in Fig. 4 for different positions of C. Supposing, for example, we regard the keyed boss at rest, and that C moves to the point marked 1, then L will also move to 1 in the other curve, and H will move to 1 in the path it describes.

To measure, then the power transmitted by the engine to the machine, all that is necessary is to observe on a scale placed in a suitable position, the radius of the circle traced out by the bright bead H, and the number of rotations made per minute, both of which can, of course, be ascertained at any time without stopping the machinery.

An alternative arrangement which we employ with very stiff springs is to have a small pinion at L', which works into a short spur segment on the pulley. A very small relative angular motion of F F' and B B' produces in this case a great angular motion of the pinion, and therefore of a light arm which turns with the pinion, at the end of which there is a bright bead.

It will be observed that this form of transmission dynamometer is not only extremely convenient when the dynamo-electric machine is driven by a strap, but will be especially suitable when the machine is driven direct from the shaft of a fast speed engine, as, for example, one of Messrs. Brotherhood's three-cylinder engines. In such a case the shaft would really be in two portions, end to end, supported by suitable brackets; one keyed boss would be on one portion of the shaft, and an arrangement something like the loose pulley we have referred to would be on the other; but in this case it would, of course, be keyed to its portion of the shaft. Motion would be communicated from one portion of the shaft to the other through the spiral springs, and the extension optically observed in the manner we have described.

FIG. 4.

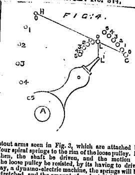


FIG. 1. FIG. 2.

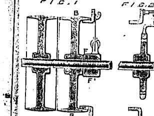


FIG. 3.

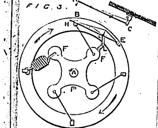


Fig. 1 is section through A B; Fig. 2 section through A C.

* A paper read before the Society of Telegraph Engineers.

64

SEPTEMBER 29, 1883.
'HE DAILY NEWS,

ELECTRIC TRANSMISSION OF POWER AT THE VIENNA EXHIBITION.

Since the invention of the dynamo machine it has been possible to produce electricity much more economically than when we were compelled to use batteries, and the field of its application has been consequently enlarged. But even in the days of batteries there were many men who saw the convenience of using electricity as a motive power. One of the most interesting historical exhibits at Paris in 1881 was the fine series of electric motors designed by Froment. That skilful instrument maker actually worked the lathes in his workshop by electricity nearly 40 years ago. But a great advance has been made since that time. Perhaps the most remarkable fact in connection with the invention of the dynamo machine is that when a current is sent through its coils it becomes a powerful engine, and is the most economical means we possess of converting electricity into mechanical work. The most important installation for the transmission of motive power at this Exhibition is certainly the Electric Railway of Messrs. Siemens and Halske. This firm has now laid down so many of these lines that the conditions of working are fully developed. The current of electricity is generated by two large-sized dynamos. These are of the new type, called compound machines, in which the coils for magnetising the machines are so wound that a large or small quantity of electricity may be taken off for use in the circuit, and the electro-motive force does not vary. It is, perhaps, owing to this arrangement that there is so little sparking to be seen at the brushes of the machine. Those who were at the Paris Exhibition in 1881 will remember that the machines which there drove the tramway sent out showers of sparks whenever the speed of the car varied, and still more so when it started. No such objection can be raised to the present installation. The current is carried from the generators by wires to the rails upon which the cars run. The rails are not such as are used with tramways, but such as are used on railways. They are thoroughly well mounted on sleepers and are quite firm. This is the reason why this experiment is more successful than any which has been made by Messrs. Siemens. The successive rails are connected at the ends by strips of metal soldered to them. But at two level crossings over carriage roads the conductors are carried underground, and the rails are disconnected so as to prevent danger to horses and people. At these points the momentum of the cars carries them across. The difference of potential of the rails is 150 to 200 volts, which is not sufficient to be dangerous. The current is taken up by the wheels of the cars, and so transmitted to the dynamos which rotate under the influence of the current and communicate rotation to the wheels of the car by wire-rope gearing. The speed which is attained on this line is twenty miles an hour, the distance being one mile, and the engines and dynamos for generating the electricity being at one end. Two dynamos are used to generate the electricity, each using up about 25-horse power. The two large tram-cars are propelled together by the current thus generated, and they often carry a freight of nearly 100 persons, there being developed in each of the two motors about 12-horse power. It is pretty clear that when we can carry 100 persons a distance of twenty miles in an hour by an expenditure of five shillings' worth of coal, the problem of electrical railways has reached a practical stage. Close to Vienna, at Mödling, the same firm has just completed an electrical railway with cars something like the one just described, and one of which is exhibited in the Rotunda. It differs from it, however, in two points—the current is conveyed through overhead conductors as it was at Paris in 1881. This is necessary, because the railway goes along the main road. Again, in these cars the rotation of the dynamo is communicated to the wheels by means of toothed wheels. It is the first time that this has been tried. It may interest electricians to know that the line-resistance is 1.17 ohms, the resistance of the generator is 1.5, and that of the motor 2.28; it works with 400 volts and uses 30 to 40 ampères of current. The motor makes 750 turns a minute, going at ten miles an hour. The distance is a mile and three-quarters. There are curves of 3 metres radius and gradients of 1 in 60. On the car additional resistances of 2, 4, 8, 16, 32, 64 ohms can be inserted to diminish the speed, or the circuit may be broken. This same firm have in the Exhibition the plans of a system of metropolitan electric railways proposed for the town of Vienna. It will consist of a series of circuits in the centre of the town, all connected together by an outer circuit. The lines will be partly in tunnels and partly overhead. Within the last week the concession has been granted, and we may feel certain that the work will be done, and well done, by the firm which has already had so much experience in this kind of work. At the present time we have an electrical railway in Ireland. When we think of the successful installations at Lichtenfeld, in the mines of Saxony and La Perronière, at Charlottenburg, and other places, we see that it is time for England to come to the front, and to take the same position with regard to electricity which she has so long held with regard to steam.

The Electrical Power and Storage Company have attracted much attention by their boat and tricycle worked by accumulators. We in England have already seen such things, and no long description is necessary. The boat is driven by 78 cells actuating a dynamo machine, which is directly attached to the propeller shaft. By an ingenious arrangement of four brushes on the machine one pair or the other can be put in action by turning a handle, and so the motion is reversed. A switch is added by which 9 or 18 cells may be taken off to reduce the speed. The boat is said to go at about 12 knots. The tricycle has four cells in two boxes, one before and the other behind the axle. There is a switch to regulate the number of these boxes. We are told that it will run for an hour and a half. The accumulators used are the Faure-Sellon-Volckmar type. In their latest form these consist each of a glass cell containing 12 pairs of plates. Each plate is a foot square and about a quarter of an inch thick. A grating of lead is first cast, having spaces about a quarter of an inch square, which are filled with minium or litharge in the usual way. Here and there one of these holes has a piece of indiarubber instead of the lead salt. This is to keep the plates apart. Each plate has two ears at the top, which hang on the side of the glass cell. One ear is longer than the other. All the positive plates have the long ears on one side, and all the alternate negative plates on the other. The long ears on each side are connected by blocks of lead, through which a rod passes, and they are firmly screwed together by nuts on this rod. These are used for lighting purposes, and are supposed to be able to develop as much power as would result from two horse-power working for an hour. The cells on the boat and tricycle are smaller and of another construction; they are lighter but not so good. It is not too much to say that accumulators are still very far from being perfect. The plates wear out rapidly. They are irregular in their action. Some cells soon become worse than others, and as is well known the efficiency of a series of cells may be measured by that of the worst in the series. The committee of experiments, who by the way are now engaged upon their labours, have ten systems of accumulators to examine. I see no novelty deserving of notice. There is one kind in which the plates are concentric cylinders. The idea is that the expansion and contraction of the plates which takes place in charging and discharging will not tend to disintegrate them. Another one has plates two inches thick, but cast so as to look as if composed of horizontal laminæ. Without wishing to prejudge the question, it looks like an inferior form of Domeriten's accumulator. Another is a plain Planté secondary battery formed as he has always formed them, but I believe without the precautions which he has latterly adopted. Knowing as I did before coming here that the Austrians and South Germans had paid great attention to accumulators, it is a disappointment to see so little that is new or good.

The Gramme Company, which M. la Fontaine presides over, has brought here two gigantic machines of identical construction. Each has 12 field magnets, arranged in a circle, to the ends of which at one side the four pole pieces are attached, and the axis of the gramme ring is central with the ring of field magnets. There are two pairs of brushes. The machine used as a generator uses up 60-horse power. The motor gives off 30-horse power; at least these are the figures which are given. The motor is used to pump water to the top of the water tower, which works a magnificent fountain in the centre of the Rotunda. There are 440 sections on the commutator of each machine. It generates an electro-motive force of 1,200 volts when doing 750 revolutions per minute. The same company exhibit the same form of machine in various sizes.

Messrs. Heilmann Ducommun exhibit the same workshop, with machines driven by electricity, as was shown at Paris in 1881. Other examples of transmission of power are shown by Siemens and Halske, Schuckert, Ganz and Co., and others. Schuckert has an ingenious breech-piece to which the brushes are attached, and which can be reversed in position so as to run the dynamo either as a generator or motor.

In conclusion, there is much here to interest those who study the transmission of power by electricity. There is no great novelty, but everywhere a distinct and marked advance in practice is to be seen since either the Paris or the Munich Exhibition.

Oct. 24, 1883.
The Engineering & Mining Journal

65

THE ELECTRICAL TRANSMISSION OF POWER.—*L'Electricité* gives the following account of M. Marcel Deprez's experiments at Grenoble, which we referred to in a recent note: The generator was placed in the cement-works of Messrs. Damaye & Co., at Vizill-Gare, where a turbine of 80 horse-power is in use. A double silicon bronze wire of ·002 meter diameter was fitted upon ordinary telegraph-poles along the road leading to Champ-Vizille, a third wire of brass serving for telephonic communication. The distance between the market-house at Grenoble and the Damaye works is eight miles 1230 yards. In the market-hall, a small workshop has been set up, in which are an endless band-saw, a circular saw, a printing-press, a Dumont centrifugal pump, etc., all of which are arranged around the receiver. This latter is the same that was used at Munich, but has been repaired. This time, M. Marcel Deprez has endeavored, if not to suppress, at least to greatly diminish, the effects of the distance to be traversed by increasing the electro-motive force, hoping to lessen the dangers of so doing by the insulation of the apparatus. He obtains this result by increasing the length of the wire on the machine, and diminishing its diameter. On the first evening, when the public was admitted by card, it was somewhat disappointed to see only the centrifugal pump at work. This raised 1200 liters of water, and formed a cascade which had a pretty effect. The speed of the generator at Vizille was about 600 revolutions, and it absorbed nearly 14 horse-power. On the Sunday, the committee appointed to make an official report verified the result at Grenoble to be 7 horse-power measured on a Prony brake; and at this time the speed of the generator at Vizille was 1257 revolutions, and it absorbed from 45 to 50 horse-power, which corresponds to a return of 15 per cent.

The Engineering & Mining Journal
Feb. 3rd 1883.

Transmission of Power by Electricity.—A novel application of the electrical transmission of power has lately been made at the Trafalgar collieries, Forest of Dean. The electrical arrangements were carried out by the Pyramid Electric Company, under the supervision of their managing director, Mr. A. Le Neve Foster. In this case, an electric motor is used to drive a pump in the underground workings. The pump is employed for pumping the drainage water from some of the deep workings to the bottom of the shaft, whence the ordinary steam-pumps raise it to the surface. The total vertical lift of the electric pump is 115 feet, while the length of pipes through which the water is forced is some 500 yards. A dynamo-machine is placed on the surface, for generating the current for working the motor, and is connected with it by wires led down the shaft and along the workings, a distance of some 500 yards. Messrs. Brain are satisfied with the result of the undertaking, and propose still further to extend the utilization of electricity as a motive power.

66

THE ENGINEERING AND MINING JOURNAL.

JULY 14, 1883.

THE TRANSMISSION OF POWER BY ELECTRICITY IN MINES.

The exigencies of special circumstances in the use of power in mines are often so peculiar that necessity forces engineers to adopt methods which above ground might be considered unwise. Work in inaccessible localities, danger of fire, inefficiency of ventilation, often make the carriage of steam through long lines of pipe practically impossible, and therefore hydraulic power, and more frequently still, compressed air, have found more frequent applications than above ground. A valuable addition to the number of methods of transmitting power over long distances has, of course, been hailed by mining engineers with much satisfaction, and they were among the first to turn transmission by electricity to account. Some time since, we submitted data gathered by work in a number of French mines, and through the publication of results by B. R. FÖRSTER, manager of the Royal Saxon collieries, we are in a position to add some details as to the experience gathered there.

Herr FÖRSTER has applied the electric transmission of power to two widely different cases. In the one, it was necessary to secure ventilation for the headings in a colliery at Zankeroda. The plant consists of a Dolguruki rotary engine, running at a speed of 800 revolutions, directly coupled to a Siemens & Halske dynamo machine placed at a distance of 367·5 feet from the shaft. The conductor, a copper rod 0·275 inch in diameter, is carried down the shaft to a depth of 850·3 feet, and from there to the fan, 1335·4 feet, a total distance of 2550·2 feet. The second machine, of the same type, mounted in the mine, is connected with the fan by belting, the fan being of the well-known Schiele type, with a 3·2-foot wheel, capable, according to the statements of the builders, of furnishing, at a speed of 500 revolutions, 6363 cubic feet of air at a pressure of 0·79 inch, and at an expenditure of power of 1½ horse-power. A series of tests were conducted above ground, with the whole plant complete, but with a length of conductor of only 160 feet. It was found that the engine delivered to the dynamo-electric machine producing the current 2·56 horse-power, of which 1·4 horse-power was converted into work in the receiving dynamo-electric machine, thus showing an efficiency, with a circuit of 160 feet, of 54·3 per cent. The dynamo was then running at a speed of 481 revolutions, which was reduced to 448 revolutions when the plant was in full operation, so that the efficiency of the transmission was reduced by 3·9 per cent in addition, thus carrying it down to very nearly 50 per cent. The fan, when the driving dynamo was running at 800 revolutions, was making 361 revolutions per minute, delivering 7000 cubic feet into the air. The cost of the entire plant was low, and it is reported to have worked efficiently for many months since its construction.

The second case of a successful application of the transmission of power by electricity is quoted by Herr FÖRSTER, who arranged the electric railroad in one of the main cross-cuts of the Oppel colliery at Zankeroda. The cross-cut is 2362 feet long, and is the outlet for the coal mined in the vein, the quantity delivered to it being 600 mine cars per day of 16 hours, each car containing 1047 pounds of coal, and weighing loaded 1594 pounds. We can not enter into details of the construction of the plant. It resembles in many points the design generally adopted by SIEMENS. In practice, a train of fifteen cars is moved at a speed of from 7·4 to 9·8 feet a second, the steam-engine at the mouth of the shaft making from 225 to 250 revolutions during the run, lasting from 3¼ to 4¼ minutes, through the 2034 feet of cross-cut. When the steam-engine was doing this amount of work, it delivered, according to brake trials made, 11·2 horse-power. The locomotive was at the same time developing 4·18 horse-power, or, assuming the friction of the gearing of the locomotive to have occasioned a loss of 25 per cent, the power actually transmitted by the electric current to the locomotive was 5·22 horse-power, or 46·6 per cent. The consumption of steam, with a pressure of 65 pounds, is estimated at 45·6 cubic feet per round trip of 15 cars. Herr FÖRSTER gives a statement of cost in which he shows that, making an allowance of 15 per cent of the cost of plant annually for wear and tear and sinking fund, it costs per car of coal hauled 3·01 pfennige with the electric road, 3·71 pfennige with horses, and 6·2 with men, when hauling 660 cars per day. When the capacity is increased to 800 cars per day, the cost for the electric road is reduced to 2·70 pfennige, while the others are not sensibly affected.

These two examples, we believe, furnish ample proof of the fact that there are probably many cases in which the transmission of power by electricity would pay well, notwithstanding the fact that the loss may be roughly placed at 50 per cent for moderate distances. This is particularly so where fuel is cheap, or where high heads of water are available, as in many of our mining districts, so that turbines running at a high speed can be used to drive the dynamo machines. There is only one point in connection with the electric railroad which needs attention. It seems difficult and dangerous to stop the trains suddenly, so that the engineer has not that absolute control over the locomotive which is desirable, even in underground roads.

M. Desprez has lately attacked the problem of transmitting, by means of an electric current, the motion of a motor A to a receiver at some distance B, as a rigid axis between the two would do, so that the angular velocity of B should be always equal in amount and sign to that of A. (The particular case was that of getting within a railway carriage a rotation identical with that of the motor wheels of the locomotive.) On the shaft of the transmitter A are fixed two commutators, each of which reverses the current that traverses it twice each turn; but the positions of the shaft corresponding to these inversions do not coincide; they follow each other at intervals of a quarter of a turn. The receiver consists of a permanent magnet or electro-magnet, between the branches of which are two straight electro-magnets, capable of rotating round an axis which coincides with that of the magnet. The currents sent through these electro-magnets from the shaft A produce the desired effect. This apparatus (it is noted) effects the transmission of work of a motor from one point to another *with conservation of the angular velocity* (which has not been realized in any electric motor hitherto used), the latter varying from 0 to 2,400 turns per minute. The alternating currents required may be generated by a magneto-electric machine. Again, any motion may be considered as the resultant of two movements of rotation; hence this apparatus, with a simple mechanism added, would serve for transmission of a motion of drawing, or writing.

67

IRON

MARCH 21, 1884.

THE TRANSPORT OF GOODS BY ELECTRICITY.—Professor Fleeming Jenkin, of Edinburgh, delivered a lecture on "Telpherage, or the Automatic Transport of Goods by Electrical Means," before the Glasgow Science Lectures Association on March 6. The chairman (Sir William Thomson), in introducing the lecturer, said that Professor Jenkin proposed to apply electricity in an altogether novel way, and one which was most interesting to this society. The professor had long been interested in engineering subjects, and his latest idea was to show how goods, parcels, and possibly passengers, were to be carried overhead through the same power as that which had done so much under the sea in the shape of the submarine cable. Professor Jenkin, at the commencement of his lecture, explained the origin of the word "telpherage," and said that it was derived from two Greek roots, and meant the "far carrying." It was the old story of a person hanging a pair of boots on a telegraph wire and expecting that they would be sent to a distant friend that had set him thinking about the possibility of really carrying the idea into practical use. By means of a model railway, built upon the platform on raised supports, wires stretched from point to point taking the place of fixed rails, he proceeded to explain the system upon which he would carry out his invention on a larger scale. Two model trains were set in motion and successfully made a round of the circular railway, the motors working admirably. The professor then explained the system under which the motors worked, and how the electricity was utilised in carrying along the load put on the suspended wire railway. In working out this idea he had simply made use of the perfectly well-ascertained electric laws which had been developed chiefly in connection with electric lighting. Some ten years ago, had this idea occurred to him he should have put it entirely to one side, as at that time there was too much to be done in respect to electricity to make it practicable. But one thing led to another, and electric lighting had developed dynamos to such an extent that sufficient power had been attained to use it as a motor, and it was the great development of that power which had led him to make the experiments the results of which he was about to explain. He then gave a description of the "line," and referred to the difficulties he had experienced in getting up a proper kind of "locomotive." He had aimed at conquering gradients that no steam locomotive could look at. It was necessary to avoid in electric locomotives all loss of power by friction. It took curves easily, and without any kind of friction whatever, and there was hardly any possibility of the trucks being thrown off the line. A model train was next run along a model railway terminating in a series of octagon circles, and the trucks took the curves freely and without a hitch. He now came to the economical question, to see how far from being a mere toy the idea could be developed into a practical working machine able to do the work required by the manufacturers of the country. The lines were not intended to compete with the railways, but rather to act as feeders to them by collecting goods throughout districts, carrying them to the stations, where they would be put into the trucks. This would have a great influence upon the railway traffic. The class of line he would put up with posts and rods ought not to cost more than £500 per mile. For engine-power for a 25 mile line he would put down £1,500 per annum. In concluding, Professor Jenkin said he did not propose to touch upon all the matters connected with the possible development of his scheme. He would simply leave his hearers with the impression that the whole contrivance was what he might simply call an electric horse and cart. Mr. Renny-Watson, in proposing a vote of thanks to the lecturer, said that the system was one that he hoped to see applied to the underground railways, and so do away with the smoke nuisance that troubled passengers by these lines.

Iron – Feb. 3, 1882

where a dividing box was placed, into which they were fixed. From this box five pairs of wires were conveyed, one pair to a circuit of six Edison lights, and others to dividing boxes, whence wires led to other smaller or larger circuits of similar lights. Whether there were one or two or five or six lights on the circuit, the light was the same. It will be seen from the above that the invention is simple, and that it is one of a very common-sense character, and that our previous statements were fully borne out by the experiments just witnessed. To say the least of it, Mr. Rogers' plan no doubt solves some of the greatest difficulties in the way of the general adoption of electric lighting, especially for domestic purposes, and at the same time leads to greater economy in its use. Moreover, though his system of division is entirely different from that of any other system, yet every system of electric lighting may be adaped to it.

by dividing boxes, which are reservoirs of electricity, and from these reservoirs the divisions of the current are drawn as the electricity is required. The divider consists of two or more copper spheres, one placed inside the other, which receive and distribute the electric current by means of wires arranged for the purpose. It appears probable that these spheres, from their construction, may to some

THE TRANSMISSION OF POWER BY ELECTRICITY.

ALTHOUGH a great deal has been talked and written about the transmission of power by electricity, very little has been done beyond a few desultory experiments. There is Sir W. Armstrong's installation of the electric light at his seat in Northumberland, the Siemens, and other electric railways, M. Menier's experiment in ploughing at Sermaize, and sundry other applications on the small scale; but no one has yet come forward with any definite proposition to utilise the Falls of Niagara or to seize upon the enormous water power running to waste in the gorge of the Severn, which latter we have been assured would be sufficient to supply all the factories in England. The subject has been fairly placed before capitalists by Sir W. Thomson, Sir W. Armstrong, Prof. S. P. Thompson, and others in this country, and includes a proposal to transmit the energy of coal to the metropolis and elsewhere by wire instead of forwarding the coals themselves by railway. There seems to be no doubt in the minds of those who suggested the transmission of power by electricity that 50 per cent. of the energy expended at the source of the power could be delivered at long distances, and it will therefore follow that even in the case of coal, if it is consumed at the pit's mouth, the power can be transmitted in the shape of electricity with economy. In the cases of water and wind, sources of energy which cost nothing first hand, there is only the interest on the sum expended in machinery necessary to utilise them to reckon as the prime cost of the motive power, and if that machinery can be constructed in an inexpensive manner, it is time that some experiments on a large scale were made. If it is possible to utilise the tidal flow of the Severn, Bristol could easily find a use for a portion of the electrically transmitted power, and both Birmingham and London are not so far off that the cost of the leading wires would prevent the use of energy so cheaply obtained. At any rate, assuming that the machines worked by the water of the Severn were placed somewhere in the neighbourhood of Avonmouth, the cost of copper rods to lead the current to Bristol would not be very heavy, and there are a sufficient number of factories and workshops in that city and its environs to fairly test the question on the large scale. It is not impossible that capitalists and others who might be inclined to take the matter in hand are waiting to see how Mr. Edison succeeds in his attempt to supply a whole district in New York with current for both power and light. His main leads are stout copper rods of about half-moon section, carefully cemented into iron tubes with an insulating material, and it is obvious that much of the success of the installation will depend upon the behaviour of the latter, for leakage of current would very seriously increase the cost, and if excessive would practically render the system inefficient. If any difficulty is experienced in keeping up the insulation where the leads are laid beneath the footwalks of cities, it is tolerably obvious that it will not be easy to keep the "wires" in proper electrical condition when they stretch over many miles of country. In his recent address, as President of the British Association, Dr. Siemens took 50 per cent. as a safe estimate of the amount of energy that could be transmitted by electrical means; and he pointed out that as large steam-engines work on a consumption of 2lb. of coal per horse-power, whereas small ones use 5lb., there is an economy which, with other advantages, balances the loss of energy in the electric system. As a matter of fact, calculations show that between producing the current in one machine and reconverting it into mechanical effect by means of another, the loss should not be more than 20 per cent., and some carefully-conducted experiments made at the Stevens Institute of Technology, Hoboken, N.J., give a smaller loss than that. These experiments were made by G. and W. E. Gibbs, and form a thesis, an abstract of which we find in *Van Nostrand's Magazine*. The machines used were of Weston's latest pattern, the generator being a "fifty light incandescent machine," and the motor a "forty light" of the same construction—viz., the "derived field" type, the field-magnets being wound with comparatively fine wire, so that their resistance was about 800 times the resistance of the armature. The dynamometer used for measuring the power transmitted by the engine to the generating dynamo was one of the Kent type, built at the Stevens Institute, and was carefully standardised for the purpose of these experiments. The bearings of the armature were "assumed" to absorb 2·5 per cent. in friction, as no suitable apparatus were available for determining it experimentally; but there is no reason for thinking it more, while it is probable that it was less. In testing the efficiency of the generator, the current was carried by iron wire resistances running across the room from side to side in the open air, so that the heat was rapidly conducted away. A switch was so arranged that the generator could be instantly thrown out of circuit, and the resistance of the line measured within five seconds by a Thomson high-resistance galvanometer. In determining the electrical energy developed by this method a calorimeter was used in circuit with the iron wire resistance. The actual figures show that the energy applied to revolve the armature was 112,446 foot-pounds per minute, and the total electrical energy developed in the circuit, 108,446·28 foot-pounds, so that the efficiency of the generator was ·963; that is, 96·3 per cent. of the power applied to the armature appeared in the circuit and magnet-coils. Deducting the electrical energy consumed in the field-circuit and the internal work, the machine gave a commercial efficiency of ·866, or 86·6 per cent. of the energy actually applied to the armature pulley. Tests by measurement of the E.M.F. and R. gave efficiency as ·975 and commercial efficiency as ·861. In determining the efficiency of the motor as a machine for converting electrical energy into mechanical, the two were connected by heavy copper rods so as to reduce the loss of energy in the line to a minimum. A Prony brake was applied to the pulley of the motor, and the pressure of its arm on a platform scale gave the measurements directly. The brake was kept cool by a stream of water, so that runs of any desired length of time could be made. The machines used were, however, so large that they could not be worked up to their full capacity with the appliances at hand, but the results obtained are interesting and trustworthy. A number of trials, made at various speeds, showed that the motor was well adapted to act as a machine for converting electrical energy into mechanical power; but the combination of the generator and the motor was not altogether satisfactory, the highest efficiency being ·587. The generator in this case absorbed 197,200 foot-pounds of energy, and the motor did 115,866 foot-pounds of work. The loads, and the difference of speed of the two machines, were varied by means of the brake, the generator being kept at one steady rate during thirteen experiments, but the best result was that given above. The authors of the thesis, referring to the low percentage of the efficiency when the generator and motor are coupled, point out that the cause is obvious. By one of the fundamental laws of electricity the work done in any portion of an electric circuit is directly proportional to its resistance; and in the case of the two machines upon which they experimented the resistance of each was very low and equal when coupled, while that of the line was practically *nil*. Under these conditions nearly half the work must necessarily be done in the generator; but in order to increase the efficiency of the combination, more work proportionately must be done in the motor and less in the generator. In the case of a single motor they propose to reduce the resistance of the generator armature, and raise that of the armature of the motor, so as to cause nearly all the work to be done in the motor. If several motors were supplied with current from a single generator they propose to arrange them in multiple arc, so that when coupled up the total resistance would be the same as that of a single motor doing the combined work of all. If the proper ratio of resistance is determined by experiment, the authors think there is no reason why the continued efficiency should fall short of 80 per cent. If such a result as that can be obtained at, say, 50 miles from the prime mover, there is hope for the general adoption of transmission of power by electricity; but at present nothing of the kind has been done, the extreme limit of any experimental transmission being well within 10 miles.

disc also carries at its centre a cone projecting upwards and entering the mouth of the pipe leading to the burner. The gas enters the bottom of the collapsible vessel from which it can issue into the casing through the hole or holes in the disc, and from the casing it passes to the burners. According as the pressure of the gas is greater or less the collapsible vessel becomes more or less distended so that the cone on its disc throttles more or less the passage leading to the burners.

The sectional figure annexed shows the general construction of the burner. A is the gas chamber connected direct to the supply, and rising from it are the three concentric rings of tubes B. Surrounding the outermost ring is a casing C fixed to the chamber A, but having around its lower part a number of slots through which the air enters freely. The second ring of tubes is surrounded at their upper parts only by another casing N which terminates at the top of the tubes in a notched air deflector. A third casing T serves as a gallery to support the chimney and to admit a further supply of air for cooling the glass. A notched air deflector E is carried on a central stem and is fixed a short distance above the tops of the inner ring of tubes. The tubes are so graduated in size that the inner give the shortest flames, the object being to insure the termination of all the flames at about the same level. The air entering through the openings in the lower part of casing C passes between the tubes of the several rings and rises up in a more or less uniformly distributed manner, as does also that entering the lower ends of the casing N and being caused by the several notched deflectors to impinge in divided streams upon the ignited gas jets issuing from the tubes, produces an intensely luminous flame. All the metal parts of the burner are in solid connection with each other, so as to prevent the injurious overheating of certain parts, by causing the heat to be more or less uniformly distributed by perfect conduction, which heat is then in great measure taken up by the entering air, thereby also increasing the luminosity of the flame. In consequence of the good conduction of the heat from all parts of the burner, the use of porcelain or steatite for the mouths of the burners can be dispensed with, but the central deflector E is by preference made of porcelain in order to act as a reflecting surface for the light. The heat conducting powers of the metal gas tubes B and the comparatively large issue orifices effectually prevent the deposit of solid carbon within the tubes, and as the air becomes heated by contact with the external surfaces of these, an upward draught is produced whereby a comparatively short glass chimney is rendered applicable.

PERRY'S METHOD OF DISTRIBUTING ELECTRICAL ENERGY.

A METHOD of distributing electrical energy has, together with the apparatus necessary for carrying it out, been recently patented by Mr. John Perry, the professor of mechanical engineering at the Finsbury College of the City and Guilds Institute. In any scheme for distributing electrical energy, it is of the first importance to so arrange the wires, &c., that any consumer may use the current for the purpose of illumination, or for motive power, just as he pleases, without being interfered with in any way by the fact that other consumers have turned off their lights or turned on their machines. Various methods have been suggested for effecting the constant and unvarying distribution of electricity; but the method preferred by Prof. Perry consists in combining with the dynamo-machine, one or more magneto-electric machines or other form of electrical machine or battery which will produce in a circuit an electromotive force which is constant and independent of any other electromotive forces in the same circuit. First: When the consumers' wires are arranged in parallel arc, it is usual to employ a "series" dynamo, and in that case is introduced into the main circuit a magneto-electric machine or battery producing a constant electromotive force equal to the electromotive force which ought to exist between the supply cable of any consumer and the return cable or earth. The dynamo-machines ought to get constant speeds, being driven by engines with good governors, and these speeds ought to be what have been termed the critical speeds. That is, the speed of each dynamo-machine ought to be such that the electromotive force created in it by its motion ought to be proportional to the current circulating in the coils of its field-magnets. In scientific language the intensity of the magnetic field in which the armature rotates ought to be proportional to the magnetising current. It is evident that one large dynamo-machine is preferable to two or more smaller ones in such a case, and it will be better to employ larger field-magnets than are usual in dynamo-machines; but to use the dynamo-machines at present in use will not introduce much discrepancy from the conditions required. As an example, if there is only one dynamo-machine, and if the resistance of the main cable, return cable, and machines, in fact of that part of the total circuit which is supposed to be constant be, let us suppose, 3 ohms, then we find that the dynamo-machine ought to be run at such a speed that the electromotive force in volts produced in its moving parts is three times the current in ampères which flows through the field-magnets; consequently, this speed can readily be found by experiment. Suppose the constant electromotive force of the magneto-machine to be 50 volts; its resistance 0·3 ohm, and the resistance of the dynamo-machine and of the other unchanging parts of the circuit 2·7 ohms, and suppose that the speed is that at which the electromotive force produced by the rotating armature of the dynamo is 3 times the current. Now let there be a consumer's resistance of 2 ohms, the total resistance is 5 ohms. Evidently the electromotive force produced in the dynamo is 75 volts, and the total electromotive force in the circuit is, therefore, 125 volts, and, as the total resistance is 5 ohms, the current is 25 ampères, giving an electromotive force of 50 volts between the ends of the consumers' part of the circuit. Now if the consumers' resistance increases to, say, 12 ohms by some of the consumers ceasing to use their circuits, there is an instantaneous alteration of the electromotive force produced in the dynamo to 12½ volts or 62½ volts in the whole circuit, and 62½ divided by 15 gives 4 1-6th ampères; and this means 4 1-6th multiplied by 12 or 50 volts as before between the end of the consumers' part of the circuit. Instead of using the dynamo-machine of the ordinary type, that is with its field-magnets forming part of the main circuit, it is sometimes used in the form where the field-magnets act as a shunt. When using a dynamo-machine of the shunted field-magnet type, it is preferred to place the magneto-machine or other source of constant electromotive force in a part of the circuit which is quite outside the machine; that is in the main circuit, so that the current passing through it is that which goes to the supply cable. The speed may be determined, which will produce the desired result. Second: So far, we have considered the lamps or machines which are supplied with electricity to be "in parallel arc"; when, however, the lamps or machines to which electricity is given are "in series,"—that is when the same current is to go through them all, what we effect is that they shall all receive the same current of electricity, however the resistance of one or more of them may vary. This is attained by using, instead of an ordinary "series" dynamo-electric machine—one or more dynamo-machines constructed so that their field-magnets are a shunt between their brushes, or the binding screws connected with their brushes, combined with one or more magneto electric machines or some other form of electrical machine or battery which will produce an independent electromotive force. For simplicity, take the case of one dynamo-machine and one magneto-machine. Let the shunt part of the dynamo be called M, whether it contains merely the wire of its own magnets, or has the magneto-machine inserted in it. Let the part of the dynamo which contains the wire of the revolving armature be called A, and let us be able to insert a magneto-machine in this portion of the circuit if we please. Now the two ends of A and the two ends of M are the same, and these may be called the binding screws of the machine. If these binding screws are joined to the two ends of any external wire or cable or system of lamps in series, which we may call the external circuit being really the part of the whole circuit which is external to the machine, then if we introduce a magneto-electric machine in the part A or in the part M, or if we have a magneto-machine in A and another in M we can, by giving a certain constant speed to the machine, deliver a constant current of electricity through the external circuit, however the resistance of that circuit may vary. The constant current we find to be that which the magneto-machine or machines would produce in a circuit whose total resistance is equal to the resistance of A. Thus if a magneto-machine or other constant source of electromotive force producing a constant electromotive force of 100 volts is inserted in A, and if its internal resistance is 0·3 ohm, and if another magneto-machine whose constant electromotive force is 160 volts and internal resistance is 2 ohms be inserted in M, and if the resistance of the revolving part of the dynamo (from brush to brush if it were working in the ordinary way) be 0·5 ohm, then when joined up to an external circuit in the manner described, and run at constant speed, the current in the external circuit will be the sum of 100 and 160 divided by the sum of 0·5 and 0·3, or 325 ampères, or else it will be the difference of 100 and 160 divided by the sum of 0·5 and 0·3, or 75 ampères; the latter case being one in which the magneto-machines oppose each others' actions. But in either case the current in the external circuit will not alter although its resistance be altered. The constant speed at which the Dynamo-machine should be run may be determined by experiment and calculation. The speed should be such that the electromotive force produced in the armature by rotation is equal to the current in M which includes the field-magnets multiplied into the sum of the resistances of A and of M. It is possible by running even an ordinary Gramme machine at lower speeds than usual to get the electromotive force produced in the armature to be proportional to the current in the field-magnets. As to the distribution of electrical power to persons who consume it in parallel arc, and distribution of electrical power to lamps or machines which are joined up in series in one circuit, the dynamo-machine must be run at a constant speed. Suppose it is found by calculation that it is necessary to run a dynamo-machine at such a speed that the electromotive force in volts produced in the revolving armature is equal to the ampères of current passing in the field-magnets multiplied into 2 ohms. Make an experiment letting a current of 20 ampères pass through your field-magnets, and let them be disconnected from the armature circuit. Revolve your armature at a speed of, say, 200 revolutions per minute, and let us suppose that you find that an electromotive force of 100 volts is produced by the rotation. If the machine is a suitable one for your purpose, so that the proportionality of electromotive force to the product of field-magnet current and number of revolutions holds, then the constant speed required is 2 multiplied by 200 and by 20, and divided by 100, or 80 revolutions per minute. In the process of electroplating, we have exactly the same conditions as there are in the distribution of electrical power when the consumers' connections are in parallel arc; that is, in an electroplating bath there ought to be maintained a constant difference of electrical potentials between the two sides of the bath however few or many objects may be undergoing the electroplating process. Instead, therefore, of employing a single dynamo-machine, which is the common plan at present, Prof. Perry employs in the circuit one or more magneto electric or other electrical machines or batteries, which will produce a constant independent electromotive force, as well as one or more dynamo-machines. In the process of charging accumulators the current that should pass through each cell depends on the size and weight of the accumulator, but not at all on the number of accumulators to be charged. When it is desired to vary at will the number of accumulators to be charged, we arrange them partly in series and partly in parallel circuit, and use either the first or second system of supplying constant electric energy to each accumulator. With the first arrangement, when it is desired to increase or diminish the number of accumulators charging, we increase or diminish the number in parallel circuit, leaving the total number in series unaltered. On the other hand, when the second arrangement for supplying constant electric energy to each accumulator is employed, and it is desired to increase or diminish the number of charging, we increase or diminish

70

A TRANSMISSION DYNAMOMETER.*

By Profs. W. E. Ayrton and John Perry.

WE now come to a dynamometer of another character—viz., one for measuring the horse-power transmitted by a shaft to any machine. Much of the vagueness which exists as to the economy in electric lighting has arisen from there not having been any easy mode of measuring the power absorbed by the dynamo machine. In the very complete investigations of Mr. Schwendler, Dr. Hopkinson, and of others, transmission dynamometers were of course employed, but they were laboratory instruments. You do not find such transmission dynamometers fitted up, almost as a matter of course, in all cases between the engine and dynamo-electric machines; and one reason of this is because such transmission dynamometers are separate machines occupying space and liable to a considerable amount of oscillation when in use, requiring therefore the employment of a dash pot to damp the vibrations, &c. Feeling the inconvenience of all strap dynamometers, we have designed for the Guilds Laboratory at Finsbury a form of dynamometers which can be permanently attached to any shaft, and which will show at a glance the force being transmitted to any particular machine—not a dynamometer that is specially fitted up with a certain amount of trouble for some special investigation, but an apparatus that is always ready and always indicating, whether or not it is desired to make any use of its indications. And as there may be others like ourselves who feel the importance of having some such instrument, which shows at a glance to a manager of works the power absorbed by any machine, we have thought you might be interested in seeing the working drawing of the dynamometer now being constructed to transmit 10 horse-power.

B B', Fig. 1, is a loose pulley used to drive, by means of a strap, any machine, such as a dynamo-electric machine. F F' is a boss keyed on the shaft driven by the steam engine: this boss has four stout arms seen in Fig. 3, which are attached by four spiral springs to the rim of the loose pulley. If, then, the shaft be driven, and the motion of the loose pulley be resisted, by its having to drive, say, a dynamo-electric machine, the springs will be stretched, and the amount of such stretching, combined with the speed of rotation, will measure the power transmitted. So far we have been merely following General Morin. Now the question is, How are we to measure the stretching of the springs—that is, the twist the loose pulley and the keyed boss undergo relatively to one another? Such a twist of course produces a tangential motion which we desire to observe without stopping the machinery, and consequently without any system of unrolling paper and moving pencil, such as General Morin employed. We have sketched out various devices, in some of which the tangential motion was transformed into a radial motion, in others into an axial motion—that is, a motion along the shaft. For example, we employed the plan of attaching a cord to the rim of the loose pulley, and passing it over a little wheel on the arm of the keyed boss, its other end being attached to a little spiral spring which again was attached to the shaft. If, then, the loose pulley and keyed boss received a twist relatively to one another, the little spiral spring would obviously be more or less stretched according to the direction in which the twist was made. A bright bead then attached to any point on the radial portion of the cord would describe a larger or smaller visible circle as the shaft spun round, and the radius of such a circle would be a measure of the force transmitted. Another plan we employed was to carry this cord under a second little wheel on the shaft, and attach the end of the cord to a collar moving loosely along the shaft, the little spiral spring which previously was in the radial portion of the cord being now placed along the shaft, and having one of its ends attached to the collar, and the other to the shaft, so as to resist the motion of the collar produced by the pull of the cord. The force transmitted would then be measured by the position of this collar on the shaft. The method, however, shown in the diagram, of converting the tangential motion into a radial one, we consider preferable to the others just alluded to. H C is an arm, which, to combine considerable stiffness with lightness, is trussed in the plane of rotation as well as in a plane at right angles to this, as seen in the upper part of Fig. 3. This arm turns about C, a pivot on the rim of the loose pulley, and is moved by means of a link L L', attached at L by a pivot to the arm, and at L' by a pivot to the end of one spoke of the keyed boss, F F'. If now the loose pulley and the keyed boss receive an angular twist, the end, H, of the harm, to which a bright bead is attached, moves almost radially towards the shaft. The exact path of of the bead H is shown in Fig. 4 for different positions of C. Supposing, for example, we regard the keyed boss at rest, and that C moves to the point marked 1, then L will also move to 1 in the other curve, and H will move to 1 in the path it describes.

To measure, then the power transmitted by the engine to the machine, all that is necessary is to observe on a scale placed in a suitable position, the radius of the circle traced out by the bright bead H, and the number of rotations made per minute, both of which can, of course, be ascertained at any time without stopping the machinery.

An alternative arrangement which we employ with very stiff springs is to have a small pinion at L', which works into a short spur segment on the pulley. A very small relative angular motion of F F' and B B' produces in this case a great angular motion of the pinion, and therefore of a light arm which turns with the pinion, at the end of which there is a bright bead.

It will be observed that this form of transmission dynamometer is not only extremely convenient when the dynamo-electric machine is driven by a strap, but will be especially suitable when the machine is driven direct from the shaft of a fast speed engine, as, for example, one of Messrs. Brotherhood's three-cylinder engines. In such a case the shaft would really be in two portions, end to end, supported by suitable brackets; one keyed boss would be on one portion of the shaft, and an arrangement something like the loose pulley we have referred to would be on the other; but in this case it would, of course, be keyed to its portion of the shaft. Motion would be communicated from one portion of the shaft to the other through the spiral springs, and the extension optically observed in the manner we have described.

FIG. 1

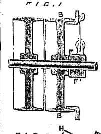


FIG. 2

FIG. 3

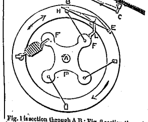
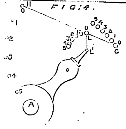


Fig. 1 is section through A B; Fig. 2 section through A C.

FIG. 4



* A paper read before the Society of Telegraph Engineers.

71

The English Mechanic

AND

WORLD OF SCIENCE AND ART.

FRIDAY, APRIL 1, 1881.

ARTICLES.

THE FUTURE OF ELECTRICITY.

THERE are few persons, acquainted with the recent progress of electricity, who are not prepared to agree with the opinion that the latter portion of the 19th century will be an era of a great and wonderful development of that form of energy which our immediate predecessors regarded as somewhat mysterious, and which we still regard as something rather inexplicable. An ingenious lecturer can make suggestions and prognostications as to the future applications of electricity, and we are ready to accept all that he says, for the simple reason that advance has lately been so rapid that we do not know how far we can go. The recent development of electricity in its applications to useful purposes has unquestionably been swift; but it should not be forgotten that many years of toil in the laboratory have been necessary before the knowledge we now possess was available to the masses. It is worthy of note that the labours, the fruits of which we are now beginning to reap, were carried on without that peculiar endowment of research for which there is in certain quarters so loud a demand at the present time. It is true that, by an abuse of terms, we may say that Faraday was endowed because he received a salary for holding an honourable situation to which certain duties were attached; but the endowment of research now demanded is a very different thing altogether, and is nothing less than the expenditure of public money in maintenance of people who call themselves scientific investigators, as distinguished from scientific professors who hold legitimate positions at our universities and colleges. In a paper read last week before the Society of Arts, by Prof. John Perry, the author said that it was for the good of the nation to provide scientific men with large laboratories, and acknowledged that he had prepared an hour's lecture, dealing with the subject of endowment of research; but, happily, he remembered that the members of the Society were acquainted with the truisms, and so he left it out, and proceeded with the subject proper, "the future development of electrical appliances." Passing over the first half of Prof. Perry's paper, which dealt with rather elementary points of the subject, we come to parts which contain statements of more or less importance to the future developments of electricity, points which require no "endowment of research" to explain. Thus Prof. Perry tells us that the true solution of the problem of electrical transmission of power was first given by Prof. Ayrton in his lecture before the British Association at Sheffield, in which he "showed" that the whole power of the falls of Niagara might be transmitted by a fine copper wire, if it could only be sufficiently well insulated. That Edison, Maxim, or Sawyer has not yet succeeded in transmitting the power of that gigantic waterfall to New York is, therefore, probably due to the difficulty of obtaining sufficiently good insulation. According to the laws enunciated by Profs. Perry and Ayrton, the power wasted is proportional to the square of the current flowing, whereas the power utilised is proportional to the current, and also to the electromotive force of the motor; hence, they argue that for the future development of the transmission and distribution of electric energy it will be necessary to use machines of great electromotive force, and they think that there is a future in this direction for the employment of such plate machines as that of Holtz. The electro-motive force of an electric machine may be increased, says Prof. Perry, by increased speed, by increased strength of magnetic fields, and by increasing the length of wire on the moving armature; and of these methods the first is the most important. He has discovered that if iron is used for the armature, its coercitive force prevents the magnetisation and demagnetisation being so complete at high speeds as at the ordinary speeds of the present day. The electric machines of the future will, he is convinced, be without iron in their movable parts; but, unfortunately, he does not say what is to take its place. The lifting-power produced in an electro-magnet is simply proportional to the heat produced in the wire on the magnet, and if it is our object to diminish this heat, we must discard all idea of working the magnets of electric machines by their own currents, and, according to Prof. Perry, use the smaller dynamo-machines with which we are familiar to feed the magnets of larger machines. His alternative is to fall back on magneto-electric machines. With such machines as he suggests—for we believe they are not yet constructed—he declares it would be possible to heat, light, and ventilate all the houses in New York, and to give to large and small workshops the power required to drive their machinery, by means of an ordinary telegraph-wire transmitting energy from as great a distance as the Falls of Niagara. There is one condition, that the method of insulation shall be exceptionally good, and that, we surmise, has not yet been discovered. However, this distribution of power from a single centre is, we are assured, a something to be looked forward to with perfect certainty in the future of electricity; and, assuredly, in this case, the larger will include the lesser. An electric railway has been a practical fact for some time; but if we may believe Professor Perry, the introduction of electric railways everywhere is merely a question of time. The electrician sees better insulation of the conductor and application of the principles utilised by Dr. Siemens to hundreds of miles of rails, instead of a thousand yards; he sees, in fact, that the larger the experiment the greater must be its success. There will not only be no vitiation of the air in underground lines, but the wear and tear of permanent way may become less than one quarter of what it is at present; for instead of heavy locomotives, each carriage will have its own driving and braking machinery, and the energy expended in stopping will not be wasted as now, but will be returned to the generator. Speaking of improvements which might be easily made, Prof. Perry referred to Mr. Schwendler's use of a dynamo-machine for furnishing the current needed for working telegraph circuits in India, and declared that it was absurd to fill houses with thousands of sloppy voltaic cells in order to work the telegraph lines. If we have not misunderstood Prof. Perry, he implies that our Post-Office authorities, in the experiments they made in this connection, blundered by using a machine far too small, and, of course, it failed. If that is so, the sooner the electricians at St. Martin's-le-Grand take a leaf from Mr. Schwendler's book the better.

Another point touched upon by Prof. Perry was the question of storing energy, and with the aid of a Leyden jar he had no difficulty in showing that it could be done in small quantity and for a short time. A thermopile had been working for nearly an hour, and had filled two test-tubes with oxygen and hydrogen respectively, which Prof. Perry said could be kept stored up for as long as was required. A windmill working a magneto-electric machine might be employed to produce a store of the two gases, which will yield up the energy again in the form of light and heat, or will reconvert it into electricity. Tidal power might also be utilised as well as that of the wind; but there are many little difficulties to be surmounted which in a popular lecture cannot be mentioned. Profs. Perry and Ayrton have recently made some experiments in the laboratory of University College which seem to them to promise great results. Zinc may be burnt in a Voltaic cell with almost perfect economy—that is, with the minimum of loss of the energy it is capable of producing; and it occurred to the experimenters that coal-gas also might be so burnt. The experiment, as shown at the Society of Arts, consisted in what may be termed the cold-burning of the gas, in which the energy is given out as electricity and without heat, therefore, without waste. A vessel containing some water is filled with gas, and a metal plate is so placed as to be partly in the water and partly in the coal-gas. This plate is connected to another metal plate outside, which is partly in water, partly in air. Electricity circulates in the wire connecting the plates, and may be transmitted to any distance. Professors Ayrton and Perry are constructing a generator of this kind which will be capable of working a sewing-machine, and the latter asserts that instead of wasting 90 per cent. of the energy of the coal—the usual waste in steam-engines—the coal-gas battery enables them to utilise the whole of the energy in a form in which it may be transmitted to any distance. We need scarcely say that the whole industrial world will await with impatience the advent of the first motor of this kind, and the gas companies will at any rate see how little they have to fear from electricians, for, if Professors Ayrton and Perry are not mistaken, there will be a gas-worked electric-motor in every house to which a gas supply is now laid on. Professor Perry also described some experiments he has been making, in conjunction with Professor Ayrton, with the phenomena of the telephone and photophone, and these investigations illustrate two important things—viz., the principle of recurrent effects in the use of the telephone has opened up a new path into unexplored nature; and the laboratory worker sees a hundred interesting phenomena which ought to be investigated at once, and which he cannot take up unless he gets more apparatus, more money, and more observing eyes and working hands. It is a pity that such a phrase should occur in the paper without a definite statement of its meaning. Professor Perry himself alluded to the fact that Birmingham men found Priestley with money to carry on his researches, and we venture to think there will be no lack of funds to carry on experiments tending to develop the applications of electricity; but if the principle of Government endowment of research is once conceded, where will it stop? There are hundreds of investigators who believe that their investigations, or rather the researches they would like to make, are of far more value than those carried on by Prof. Perry; and although we may know they are not, it would be difficult to silence the clamour for payment. Of the value of the investigations we have attempted to describe merely in outline there can be no question, and another important one is an idea of a water siren, the tones of which would be conveyed by the water itself to the

HE TIMES, SATURDAY, MARCH 17, 1883.

THE NEAR FUTURE OF ELECTRIC POWER.

Professor Ayrton, F.R.S., delivered on Thursday night, at the London Institution, the second of his two lectures on "Electric Lighting and Locomotion." It was as effectively illustrated by diagrams and working models of the most striking kind as the first, which was reported in *The Times* of the 24th ult., and there was a no less crowded and attentive audience.

The lecturer began with a recapitulation of the important facts to be attended to in all large transmission of power by electricity to distant places. Great electrical pressure is of supreme importance, so that the serial working of lamps and motors is better than the parallel system. To insure safety, the going and return cables must be well insulated from one another as well as from the earth, and the current must be absolutely constant in its strength, not merely having the mean constancy attainable with many of the so-called constant current dynamo-electric machines. Many motors were shown in action, each coupled up directly to a drill or a fan or a circular saw, without intermediate gearing, and the lecturer laid great stress on the fact that one employment of electric power—viz., the driving of fans by electro-motors, appeared to him to be at the present moment of vital importance. For years past we had been breathing foul air in the Underground Railway. Much grumbling had resulted, but no ventilation, and at the present moment we were threatened with unsightly openings on the Embankment to let out the obnoxious gases. Now it was quite possible by means of comparatively small pipes to extract this foul air if fans were used; but inasmuch as fans were usually driven by steam engines and the smoke of steam engines was objectionable, it was necessary to drive these fans electrically. Electric fans of suitable size, placed at proper intervals, could receive as large an amount of power to drive them as might be desired through a single insulated going and return wire passing from motor to motor from a large dynamo machine outside the tunnel driven by a steam engine in some backyard, but giving perfect ventilation to the Underground Railway. It was difficult for the ordinary public or the mechanical engineer to understand what enormous power might be transmitted electrically through wires in the heart of a coal mine or in the middle of a tunnel. The lecturer pointed out that the motors on the table, which were capable of giving out half-a-horse power continuously for a long time, weighed less than 40lb., and were of very small size, so that, whether they were attached to a carriage to drive it or were to be used in some confined space, they were a very great advance on the steam engine. Comparative experiments were then made with a governed motor and a common motor having the same appearance, and it was shown that a change of load which diminished the speed of the ungoverned motor from 1,560 revolutions per minute to 508, reduced the speed in one of Ayrton and Perry's governed motors from 1,250 to 1,184 only.

The governing of motors so that they should run at a constant speed, whatever work they might be doing, was of considerable importance for the driving of lathes and other machinery, but for motors on electric tramcars, tricycles, &c., it was necessary to run at any desired speed forwards or backwards, and it was often particularly important that a motor should turn with very great force at the slower speeds. The lecturer then exhibited and described the use of the regulating handle, which he and his colleague had fitted to their motor for backward and forward motion at different speeds.

Having described many details in the electrical railways of the future, the lecturer entered on a consideration of the merits and defects of existing electric railways. The specimen at the Giants' Causeway he considered to be the latest and probably the highest development of the model so familiar to us years ago. He had ventured, however, to prophesy last year that when the old familiar idea of insulating the rail close to the ground for the conveyance of electricity to a distant train was attempted to be carried out in a damp climate, on a railway six miles long, the leakage would be so great as to prevent more than a very small fraction of the electric power reaching the distant train. The lecturer demonstrated this by an artificial rainfall, and said that of course this simple plan of working had to be discontinued at the Giants' Causeway and an elevated rail supported on wooden posts rubbed by brushes fastened to the train had been substituted. The objection to the elevated insulated rail was that on any but the simplest railways where no crossings occur it becomes impossible to use it.

He then described the system of Professor Perry and himself in the following words:—

"We electrically subdivide the rubbed rail into a number of sections all fairly, but by no means perfectly, insulated from the ground. We do not apply our electricity directly to this rubbed rail, but, instead, to a well-insulated conductor, which may be buried underground or may be insulated by resting like a telegraph line on insulators or posts, and we arrange that whenever a train enters on to any section, it automatically makes an electric connexion between that section of the rubbed rail and the well-insulated conductor which supplies the power and at the same time automatically cuts off the electric power from the section the train has just left, and in this way we confine the leakage of electricity to that section on which the train is at any particular time, and so reduce the leakage and waste of power on the longest electric railway to less than it is at present on the shortest line constructed on the Berlin plan. But not only does a train on entering any section automatically turn on the electric power to that section, and cut it off from the one just left, but it accomplishes something more; it blocks absolutely the section just left."

This was experimentally exemplified. So, too, whenever a train was approaching too near another in front, and was thus deprived of driving power, it was automatically braked. Whenever, then a train, even a runaway engine, entered on a blocked section, not only was all motive power withdrawn from it, but it was also automatically powerfully braked, quite independent of the action of signal-man, guard, or engine-driver. No fog nor colour blindness, nor different codes of signals on different lines, nor mistakes arising from the exhausted nervous condition of overworked signalmen could produce a collision. The common English system of blocking meant merely giving an order to stop. Their absolute automatic block acted as if the steam were automatically shut off and the brake put on whenever the train was running into danger; nay, it did more than this, it acted as if the fires were put out and all the coal taken away. The lecturer next entered on the question of the use of accumulators in electric lighting and locomotion, and showed that the transmission of electric power, whether for lighting or the driving of machinery, could safely be done by the use of accumulators. He said:—

"For the economic electric transport of power we must, as I have explained, produce a great difference of potentials by a dynamo at the place where the power is obtainable—in the suburbs, where, for example, is the steam engine or water wheel—and employ some mechanism which can be worked by the great difference of potentials at the place where the power is to be utilized—that is, in the town. There is no difficulty in arranging a dynamo wound with fine wire, or a set of dynamos in series with one another, to produce any difference of potentials required; but there is a far greater difficulty in using the great difference of potentials at the town end of the line. If lamps and motors of the present construction are used they would have to be put in series, but in that case if the current is stopped passing though one it will be stopped passing through all. This difficulty can to a great extent be avoided by using 'cut-outs,' as I described to you in my last lecture. At the same time nobody would be perfectly satisfied that his supply of electric power should depend on the good working of all the electric apparatus in the same street, much less that it should depend on the good working of all the electric apparatus in the same town. We are content that our supply of gas or water should depend on the good working of the gas or water works, but we could not tolerate the possibility of Betsy Jane, in Moorgate-street, through carelessness, being able to cut off our supply at the London Institution. What, then, are we to do? High difference of potential we must use, and we cannot work the lamps and motors in parallel unless they have a resistance of tens of thousands of ohms, in fact, are of a totally different description from the lamps and motors of the present day. The solution was first suggested by Sir William Thomson, in 1881, and I am happy to say will be very shortly carried out by Professor Perry and myself, under the auspices of the French Electrical Storage Company, in Paris. It is to use the small current and great difference of potentials to charge a very large number of accumulators, in series, in the town, and to discharge them in sets, each set supplying the energy for one street, or, possibly, for one district. Of course, the going and return wires between the dynamo and accumulators must be separately insulated, and put so far apart that there is no fear of a man or an animal accidently touching both. If, in addition, it is feared that although this precaution is taken still somebody may touch a leading wire, this may be also entirely avoided by electrically disconnecting the various sets of accumulators from one another, and from the main charging wires coming from the dynamo before they are connected respectively to the local leads in the streets for being discharged."

After giving important practical confirmation as to the size and cost of copper wires for the safe conveyance of electric power to a distance, the lecturer showed how it was possible to charge the consumer of electricity, whether he used it for giving light or for driving machinery, so that he should just pay for the exact quantity of electric power he had used during the last three months. Ayrton and Perry's "Ergmeter" performed this function. The lecturer demonstrated that the different systems of lamps in use at the present time required different pressures in the mains, so that the money value of the ampère from Edison was twice as great as that of one ampère from Swan, and that even in any one system it was not possible to maintain the same pressure for all consumers. The pressure must vary according to the number of lights in use at the time, even if the pressure at some one particular house were kept constant. He showed that the working of machinery by electricity will probably be more important than lighting, since it will go on all day long, so that the meter wanted is one to measure electric energy and not the mere quantity of electricity.

After briefly describing the driving of boats and tram cars carrying accumulators, the lecturer went on to say that the latest development in the use of accumulators was the electric tricycle of himself and Professor Perry, the first tricycle ever propelled and lighted from accumulators. This tricycle was placed upstairs in the library, where the lecturer drove it round and round the room at considerable speed. The tricycle was one of a well-known firm, altered to suit the circumstances of the case. No work was done by the rider, but ten little black boxes carried on the base board contained the stored electric energy pretty much in the same way as a horse's body contained its breakfast of oats and hay, but with this difference—that in these accumulators it was the receptacle alone which had weight, so that neither in receiving its feed in the morning nor in discharging its power during the day did the accumulator gain or lose in weight. The rider sat with the steering handle on the one side and on the other his electric supply tap. If he wished to go faster or uphill he increased his supply. The little motor, which was somewhat similar to the other motors exhibited during the lecture, was fastened under the rider's seat, driving the wheels by means of spur gearing. With this tricycle a measured mile had been run in 8½ minutes when carrying a man of average weight and enough accumulators to furnish power for a run of two hours.

Professor Ayrton, in conclusion, said—What stored electricity could do the accumulators before the audience had shown. What the future of electrical locomotion might be who could say? At present much household work was done by hand, simply because there were no easily worked machines for doing it. The old knife board had given way to the rotary knife-cleaner, but even that required a certain amount of grinding to give the knives a polish, so that for large establishments a knife-cleaner boy was still necessary. The blacking of boots, the blacking of grates, the cleaning of doorsteps, &c., were all done in a most laborious way by hand, judging from the smutty appearance of Sarah Anne after the process. Now there could be no doubt that very shortly electricity would be supplied, as gas was now, to houses for lighting purposes, and when this had been accomplished, the same ways that conveyed the electricity for lighting would be employed to convey the power to work electric motors to turn rotary knife-cleaners, to turn a wheel for the blacking of boots, and a small motor carrying a brush would simply be passed by the servant all over the grate for the purpose of giving it a good black polish. The black lead brush would then be taken off, and replaced by the blacking brush for the boots, and later on in the day a rotary flannel would officiate for the door steps.

Engineering, March 10, 82.

ELECTRIC POWER.

The latest novelty in the application of electric power is the driving of some piles to support a cofferdam across the River Lea at Hatfield Park, the seat of the Marquis of Salisbury. The power was transmitted by two dynamos connected by two conducting wires to a pile-driver on a barge in the river, and the dolly weighed from 4 cwt. to 5 cwt., and worked with ease and regularity. The first application of electricity to the propulsion of tramcars in England was made on Saturday, the 4th inst., at the works of the North Metropolitan Tramways Company, Leytonstone. The car employed was one which has already been tried in France. It is fitted with Faure accumulators under the seats, and connected to an electric motor beneath the car, acting by pinions on the wheels. The experiments were successful, and short runs were made along Union-road to the surprise of the spectators, who could see no visible driving. The accumulators weighed 30 cwt., and were charged to yield 25 horse power for an hour or 5 horse power for five hours. Thus the car could have run with its passengers for half a day allowing for loss of energy. The drawbacks are that the car and cells weigh so much—5 tons—and that the pinions make a disagreeable grinding noise, but this is of course only a mechanical defect. The experiments were undertaken by Mr. Radcliffe Ward on behalf of the Faure Accumulator Company, and the promoters hope to work the car at one-half the cost of horses, and also to drive cabs and omnibuses in a similar manner.

Dem – March 3, 1882

ELECTRIC CURRENTS.—Professor Sylvanus Thompson, of Bristol, delivered a lecture on February 22, at the Crystal Palace, on "Electric Currents: What are they?" This lecture is the first of a series which the directors of the Palace have organised in connection with the International Exhibition of Electricity. The lecturer began with an enumeration of the multifarious services now rendered to mankind by the electric current. Yet, though its applications were endless, it was remarkable how little was known of its intimate nature. To understand the true nature of electric currents, or even of electricity itself, necessitated a wide range of study, the more careful because of the great variety in the different properties and phenomena. Electricity might remain in the form of "charges" on the surface of bodies, or might flow through their substance in continuous "currents." Yet it was not a material fluid, and the term "electric fluid" was now only used by those who knew nothing about modern investigations in the science. Nevertheless a study of the various properties of electricity, the attractions and repulsions it set up, the sparks to which it gave rise, the chemical decompositions it effected, the magnetic actions it produced, all led toward a certain theory, only to be grasped when all these diverging lines were traced back to their logical origin. It was a matter of congratulation that so many eager and able scientific men were now devoting themselves to this youngest of the sciences, more especially as it was pre-eminently a British science. Almost every great discovery in electricity had been made by Englishmen. From the time of Dr. Gilbert, who founded the science in 1600, Englishmen had been foremost in electric discovery. Stephen Grey discovered that electricity could be made to flow in currents through wires; John Canton discovered the influence exerted by electricity at a distance; Benjamin Franklin, the inventor of the lightning rod, was a Briton, though resident then in Philadelphia; Humphry Davy, the discoverer of the electric light; Spencer, the inventor of electro-plating; Faraday, the greatest experimentalist in electric science that ever lived, to whose fundamental discoveries modern dynamo-electric machinery may be directly traced; Ronalds, Cooke, and Wheatstone, the fathers of the electric telegraph, and Swan, the inventor of the carbon-filament lamp, were all Englishmen, while Graham Bell, the perfector of the telephone, was Briton-born. Not that some great discoveries had not come from other lands. Cunæus, a Dutchman, discovered the Leyden jar; Volta, an Italian, discovered the voltaic cell; Oersted, a Dane, discovered the relation between magnets and electric currents; Reis, a German, invented the first rude telephone by which articulate speech was transmitted; and Plante, a Frenchman, invented the storage-battery or accumulator. After referring to the relation between the power of electric currents and the power that is spent in producing them, Professor Thomson spoke of the certainty that in the near future all heavy mechanical work would be done by electric currents in the place of steam, a theme which will claim further attention in a subsequent lecture. Developing the question of the production of electric currents in voltaic batteries, the lecturer referred to the discovery that such batteries were reversible, and that in this reversibility lay the newly-discovered power of storing or accumulating electric energy in cells which could be charged and discharged at pleasure. The magnetic, thermal, and physiological properties of the electric current were illustrated experimentally, the lecturer remarking with much emphasis that the mistake of confounding physiological with medical or remedial effects led to the gross impositions of the quacks and rogues who deal in so-called magnetic appliances, and disgrace alike the sciences of electricity and of medicine, while knowing nothing of either. The nature of electric currents was reverted to, and an outline was given of the theory of Clerk Maxwell that all electric phenomena were due to actions going on in the thin medium that fills the whole universe—the æther—vibrations of which are light and heat, the accumulations of which are electric charges, the streams in which are electric currents, and which, where it was made to spin round in vortices or whirlpools, gave rise to magnetic attractions. In conclusion, the lecturer commented on the immense importance of the revolution now beginning in the substitution of electric machinery for steam engines, and urged that if England desired to reap the benefit of this impending reorganisation of the methods of mechanical production, if she desired that her workmen should rise to the immense future before them, she must not lose an hour in providing them with an education in matters electrical, seeing that a knowledge of electric currents and their properties will be of far more practical importance than a knowledge of any other branch of science. If technical education did not come in any other way, it would be forced upon us by the practical fact that electricity is to be our servant in the place of steam and of coal.

74

Iron - April 1, 1881

THE FUTURE OF ELECTRICITY.—At the meeting of the Society of Arts, on Thursday evening last week, Professor John Perry read a paper, which was illustrated by many experiments, "On the Future Development of Electrical Appliances." He said electrical energy can be transmitted to a distance, and even to many thousands of miles, but can it be transformed at the distant place into mechanical or any other required form of energy nearly equal in amount to what was supplied? Unfortunately, hitherto the practical answer made by existing machines is "No." But, fortunately, Joule's experiments and other facts tell us that in electric machines of the future and in their connecting wires, there will be little heating, and therefore little loss. We shall, at no distant date, have great central stations, possibly situated at the bottom of coal-pits, where enormous steam-engines will drive enormous electric machines. We shall have wires laid along every street, lapped into every house, as gas-pipes are at present; we shall have the quantity of electricity used in each house registered as gas is at present, it will be passed through electric machines to drive machinery, to produce ventilation, to replace stoves and fires, to work apple-parers and mangles, and barbers' brushes, among other things, as well as to give everybody an electric light. It had been supposed that to transmit the power of Niagara Falls to New York a copper cable of enormous thickness would be needed. Professor Ayrton showed that the whole power might be transmitted by a fine copper wire, if it could only be sufficiently well insulated. He also showed that the one thing preventing our receiving the whole of our power was the mechanical friction which occurs in the machines. He showed, in fact, how to get rid of electrical friction. Professor Ayrton and himself had come to the conclusion that very large continuous current machines, with separate exciters, or perhaps even magneto-electric machines, driven very fast by steam-engines, will have an important place in the future transmission of energy by electrical methods. With such machines it would be possible to heat, light, and ventilate all the houses in New York, and to give to large and small workshops the power required to drive their machinery by means of an ordinary telegraph wire (but with some exceptionally good method of insulation), transmitting energy from as great a distance as the Falls of Niagara. The experiments of Dr. Siemens showed that there could be no doubt that the introduction of electric railways everywhere was merely a question of capital and the sacrifice of much existing plant. This kind of proof was very much needed by capitalists. But the electrician saw much further; he saw better insulation for the conductor, and application of the above principles to hundreds of miles of rail instead of a thousand yards; he saw, in fact, that the larger the experiment the greater must be its success. He looked forward to the absence of a vitiated atmosphere in our underground railways. He saw that the weight of rails (for there would be no heavy locomotive in the future, each carriage would have its own driving and breaking machinery) and the cost of bridges and wear and tear of permanent way might become less than one-quarter of what they are at present; he saw, in fact, all the advantages that would arise, when, instead of making a heavy steam-engine travel backwards and forwards with carriages, the carriages alone travel, and the steam-engine is not near the railway at all. After a number of interesting experiments bearing on the subject of the storage of energy, the lecturer concluded by exhibiting models to illustrate his belief that it will become possible by electricity to enable a man in London to see an occurrence going on in a distant town.

Engineering March '83

ELECTRIC TRANSMISSION OF POWER TO GREAT DISTANCES.

The recent experiments of M. Deprez in transporting power by electricity from the workshops of the Chemin de Fer du Nord have attracted much attention. An ordinary telegraph wire of 4 millimetres diameter and 160 ohms resistance, running between Paris and Bourget and back, a distance of 17,000 metres, was the conductor employed. The two machines were also connected by another short wire; the conditions of working being the same as if they were placed in relation to each other at a distance of 8500 metres, and connected by a going and returning wire. The generator had a double bobbin wound with wire 1 millimetre in diameter, and was of peculiar form in the armature. The receiver was a large Gramme machine of the military type modified to suit the occasion. The resistances of the two machines were 56 and 83 ohms respectively. All the electric and other measurements were carefully made during the trials which took place last month; the former being made by Dr. J. Hopkinson, F.R.S. The mean result of six trials on February 11th showed that 2.03 chevaux (each cheval being equivalent to 75 kilogrammetres per second, or 0.9863 horse-power) were transmitted of the whole 6.21 chevaux registered by the dynamometer at the transmitting station. This corresponds to a return of 0.327 H.P. per horse-power absorbed. A detailed examination of the transmitting system shows that the resistances of the generator, the heat developed therein, the loss at the brushes and in sparking, absorb 30 per cent. of the energy. Another 30 per cent. was lost in the passage of the telegraph line; or, in other words, 122 kilogrammetres of energy were dissipated in the conductor. The resistances of the receiver with its wires and brushes also absorbed some 30 per cent. of the electric work. Thus each of the three working parts of the installation had an efficiency of 0.70. Roughly speaking the energy actually transmitted to a distance of 8.5 kilometres (about 5.3 miles) by an ordinary iron telegraph wire of 4 millimetres in diameter, represents one-third of the original quantity.

75

THE DEPREZ SYSTEM OF ELECTRICAL TRANSMISSION.

SINCE 1873, when M. Fontaine made his historical experiment at the Vienna Exhibition, illustrating the transmission of force by electricity, a wonderful advance has been made in the utilisation of the principle demonstrated in that experiment; and in Europe, as well as in the United States, electricity as a motor may be said to have almost—not quite—reached the development necessary for a widespread though not economical application. We have already described in some detail the motor of M. Trouvé, that was exhibited in no very practical shape at Paris; and we may now interest ourselves with a more important arrangement—the electric motors of M. Marcel Deprez. Although Mr. Edison, amongst others, appears practically to have solved the problem of subdivided transmission of power, up to the present employers of the electric current either for the production of light, for power, for electrotyping, &c., are all obliged (except for incandescence lighting) to be the producers also, and to procure a more or less important plant for the generation of the currents they require. They are, in fact, in the position of a gas consumer who, instead of receiving his supply from the mains, has to manufacture it for himself. Central works for the production of electricity, as they exist in London, at Charing Cross for lighting the Thames Embankment, or in Paris in the cellars of the Opera for lighting the Place and the Avenue, are only special establishments for the one or two clients who light and extinguish all their lamps at the same time, and work their generators under fixed conditions. The same thing applies to the transmission of power. The valuable principle of reversibility on which such transmission is based, has up to the present been applied only within narrow limits by manufacturers who find it economical to have an installation for producing the power and transmit it to the points where it is to be utilised by the aid of two connected machines. So far, however, nothing at all comparable to the distribution of gas has been done, no system by which, from a central establishment, a *réseau* of lines is laid in different directions to supply light, to drive machines, or to use for heating purposes. In such an arrangement each consumer would be independent of his neighbour; he would open and close his meter when he pleased; light, regulate, or put out his lamps; apply the current to his motors, or heat his apartments—none of these operations would involve any inconvenience to the other consumers in the same *réseau*. This is the principle to be perfected for the popular and domestic application of electricity—the principle Mr. Edison is putting into practice, which M. Deprez has utilised, and which, as far as power is concerned, is already the business of a large company in Philadelphia, who are introducing the Griscom motor.

We have now to do with the system of M. Deprez, and we will postpone for a future article the simple explanation of the method which he has followed in working out his system, and will limit ourselves to-day to explaining the principle in a general manner, and to describing the installations at the recent Palais de l'Industrie. Let us suppose that M, Fig. 1, is a dynamo-electric machine producing a

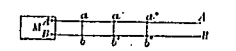


FIG. 1.

current, and that A A^1, B B^1 are two copper conductors attached to the terminals serving as the points of departure to the exterior circuit. If we connect the ends of the two wires, the current will circulate by reason of the difference of potential at the points A B, or rather by the electromotive force of the machine. If instead of this we connect certain points $a\ a^1\ a^{11}$ of the first conductor with corresponding points $b\ b^1\ b^{11}$ on the second conductor, the lines $a\ b$, $a\ b^1$, &c., will receive partial currents, the intensities of which depend on the difference of potential at the points $a\ b\ a\ b^1\ a\ b^{11}$. If then by any means the connexions can be so made as to render their difference of potential constant, whatever may be the number or extent of the branch lines, the passage of the current will be equal in each of them, and it will be possible at will to suppress or establish any number of the branch currents without interfering with the circulation in the others. Each branch would thus be entirely independent, and the mechanism it drives would work without variations due to other mechanism being thrown in or out of operation. This is the problem proposed by M. Deprez, and which he has solved with great success. Further on we will describe by what series of deductions he arrived at his system of automatic potential regulation; for the present we will confine ourselves to the way in which it was carried out at the Exhibition of Electricity. M. Deprez's patents are the property of a syndicate, and the apparatus which secured for their inventor a diploma of honour, were exhibited by M. Guichard, who it may be remembered was one of the earliest to interest himself in the Jablochkoff system of electric lighting. It was at his works indeed that the first experiments of M. Deprez were conducted that have since been developed on a large scale, and were shown so extensively at the Palais de l'Industrie.

The current transmitted and divided between the various apparatus by which it was employed, was produced at the Palais de l'Industrie by an Otto and Langen gas engine driving a Gramme machine, modified as we shall indicate on a future occasion, and excited by a small Siemens machine. These were placed in the middle of the group of motors installed by the syndicate, and behind the exhibit of the French Gas Engine Company; the position is marked M on the annexed plan, Fig. 2. We may mention here the velocities of the machine — 800 for the

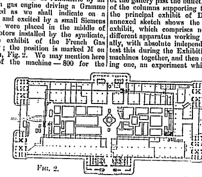


FIG. 2.

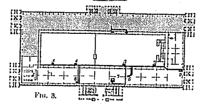


FIG. 3.

Gramme machine, and 2000 for the Siemens. The two main conductors from which the various branches were led off have a special peculiarity. If they had been arranged as shown in the first figure, it will be seen that the successive derivations would be made at constantly increasing distances from the machine. More favourable conditions are obtained by bringing back each conductor to its point of departure, and in leading off each deriva-

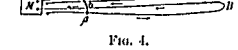
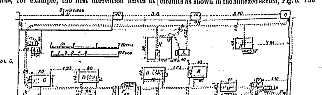


FIG. 4.

tion at an equal distance from the point of departure and the point of arrival of the two conductors. Thus, for example, the first derivation leaves at

FIG. 5.



the point a, Fig. 4, at 50 metres from the first binding screw of the conductor A, and is connected at β at 50 metres from the end of the conductor B. If the total length of the conductors be 1000 metres, which was the case at the Exhibition, it will be seen that all the points of derivation correspond to an equal length of main conductor, that is 1000 metres. On the two accompanying plans, Figs. 2 and 3, of the ground floor and the galleries of the Palais de l'Industrie, respectively are shown the direction of the main circuit. After leaving the machine the conductors were raised and followed the ceiling of the main machine gallery. The first branch taken off fed a small Marcel Deprez motor (which will be described further on) which drove a light shearing machine for metals, with about one-twentieth of a horse power. This machine, which was exhibited by M. Bunon, is marked l on the plan, and was placed behind the Hermann Lachapelle engine. The branch wire was of copper .9 mm. (.036 in.) in diameter, and 72 ft. long for the whole circuit. The main conductors then continued along the ceiling of the gallery past the buffet, and descended at one of the columns supporting the main staircase, to the principal exhibit of Deprez motors. The annexed sketch shows the arrangement of this exhibit, which comprises no fewer than fifteen different apparatus working together, or individually, with absolute independence. It was easy to test this during the Exhibition by starting all the machines together, and then stopping them excepting one, an experiment which invariably showed that the speed of this latter was not modified, and that it continued to work without being in any way affected. The plan shows the general arrangement of the main circuit, and the approximate positions of the derivations. The apparatus worked on this circuit were as follows (see Fig. 5).

A wood-cutting machine A is driven by a small Deprez motor; b is the table on which the wood is placed; a represents the motor; C is a sewing machine, D a plaiting machine, E a sewing machine, F a small copper chain-making machine that was exhibited by M. Bunon; G is a gauffering and plaiting machine. All these were driven by separate Deprez motors. On the table H was placed a Deprez galvanometer and a Gülcher lamp J. These two, as well of the Lane Fox incandescence lamps K, and the Siemens machine L, were on successive subcircuits as shown in the annexed sketch, Fig. 6. The other installations were as follows: M is a gauffering machine shown by M. Tuquet; N is a plaiting machine, and P a wood-cutting machine; these also were worked by separate Deprez motors. The sew-

LITERATURE.

Roorkee Hydraulic Experiments. By CAPTAIN ALLAN CUNNINGHAM, R.E. Printed and published at the Thomason College Press. In Three Volumes. Roorkee, 1881.

THIS large and important work, giving full detail of one of the most extensive series of hydraulic experiments made in recent times, consists of three volumes; the first of text, consisting of nearly 400 pages, mostly in rather small type; the second of about 200 pages of tables, mostly in small type, the latter part of which consists of abstracts from the preceding 150 pages; the third of fifty-two plates illustrating the subject.

The experiments, conducted on a large scale under the auspices of the Indian Government, had for their main object, to obtain further and more precise information on hydraulics that would be of use to engineers and others connected with the large canals of India; the specific primary objects being:

I. The discovery of a good method of discharge measurement.

II. Testing the applicability of known mean-velocity formulæ.

III. The discovery of a good approximation to mean velocity.

The whole of this to be applicable to large bodies of water in distinction to the results of the French hydraulic engineers obtained from experiment on small branch channels, such as the Bief de Bourgogne. The experiments on the flow of water were made on the Ganges Canal and its branches between December, 1874, and March, 1879, in which period there were some intermissions, at the comparatively low expenditure of 5400*l*. The main results and deductions gained were the following:

1. Loaded tube rods give a rapid and sufficiently close approximation to mean velocity past a vertical. They are so convenient that they should supersede all other instruments for the purpose, in depths not exceeding 15 ft.

2. With good arrangements, discharge measurements obtained under similar conditions by the system advocated, may be expected not to differ more than three per cent.

3. None of the known mean-velocity formulæ appear to be of really general applicability. Kutter's appears to be the most general. The approximation likely to be given by it falls far short of that given by direct discharge measurement.

4. Central mean-velocity measurement appears to be the best means of rapid approximation to mean sectional velocity; but the reduction must at present be effected by a coefficient to be found by previous special experiment at each site.

Among the minor or secondary results, the following are a few of the more interesting:

5. The motion of water in large open channels is essentially unsteady. Even in long straight fairly uniform reaches, the velocity at any point is extremely variable from instant to instant, and the stream lines interlace freely in all directions.

6. The water surface is not sensibly convex across the channel.

7. The average velocity surface is, as a rule, convex throughout.

8. The maximum velocity past any vertical is, as a rule, below the surface; the depression increases from the centre towards the banks in a rectangular channel. The depression is not much affected, if at all, by wind.

9. Loaded rods nearly grazing the bed move slower than the mean velocity past them; so that to measure mean velocity past a vertical, their immersed length should be decidedly less than the full depth.

10. The mean velocity at a given site depends more on the surface gradient (which is determined by the state of control above and below the site), than on the mere depth of water at the site.

11. A discharge table for a given site must hence be necessarily one of at least double entry, showing the discharge as depending on both surface gradient and gauge reading.

A general review of the whole results obtained is thus verbally expressed by the author himself.

"The general result of this work may perhaps be considered in some way disappointing, in that there are no brilliant results, no simple laws of fluid motion discovered, not even a new formula proposed for mean velocity; the complexity of fluid motion becoming indeed the more apparent, the more the conditions of experiment are varied. Nevertheless, the author submits that on the whole the practical objects proposed have been attained, and that taking this together with the great scientific interest of the other results, the great outlay on this work has been usefully incurred."

This review certainly errs on the side of modesty; the expenditure on such a large series of experiments over so long a time and at such a place appears small; the discovery of new simple laws could not for a moment be expected by any one very conversant with hydraulics; the pursuit of a chimera in the form of an entirely new formula, as that of Gordon, could be nothing more than a disappointment to those pursuing it; the main practical results have been obtained, and these are exactly such as might have been legitimately expected by many hydraulic engineers. Their importance, however, should not be underrated. Apart from a perhaps excessive confidence in tube-rod measurement of mean vertical velocity, due rather to relative performances than absolute precision, the conclusions drawn from the experiments, affecting vital matters in hydraulics on a large scale, are of high interest to scientific men, to all professional men whose duty it is to be well informed on such subjects, and to the general public that are inevitably affected directly or indirectly by all scientific results.

Although a very few, with unusual opportunities of observation joined to unsparing labour, might have foretold the results in broad terms; although the columns of ENGINEERING have for several years past advocated such principles as are now proved to be substantially correct on a large scale—the mass of professional and scientific men have long remained undecided on the most important points. The sweeping condemnation of all calculated mean velocity formulæ, with the exception of that of Herr Kutter, is now fully borne out by experiment; and as to the correctness of the Kutter coefficients, the following is the verbatim statement:

"Kutter's coefficient is one of pretty general applicability; when the surface slope measurement is a good average, that coefficient will give results, whose error will probably seldom exceed 7½ per cent. in large canals."

There can now be little further hesitation on these points except among those that will not read, or those who, seeing, will not perceive; no longer will the old hydraulic tables be used, and the world is relieved from a sea of error. The value of such knowledge cannot be over-estimated. The other valuable result gained is the knowledge that the depression of the locus of maximum velocity past any vertical is not much affected, if at all, by the wind. This will open the way for the future of experiment and observation, and place velocity observation on a firm basis, a matter of very high importance.

While thus giving a cursory notice of the book treating of these experiments and their results, we postpone the detailed examination of the experiments themselves to future numbers of this paper, as their importance carries them beyond the limits usually assigned to literary notices, and into the wider subject of hydraulics generally. The pains-taking labour involved in the experiments, the difficulties to be surmounted, the ability shown, and the excessive elaboration of detail in these volumes, combine to place Captain Allan Cunningham in the first rank of hydraulic engineers of the present age, and to rescue Englishmen from the charge of being behind Continental scientific men in such matters.

Fehland's Ingenieur Kalender for 1882. Berlin: Julius Springer.

This engineer's pocket almanack, which we briefly noticed last year, has again come to hand, revised, altered, improved and brought up to date. It is truly astonishing where these numerous engineers' pocket-books find a market in Germany, still their number increases every year, and the old-established books would soon find themselves behind if their contents were not carefully revised for each new edition. In this respect they form a striking contrast to our own technical pocket-books.

In Mr. Fehland's calendar for 1882, several chapters, particularly those on iron and steel-making, have been completely rewritten. The Thomas-Gilchrist process is treated upon, and the Bessemer and Siemens-Martin processes have been brought up to date; it almost appears that the author has taken advantage of the meeting of the Iron and Steel Institute meeting at Dusseldorf last year to embody the latest information in his handy and useful pocket almanack. Other chapters on mechanical construction have been corrected and improved, a railway map of Central Europe will also be welcomed by many, and a variety of information on postal, telegraph, and other matters of general interest, readily explains the fact that most German engineers always carry one or the other of those engineers' pocket calendars about with them.

BOOKS RECEIVED.

Katechismus der Stationären Dampfkessel und Dampfmaschinen. Von TH. SCHWARTZE. Leipzig: J. J. Weber.

The Book of Scales; Principally Designed for the Use of Students preparing for Entrance into the Royal Military Academies at Sandhurst and Woolwich. By A. W. HOLOHAN. London: Longmans, Green, and Co.

Experimental Researches into the Properties and Motions of Fluids, with Theoretical Deductions therefrom. By W. FORD STANLEY. London and New York: E. and F. N. Spon.

The Baggage, Parcel, and Mail Traffic of Railroads. By MARSHALL M. KIRKMANN. Chicago: Railway Age Publishing Company.

Lectures on Architecture delivered at the Royal Academy. By the late E. M. BARRY, R.A. Edited (with Introductory Memoir) by ALFRED BARRY, D.D. With Portrait and Illustrations. London: John Murray.

The Royal Engineering College, Cooper's Hill, Calendar for 1881-82. Published by Authority. London: W. H. Allen and Co.

The Stock Exchange Year Book for 1882. A Careful Digest of Information relating to the Origin, History, and Present Position of each of the Public Securities and Joint Stock Companies known to the Markets of the United Kingdom. By THOMAS SKINNER. Eighth year of publication. London, Paris, and New York: Cassell, Petter, Galpin, and Co. [Price 7s. 6d.]

THE ELECTRICAL TRANSMISSION OF POWER.

IN our last number, we described the method devised by M. Marcel Deprez for the electrical transmission of power to a distance. His remarkable success in dealing with this important problem is due, in great measure, to his thorough mastery of the theory of electrical work. We shall endeavour briefly to give his views of this subject as we find them in a paper recently communicated by him to *La Lumière Electrique*.

When a battery is used to effect chemical decomposition, work is done both in the electrolytic cells and in the battery itself, the latter being reckoned positive work, and the former negative. The absolute amount of work done, however, does not vary from point to point, but remains constant throughout the circuit, as was shown by Faraday, and embodied by him in his celebrated laws of electrolysis. If we couple together N cells, say, of Grove's gas battery, and place n voltameters in the same circuit, the latter will set up an electromotive force opposite in direction to that of the battery. If E be the electromotive force of one cell, N E will be the electromotive force due to the battery, and n E that due to the voltameter. Their ratio is $\frac{n\,E}{N\,E}$ or $\frac{n}{N}$. Since the chemical action is the same in every part of the circuit, it follows that the quantity of gas which disappears in each battery cell will be precisely equal to that evolved in each voltameter. If V be the volume consumed in unit time, the battery will absorb N V, and the voltameter will give out n V volumes. The ratio is $\frac{n\,V}{N\,V}$ or $\frac{n}{N}$, a numerical expression for the ratio of the negative to the positive work, and at the same time for the ratio of the electromotive forces.

When $\frac{n}{N}=1$, the positive and negative electromotive forces neutralise each other, and consequently no work can be done. We also see that according as N increases the number of units of work produced diminishes. A certain portion of the current is also converted into heat, owing to the resistance of the circuit; and it is in this new form that we must look for the balance of the energy which is developed by the battery and does not appear as useful work.

The distance which separates the two parts of the circuit must not be neglected. Its effect may be calculated and even eliminated. M. Deprez has found that the chemical work done in the battery, and the chemical work produced by the current at any point of the circuit, are independent of the distance when the respective positive

LITERATURE.

Die Maschinenelemente, ihre Berechnung und Construction. By Professor C. Bach. Stuttgart: J. G. Cotta.

This work, intended as a text-book for technical educational establishments as well as a book for reference in the drawing office, is accompanied by an atlas containing forty-two plates, independently of numerous woodcuts in the text. Professor Bach devotes the early part of his work to chapters on elasticity and strength of materials, and treats this subject on the basis of the series of experiments conducted by Professors Wöhlert and Bauschinger, with a view to establish the amount of fatigue produced on materials when subjected to a series of strains continued for long periods and varying in intensity. It will be remembered that by these experiments, extending over a number of years, it was proved that even very minute strains, if only repeated for a sufficiently long period, would ultimately result in a molecular change of the material. The practical conclusion to be drawn is, not to base calculations of strength of material, in whichever way strained, on the ultimate breaking load, but rather on the elastic limit, which was ascertained for various materials, and various modes of straining by these experiments. A large number of Professor Wöhlert's experiments are actually given, and corresponding conclusions drawn therefrom, most of which, however, have for years been objects of every-day practice. That sharp corners are detrimental to test bars or plates, particularly in steel, has led to carefully planing the edges of steel plates for boiler work and for other purposes.

Rolled plates tested by Professor Bauschinger showed, after having been once strained, an increased resistance in the longitudinal direction of fibre, but a decrease when strained transversely. In straining materials three principal modes of operation were employed: a bar loaded with a dead weight, a bar bent in one direction only for an unlimited number of times, a bar bent in all directions for an unlimited number of times, and for these three distinct groups Professor Wöhlert's experiments give as result the proportionate numbers 3 : 2 : 1.

Tensional strain is taken as the unit; for shearing only 0.8 of this is admitted, while for torsional strain 0.4 is the result finally arrived at for all materials except cast iron.

The author further points out the necessity of carefully considering the conditions under which the same material may be strained, and quotes that for instance it would be quite wrong to allow a driving belt to be strained as heavily as a belt or rope used for lifting a load as in a hoist.

In the second part of the work which deals with elements of machinery, the author carefully avoids proportioning any parts according to empirical formulæ, which are misleading to the student, and carry no correct idea of the strains involved, but in all cases calculates them according to the amount of strain they have to bear. To this part of the work, the illustrations in the atlas principally refer; the early chapters, treating on wedges, keys, screws, rivets, &c., we may pass over without any remarks. In his choice of calculations and sketches for a steam boiler intended for 75 lb. working pressure, the author is not happy in assuming single-rivetted joints, in giving two pages of calculations on the exact shape of the plates, forming a conical ring of the shell, and then calculating at length the number of rivets required. He shows, moreover, in the sketch, the gusset stays fixed close behind the end plate seam, and the longitudinal seams close together, so that the drawn out plate corners may fill better; these are misleading points to the beginner. Gearing and cog-wheels are next treated, followed by pulleys and general notes on driving both belt and rope, and are profusely illustrated. Amongst the bearings we notice several novelties, and special attention is paid to self-adjustable bearings and bearings admitting of fixed adjustment in various directions; a four-parted crankshaft bearing on Plate 17 is of very neat design. Pistons, stuffing-boxes, cranks, eccentrics, and other engine details follow, mostly of sound design and of modern construction, only occasionally we meet with illustrations of types which it would be best to forget rather than reproduce in a new work; among the latter might be classed some of the expansion joints shown and described; nor is the author very happy in his design of pump valves on Plate 39, which would probably give some trouble at high speeds.

The work as it is—the second part can only be called descriptive of the atlas of plates—is a very good and useful book to assist the young designer, and has the great advantage over most of its rivals that mostly new and good types are illustrated in it; its value would however have been materially increased had each chapter contained some general hints on designing the particular part under consideration, instead of simply giving a list in words and the picture of forms generally used. It is not in the want of form that the young engineer mostly fails, but in the judicious selection of the most suitable under certain conditions, and some general notes would here be of great value, although of course experience is the best teacher.

The Book of Scales. By A. W. Holohan. London: Longmans, Green, and Co.

This is a somewhat elaborately got-up book on the construction and use of scales, particularly intended for students at military academies, and when first opened it rather conveys the idea that military students are not credited with too large an amount of common sense, for, in constructing ordinary scales for drawing purposes, such as for instance one inch to a chain or a mile, or a proportional scale of one in 250, we do not recollect having noticed such difficulties as the author evidently assumes to exist amongst students. However, the subject of scales is exhaustively and carefully treated and excellently illustrated, and if the author errs, it is certainly on the right side, the explanations being rather too complete than otherwise. In fact, a student might open the book of scales at any page, and without referring back, be able by the information there given regarding the particular scale he requires be enabled to lay it down on his drawing paper. The first plate contains a comparative table of English linear measures from one mile down to one inch, with all intermediate divisions, from which the equivalents may be read off at a glance; this is the handiest table of its kind we have yet seen. When speaking of foreign, principally Continental, measures and English equivalents, the author gives all the old measures now mostly abolished in favour of the metric system; this may be very useful to have, but a note to the effect that almost all Continental nations now use the metric system, and have done so for about ten years, should have been added. Good and plain descriptions are given of a number of drawing instruments and their application, examples being in all cases quoted; these include the sector, the protractor, the clinometer and omometer, and the book finishes up with some exercises on scales. To all not experienced in drawing, and also for handy reference to English and foreign measures, the book will prove useful, and to the student the excellent style in which the scales given, are drawn and divided, it will be a useful guide, while the latter part treating on the protractor and its various combinations, may be considered a text-book on a subject not frequently treated elsewhere.

BOOKS RECEIVED.

Cooking and Heating by Gas. By William Denny, F.R.S.E. Dumbarton: Bennett and Thomson.

Calvert's Mechanic's Almanack and Workshop Companion for 1882. London and Manchester: John Heywood.

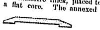
The Railway Diary and Official Directory, 1882. London: M'Corquodale and Co., Limited.

The Water Supply of England and Wales, its Geology, Underground Circulation, Surface Distribution, and Statistics. By Charles E. De Rance. London: Edward Stanford.

Lectures on Architecture delivered at the Royal Academy, by the late Edward M. Barry, R.A. Edited (with Introductory Memoir) by Alfred Barry, D.D. London: John Murray.

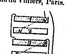
JABLOCHKOFF'S ALTERNATING CURRENT GENERATOR.

In a previous number (see page 391 *ante*) we referred to the general conditions which led M. Paul Jablochkoff to elaborate a type of electric generator which should avoid as far as possible the small causes of deterioration which are inherent to the Gramme ring, and which may result in more or less costly repairs. It is this object which is explained in the French patent of the 25th September, 1878, by M. Jablochkoff, for "Improvements in the construction of magneto and dynamo-electric machines," and the specification begins thus: "The improvements we have introduced in the construction of magneto and dynamo-electric machines have for their object the improvement in the working of such machines, the increase of their duty, or the reduction in the motive power they absorb, and to facilitate their maintenance and repairs." The generator to which this patent refers, after having been studied theoretically by M. Jablochkoff, was brought to a practical form only a long time after, when the inventor had returned to Paris from a protracted stay in Russia. It is shown in Figs. 1 to 4 on the next page, which represent the general arrangement of the first type constructed for feeding sixteen lamps. It will be seen from these engravings that it consists of eight electro-magnets of a helicoidal form. To avoid the serious difficulties that would be met in the construction of the spiral electros, if they had been formed in a single piece, they were made in a series of stars of plate iron from three to four millimetres thick, with eight branches, and pierced with a hole at the centre; these were mounted on an axis, one against the other, and to each a slight angular advance over the preceding one was given; by this means the desired spiral surface was obtained. The eight branches are connected by locking bolts passing through the stars, and the steps formed by the angular advance are reduced to a continuous surface by filing, or other mechanical means; the core formed in this manner is externally solid and compact, and not likely to be injuriously affected by the action of centrifugal force. We shall moreover see, further on, that the speed at which the Jablochkoff machine is driven is sensibly less than that of other generators. On the inclined surfaces of the core, coils are wound in which the current of the exciting machine circulates; this is ordinarily a direct-current Gramme of the ordinary workshop type; the coils are kept in place by the form of the arms of the core. We shall see presently that these coils are wound in such a way as to give contrary magnetisation to the successive poles. The fixed coils receiving the induced current are formed in a somewhat similar manner to the inductors, being made of a series of iron plates one millimetre thick, placed together so as to form a flat core. The annexed sketch



shows the form of these plates, which are held together by four clips. The wire is wound around these cores perpendicular to their length, that is to say in the direction of the motion of the armature. This is evidently a good arrangement as regards the safety of the machine. If any wire from the electro-magnets should become detached from the core, the movement of the armature would tend rather to protect than destroy it. In the core of the electro-magnets the plates are separated from each other by thin pieces of paper, which prevent the creation of currents injurious to the proper working of the machine, and reduce the tendency to heating. The magnets, the form and arrangement of which are shown in Figs. 1 and 2, are fixed by two copper armatures held at their ends by two rings attached to the frame. Their dimensions, and that of the wire covering them, are so calculated that each of them corresponds to a normal Jablochkoff candle of four millimetres diameter, so that a generator with sixteen magnets is also a sixteen-light machine. If in the course of working, one of these magnets is disabled, it is very easy to remove it and replace it in a few minutes by a spare one, an advantage peculiar to this machine. On account of the special characteristic of having each magnet to correspond to one lamp, it is possible to make the exchange when the generator is at work, by simply cutting out the lamp corresponding to the magnet being shifted, and without extinguishing the other lights.

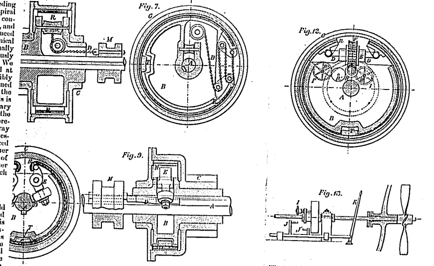
The following are some general particulars of the 16-light machine of the first type that was experimented with at the works of the Jablochkoff Company, 61, Avenue de Villiers, Paris. The generator,

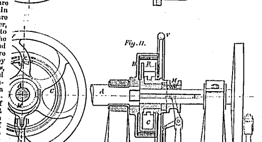


arranged as described, was furnished with a current from a Gramme exciting machine revolving at 750 revolutions per minute, and furnishing a current of

objects which indicate
working. It utilises
luced by a flat plate
d dimensions, and its
ace of a pulley in which
produce an elastic brake.
artially the pressure of
a complete or partial
, the brake mechanism
spring, carrying on its
ntended to produce the
the inner face of the
oduced. This spring is
the pulley and keyed on
the spring is free to
er band around its edge

arising from shocks is avoided, and the motion is always very easy and regular. Motion to the spring is communicated by several different means; we may first notice that used for the Jablochkoff generator. This is represented by Figs. 6 and 7, which are, respectively, a longitudinal section and a face view. The driving shaft is shown at A; on it is keyed the sleeve B; C is the pulley mounted loose on the sleeve; R the spring which almost entirely covers the inner face of the pulley. It carries a stud T which engages in a corresponding recess in the sleeve, and determines the adhesion of the spring and the sleeve, when they are connected. The retraction of the spring is effected by means of the outer sleeve M, to which a chain is connected, running over a series of rollers. When





co of the pulley, and conse-
connexion of the latter with
loy is then fixed. If on the
is bent so as to cause its
proach, the leather band be-
pulley, and leaves it more or
ling to the degree of contrac-
When the latter is fully re-
comes loose. It will be remarked
rt of the pulley is proportional
rted by the spring. This pres-
ts maximum, and consequently,
is produced, the pulley would
covering of the spring, up to
ne friction would have absorbed
o. By this means the danger

the sleeve is moved it acts upon this chain in the manner shown in Fig. 7. We have already indicated the special mechanism by which the sleeve M is moved in the Jablochkoff machine.

Before concluding this article we may indicate three different modifications made in the Mégy pulley. In each case the action of the spring on the face of the pulley controls the apparatus, the means of actuating this spring constituting the difference. Figs. 8 and 9 show an arrangement in which wedges are made use of. Here the chain is replaced by two levers E, the upper ends of which act on the ends of the spring. The lower ends of the lever carry two rollers, and the lateral movement of the sleeve forces, between the shaft and the rollers, two wedges which are pushed forward, and, consequently, draw the ends of the spring towards each other. Figs. 10 and 11 show an arrangement worked with a pedal. In this case it is required to make fast or loose two shafts, A A', one of which forms an extension of the other. The driving shaft is A, and it carries the pulley B; the sleeve C is keyed on to the shaft A'. The flywheel V runs loose on the sleeve C, and moves with A' by the clutch M; the chain of the spring is fixed to the flywheel by one of its ends. It will be seen that by pressing on the pedal, the sleeve M slides from the flywheel, of which the movement is then rendered independent of that of the shaft A'; the shoe *s* stops it, and the spring is operated through the chain.

Lastly, Fig. 12 shows a further modification. The two shafts occupy the same relation as in th preceding arrangement; the sleeve B is keyed o the shaft A, and the box C on the shaft A'. Tl ends of the spring are connected to two ro screwed in opposite directions which enter th nut E; the toothed wheel F gears into an endless screw. It will be seen that the movement of the latter regulates at will the relative position of the ends of the spring. The worm carries a toothed wheel H which gears into the wheels R R', the axis of the former is a palette wheel I. The wheel R' gears into the wheel R'' carrying on its axis a second wheel I; the sleeve B carries with it in its movement the wheels I and I'. By means of the lever K a rod is worked having two fingers J J which can be placed in the plane of rotation by the wheels I I' turning them, and consequently actu ating the pulley mechanism. To prevent th spring from being forced on itself or against th box C, if the lever is not withdrawn in tim the wheels I I' are free to shift on their axis. Thi movement can be regulated in such a manner, th beyond a certain point the fingers J J' are free the palettes. Fig. 13 represents this system plied to driving a screw shaft.

THE ELECTRICAL TRANSMISSION OF POWER.

(*Continued from page 592.*)

The machines of Pixii and Pacinotti were the prototypes of the two great classes of electric generators now in use. In the one the armature revolves between the poles of strong steel magnets; in the other large masses of soft iron are converted by the action of the current developed in the armature itself, into powerful electro-magnets, which in turn produce an intense magnetic field.

80

Iron — July 18, 1882.

ELECTRICAL TRANSMISSION FROM NIAGARA FALLS.*

By Mr. BENJAMIN RHODES.

DYNAMIC electricity is used substantially only for the electric light, but this has become a great industry. It is the object of this paper to show what has been done and what may be done toward the utilisation of Niagara for electrical purposes. The power of Niagara can be estimated very approximately. The average flow of the river, according to the many careful measurements, is 275,000 cubic feet a second. The fall through the rapids immediately above the falls is 65 feet. The height of the falls is 165 feet, making a total of 230 feet; thus we have for the whole power 7,000,000 horse-power. To utilise this amount of power by water-wheels, generate electrical currents, and transmit to various cities within 500 miles would necessitate a plant representing at least $5,000,000,000. Such figures as these give some idea of the enormous amount of power here in reserve. A small proportion of the power of Niagara is already utilised, and a much larger amount can be developed at moderate cost. On the Canada side, the entire use is represented by a small overshot wheel under 6 feet head, which has for many years propelled a solid piston single-acting pump, furnishing a meagre supply of water to the adjoining village. On the American side, along the rapids on Goat Island and the mainland, there are five separate raceways using from 4 to 16 feet head, and developing in all from 800 to 1,000 horse-power, most of which is now in actual use. If the project for the appropriation of lands at Niagara for a state reservation is carried out, all these races will come within the fixed bounds of the park, and will, of course, be odious in the eyes of the commissioners and be swept away.

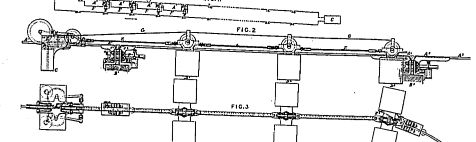
The greatest power now in use at Niagara, however, lies outside the proposed State Park. It is the Hydraulic Canal, and was constructed about 1855. It is cut through the solid rock across the peninsula on which the village of Niagara Falls is built, taking the water from the extreme head of the rapids and discharging below the falls, giving opportunity to use the entire head of 230 feet. The canal is nearly one mile long, and was planned 100 feet wide and 10 feet deep. It has been excavated but 70 feet, and half the distance it is but 35 feet wide. It is at present partially filled with débris, being at certain points no more than 5 feet in depth. At the lower end is a basin nearly at right angles with the canal, which may be extended as needed along the river frontage belonging to the Hydraulic Power Company. The canal lay idle for a quarter of a century, and it remained for an enterprising citizen of Buffalo, Mr. J. F. Schoelkopf, possessed of a large capital and zeal, to open up this great power. At the time of his purchase—in 1878—there was only one water-wheel on the canal. There is now a large and increasing number of buildings for manufacturing purposes distributed along the high bank of the river, using an aggregate of nearly or quite 5,000 horse-power. The wheels in these buildings are set under heads of from 50 to 100 feet, and discharge the tail water over the side of the precipice, the various streams falling over 100 feet to the river below. Some of these wheels are of large size when the head is considered, several being capable of giving from 1,100 to 1,500 horse-power each. The last two years have seen great improvements in the making and setting of wheels, and the working of all the mills is now regular and continuous. Further developments of power at Niagara may be made at little expense. The Hydraulic Canal can be deepened and widened and wheels may be set under greater heads, the total amount thus made available here being equal to the necessities of many years. Large powers may also be developed at Goat Island and Prospect Park in case the State Park plan is not effected, in either place 10,000, 25,000, or even 50,000 horse-power being easily available. It may safely be said that the use of Niagara has just begun. Low water is unknown, troubles from ice are slight, hours of use are not limited to eight or ten, but twenty-four hours in the day, and 365 days in the year, and unlimited power is ready, making this the most reliable, as it is the grandest, water-power in the world.

The application of the water-power of the Niagara to electrical purposes has been limited, being hitherto confined to the local use of the electric light, but this use has been such as to give much valuable experience. A Brush dynamo has been in use in Prospect Park for the illumination of the falls and grounds, since July 4, 1879. This machine is run under peculiarly favourable conditions, having always the same number of lamps in circuit, with power supplied by a water-wheel of proper capacity, and the plant operated only two hours of each day. The working has always been smooth. A Weston dynamo, with a Serrin lamp and reflector, was for some time used to light the beautiful rapids in the rear of the Cataract House; some difficulty was found with this plant, not, however, due to the power. Several isolated Edison installations have been made in various mills, the dynamos in each case being run by the water-wheel that furnishes power for the mill. While the power is continuous the light is excellent, the only difficulty with such a plant being that, in case of shutting down for repairs, auxiliary power must be supplied for the dynamos or other light used. A local Brush company was formed in the fall of 1881, and has since been lighting the streets and dwellings of the village of Niagara Falls with from forty to sixty lamps. The company has met with not only the usual difficulties of such organisations, due to inexperience and the sudden introduction into general use of new machinery and unfamiliar principles, but in addition other troubles due to the interruption in the power from various causes, so that a steam plant has been maintained by the side of the water-wheel. As heretofore noted, the improvement in power has been marked, and it is probable that the steam plant will be used hereafter only in such extraordinary emergency as might be classed with the bursting of a steam boiler or the destruction of a building by fire. Experience has shown the immense difference in cost between the use of steam and water-power. Electric street lights are furnished profitably at a price much lower than at any other place, and if the number were greater, the price could be still further reduced. The future application of Niagara's power to electrical purposes is an interesting subject. The local use will keep pace with the growth of the town, but will of course be comparatively small. In order profitably to transmit currents of electricity to a distance, several conditions must be observed: The cost of transmission must be less than the difference between the cost of steam and water-power; the distant point must be one where the currents of electricity can be used, and where water-power cannot be obtained.

There is no point so likely to fulfil these conditions as the city of Buffalo, and the project must be proved practicable there before being attempted in larger and more distant cities. The estimates following are based upon the Brush system, not on account of merit in this beyond other systems, but because it happens to be there in most general use. There are in Buffalo 400 arc lights, requiring the use of steam plant of about the same number of horse-power. The number of lights is increasing as in other cities, and it may be assumed that there will be 1,000 lights in use within two years. The length of circuit required between Niagara Falls and Buffalo is about fifty miles. Experience has shown that from forty to sixty lights can be run on one circuit with an electro-motive force of from 2,000 to 3,000 volts, but a greater number requires a current of so great intensity as to be in some danger of burning the insulation on the dynamos as at present constructed. There is no doubt the dynamos will hereafter be improved in this respect so as to permit 100 arc lights to be in the circuit. As the resistance of the circuit and consequent loss of power vary directly as the length and inversely as the area of the wire is used, there will be found for every case a size of wire such that the sum of its cost and the capitalised loss of power will be reduced to a minimum. The size of the wire will be less for water-power than for steam. The cost of erection complete of a number of circuits of proper length would be about $4,000 per circuit. The resistance would be 76 ohms—equal to 16 lamps; or, assuming the very general practice of coupling, in series, a 40-light and 16-light Brush dynamo, the loss would be about 28 per cent. The rental power at Niagara Falls may be assumed at $10 per horse-power per annum, delivered on the shaft. The cost of transmission will be interest, repair, and depreciation, which will be all covered by 10 per cent. on the investment. The items of cost of dynamos, carbons, lamps, and care of lamps are common to the use of steam and water, and need not be considered. The most enthusiastic advocate of steam-power will hardly claim that it can be produced for from ten to twelve hours a day at less than $50 a year, and as used for electric lights with small engines the cost is actually nearer $75. The saving then may safely be assumed at $40 a year, or, on a plant for 1,000 arc lights, the sum of $40,000 yearly. Enough has been said to show that the power of Niagara can be transmitted to a distance of twenty-five miles with a great saving over steam, and that, with improvements in storage batteries and electro-motors, this distance can be increased with economy to from 100 to 150 miles. With further improvement in dynamos and insulating material, to permit the use of currents of higher intensity, the economical distance may be still further increased.

81

JENKIN'S ELECTRIC TELPHERAGE.



culations made by the staff of my firm, under the direction of my partner, Mr. Charles Christie. The calculations were from Lloyd's rules in force in 1877, but although additional material has since been added, the basis of Tables G and G_1 remains the same, and therefore I reproduce the diagram (see Fig. 7). The additional material required by the rules at present in force would carry the curve of material higher up, as shown. The curves, which have been derived from actual calculation in each instance, show clearly enough that while the strains vary as the square of the length, the material to meet them varies more nearly as the first powers. It must be noted that in this particular calculation the midship section is assumed to be the same with each different length, wherefore the strains vary as the squares, not as the cubes, of the lengths.

As regards differences in model, seeing that strains depend so directly upon proportionate dimensions and upon displacement, it will probably be generally conceded that a wide door for error is left open when these are attempted to be averaged. The co-efficient of fineness of displacement, reckoned from the top of the keel to the load-line, has been in vessels recently built as high as .81 or .82, and I suppose in some vessels of special type it will be found to be below .50. In Fig. 7, I give the strains relatively with models of .50 and .78 of the parallelopiped taken to the bottom of an ordinary keel.

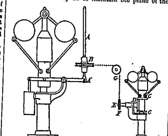
The classification societies, forming their rules tentatively, have preferred, not perhaps unnaturally, to make out tables and prescribe rules, both based largely on practice, rather than to enunciate principles or simply to prescribe a limit, as the Board of Trade do in the case of bridges. It is not therefore easy, or even possible, to say how far any of them recognise the depth of the girder as an element of strength. The calculations shown in Fig. 7 refer to the practice of one society only. Similarly as regards an added constant for corrosion, it is not stated how much is allowed.

It is probable that changes will ere long be made in the rules of one or all the classification societies. Many shipbuilders are far from satisfied, and it is in every way undesirable that we, the builders, who are the designers and constructors, should not be content with the regulations of those who in so many respects assist us and aid us, and to whose funds we are the principal contributors.

KNOWLES' AUTOMATIC SUPPLEMENTARY GOVERNOR.

IT is well known that the action of a centrifugal governor produces only an approximate uniformity of speed in a steam engine. For every position of the throttle valve, or of the trip mechanism of the automatic expansion gear, there is at a given pressure a corresponding speed of the engine, not usually differing greatly from the determined speed, but still sufficiently to be of importance in many industries, particularly in cotton spinning, where the machinery is normally run at its highest possible velocity for good working, and is especially sensitive to sudden fluctuations. Many attempts have been made to produce governors that should not be subject to this disadvantage, but hitherto with very slight commercial success. Lately, however, Mr. Wm. Knowles, of Bolton, has devised an exceedingly simple and effective method of overcoming the difficulty. Instead of seeking to produce a theoretically perfect governor that should have no margin of error, he has adopted the existing type, and has corrected its variations by the aid of a supplementary apparatus, whose action is intended to be limited to the small difference of speed, corresponding to the difference between the highest and lowest working positions of the governor balls. This supplementary apparatus consists of a small centrifugal governor, having upon its spindle two friction discs, situated so far apart that there is room for a friction bowl to be placed between them. When the engine runs at the normal speed both the friction discs are clear of the edges of the bowl, but the slightest alteration in speed, either upwards or downwards, brings one plate in gear with the disc, and thereby rotates it. This motion may be utilised in various ways in controlling the engine; in the illustration below an arrangement is shown in which the rod connecting the main governor to the automatic expansion gear, is lengthened or shortened by means of a right and left-handed nut driven from the friction disc of the supplementary governor. A A^1 are the two parts of the rod; B the nut, carrying a grooved pulley; C C the friction plates, D the friction disc, and E a pulley that transmits motion to the nut B.

It will thus be seen that the main work of governing the engine devolves, as in the past, upon the large governor, which can be set to any required degree of sensitiveness and rapidity of action, while the hitherto uncorrected variations, due to the different positions of the governor balls, are compensated by the small governor, which reduces or increases the length of the rod A in such way as to maintain the plane of the



large governor constant. A number of diagrams have been taken by Moscrop's speed recorder from first-class engines, running alternately with and without the supplementary governors, and the improvement in uniformity in the former case is most marked, particularly where the steam pressure is subject to variations. Messrs. Hick, Hargreaves, and Co., of Bolton, are the manufacturers of the improved governors.

PROFESSOR FLEEMING JENKIN'S ELECTRIC TELPHERAGE.

"TELPHERAGE" is the name given by Mr. Fleeming Jenkin, the well-known electrician and professor of civil engineering in the University of Edinburgh, to a system which he has devised for transporting vehicles, containing goods and passengers, to a distance by the electric current independently of any control exercised from the vehicles themselves.

The system has been patented, and it is to be hoped that a practical trial of it will soon be made. Professor Jenkin's idea is to employ strained metal cables which will serve both to sustain the load and convey the electric current. The frames or trucks supporting the load run along the cable on wheels, and the cars or loads are suspended below them from the axles of the wheels.

In the simplest arrangement of the line there is a break of continuity at each post supporting it; and the sections of cable are themselves insulated from each other, and the earth. They are, however, capable of being connected by movable coupling pieces, actuated by the train, so that all the sections receive the exciting current and form part of the general circuit.

The current is supplied to the line by a stationary dynamo-electric machine driven by a steam engine or other motor; and since the line is elevated from the ground on insulating standards, the same dynamo will supply a considerable length of line, as the leakage need not be excessive if proper precautions are taken. With ground lines of electric railway, like that of Siemens or Edison, the leakage is very marked, and Mr. Edison has adopted the plan of dividing the whole line into short sections of a few miles, with stations and feeding dynamos at each. Dr. Werner Siemens favours the use of an insulated conductor supported beside the line, and giving current to the motor on the train by means of a running connexion pulled by the train. Professor Ayrton and Perry have, as is well-known, sought to overcome the leakage difficulty by making the line in very short sections, each of which is put in circuit with the dynamo in turn as the train progresses, by an automatic action of the train itself. In this way there is only one section electrified at a time, namely, that over which the train is running, and the leakage on the whole line is consequently very small.

The loads or cars on the telpherage line are connected together in trains, and the length of a train is nearly the length of a section of the cable or conductor. On passing either of the movable coupling pieces between two sections, the train throws it out of action, disconnecting the two sections at that point; but the circuit between these sections is maintained through the wheels of the train itself and a conductor on the train. In circuit with this conductor is a dynamo-electric motor, which is actuated by the current, and propels the train by driving the wheels. The power provided is more than sufficient to keep up a maximum speed, and the train is provided with a governor which, when the speed is sufficient, closes a shunt and allows the current to pass without traversing the coils of the electro-motor. The governor acts directly to check the train if the speed becomes excessive, by short-circuiting the electro-motor, or otherwise bringing electric brakes into operation.

To further insure that one train shall not overtake another, Professor Jenkin provides an automatic telegraphic communication along the line, and the trains in passing close and open the telegraphic circuits. This automatic telegraph actuates circuit closers between the different sections of the main cable or conductor, so as to maintain connexion between the sections for a certain distance behind the train quite independently, it may be, of the movable coupling pieces. It is obvious that a following train entering upon a part of the line in which the sections are thus connected will have its speed checked, as the application of the power upon the train depends upon there being a break in the electrical coupling between the two sections on which the train is for the moment supported.

It will be seen from the above description that the control of the trains is completely automatic and independent of the guards or engine drivers. Fig. 1 will serve to explain the system more clearly. Here A^1 A_2 A_3 A_4 are separate sections of the insulated cable, and B B B are bridge pieces which establish metallic connexion throughout the series of insulated sections, so that wherever there is no train on the line the sections are coupled together and form part of the circuit. At one end of the line C, there is a stationary dynamo supplying a constant current to the circuit, despite the variations of resistance caused by more or less trains upon the line. A train on the line between sections A_2 and A^1 is indicated at D; and the length of this train is such that it always spans at least one of the junctions between two sections. The train, as it enters on a new section, removes the bridge or coupling piece B, which connects this section with that in rear, and thus compels the current, in order to maintain its circuit, to flow through a connecting wire or conductor G_1 (Fig. 2), on the train in which one or more electric motors are connected. These serve to turn the wheels of the cars by proper gearing, and propel the train.

traders, instead of passing through a middle man, and being swept away to the Presidency towns, to be subsequently remitted to England

THE ELECTRICAL TRANSMISSION OF POWER.

(Concluded from page 619, vol. xxxii.)

In the transmission of energy by electricity we have to consider not only the generator, but also the instruments and various machines that may be placed in circuit. There may, at a given moment, be many of these, and at another only a few; so that the total energy required to meet these different cases is a very variable quantity. The whole energy, we know, is represented by the product of the electromotive force and the current ($=EI$). Hence we have two ways of varying this product, viz., by varying both factors simultaneously or each of them separately. The latter, however, is alone eligible on account of its simplicity. If we wish to keep I constant, we must arrange the receiving instruments in series; then as every change in the number of machines in circuit produces a corresponding change in the current, it will be further necessary to be able to vary the potential of the generator accordingly, *i.e.*, we must be provided with some kind of a potential regulator.

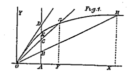
If we prefer to keep E constant, we must connect the receiving machines as we would the cells of a battery "for quantity." A moment's reflection will show that even this system will not always work without a regulator; for let the current from the generator be sent through a circuit of resistance R, then $I_1 = \frac{E}{R}$. If we now insert a machine of resistance R, the whole resistance will be halved so that $I_2 = \frac{2E}{R}$, and there would be sufficient surplus current to work the second machine.

But this assumes the internal resistance (r) of the generator to be *nil*, which is plainly inadmissible. We should have $I_1 = \frac{E}{r+R}$ and $I_2 = \frac{E}{r+\frac{R}{2}}$, whence it does not follow that $I_2 = 2I_1$, nor can we say that the second machine will work effectively.

In both cases a regulator is required which will vary the electromotive force E of the generator, so that the difference of potential at the terminals may be permanently kept at a certain value e, notwithstanding the introduction of machines into the circuit or their withdrawal from it. This implies three conditions: 1, that each apparatus shall receive its share of the total energy and work independently of the others; 2, that the regulator act instantly and automatically; 3, that the regulator control the generator in such a way that the latter will produce just the quantity of electricity required for the service of the machines then in circuit. It is obvious that the arrangement in series is the less favourable to the realisation of these three conditions, for the various instruments, when thus connected, are much more dependent upon one another than when arranged "for quantity." M. Marcel Deprez in the investigation published in *La Lumière Electrique*, and which are following, has examined this somewhat complex question, and applied the graphic method to its investigation. He has succeeded in this way in explaining several curious and imperfectly understood phenomena observed in dynamo-machines, and also in showing how the above conditions may be carried out in practice. We shall proceed to give the principal theorems, applying them to any continuous current machine, say a Gramme.

We commence by making two distinct circuits of the armature and electro-magnets. Around the latter we send a current of known strength. Then starting the armature we measure the electromotive force corresponding to this speed V_1. We next vary the current, keeping V_1 constant, when we shall find for each value of I a definite electromotive force E. We draw two lines at right-angles for our axes and measure I along X and E along Y. We shall obtain in this way a series of points which, when connected together, will give a curve that quite characterises the machine driven at the speed V_1. This curve, called the "characteristic," depends for its form and properties upon the construction of the machine, its dimensions, and the relative disposition of its parts. Such a curve is shown in Fig. 1 and the following diagrams.

If now we restore the former connexions and drive the armature at the speed V_1, the current I developed in the armature circulates round the inductors thus producing the magnetic field. Let O F (Fig. 1) be marked off equal to I, then O G H



being the "characteristic" of the machine, F G will be the corresponding electromotive force. Ohm's law gives $I = \frac{E}{R}$ whence $R = \frac{E}{I}$, and applying this to Fig. 1, we find that $\frac{E}{I}$ is the tangent of the angle F O G. The resistance of the circuit is thus represented by the tangent of an angle.

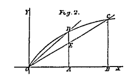
If we chose to diminish the resistance, *i.e.*, the angle F O G, the line O G would approach the axis of X, and, from the concavity of the curve, we see that the electromotive force would increase rapidly at first, then slowly, until ultimately it becomes constant. The curve then reduces to a straight line parallel to the X.

This phenomenon is explained by the changes which take place in the magnetic conduction of the inductors. The magnetisation increases rapidly at first with the current, and almost imperceptibly as the point of saturation is approached.

On the other hand, if instead of diminishing we increased the resistance, the line O G would rise towards the axis of Y; and for a certain position, viz. O D, would become tangent to the curve at the origin O. The electromotive force would then entirely vanish, and the machine cease to work. This is the phenomenon of the demagnetisation, and Fig. 1 shows that there is a definite resistance, viz., the tangent of D O A, for which the inductors are completely demagnetised.

When we have determined the "characteristic" for a velocity V_1, we can readily draw that corresponding to any other velocity V_2. It will be obvious that we have simply to multiply the ordinates of the first curve by the ratio $\frac{V_2}{V_1}$.

If we keep the velocity constant, and change the number of convolutions of the wire wound round



the armature from t_1 to t_2, we shall obtain the new curve by multiplying the ordinates of the first by the ratio $\frac{t_2}{t_1}$, providing, however, the volume of the wire has not been materially changed.

This graphic method also furnishes a convenient way of determining the difference of potential e between two points of a circuit of resistance $R+r$, separated by a known resistance r.

In Fig. 2, take the angle D O X such that tan. D O X equals $R + r$ and C O X such that tan. C O X$=$R. Then from the figure, we have:

$$D\,A = O\,A \tan. D\,O\,A = I\,(R+r)$$
$$E\,A = O\,A \tan. C\,O\,A = I\,R.$$

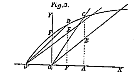
Therefore, by substraction,

$$D\,A - E\,A = D\,E = I\,(R+r) - I\,R = I\,r.$$

And by Ohm's law, Ir equals e the difference of potential at the two ends of the circuit r through which the current I is passing.

As a particular case, let tan. C O X represent the internal resistance of the machine, and let the total resistance be variable. Then when the resistance equals tan. D O A, D E will be the difference of potential e at the terminals of the machine. Let D O coincide with C O, then e is *nil*; moving away from this position of coincidence towards the axis of Y, e will gradually increase until it reaches a certain maximum, after which it will rapidly decrease until it again vanishes when D O becomes tangent to the curve.

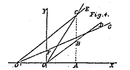
It may be important to consider the consequences of having an initial magnetic field. This may be obtained by winding the inductors with two separate circuits. If a current from a battery or a second machine be sent through one of the circuits, the magnets will be "made" and will give rise to the primary magnetic field. Let O' F C, Fig. 3, be



the "characteristic," obtained as before, *i.e.*, when an independent current is sent round the inductors. Let O' O represent this current, then O F will be the electromotive force, and F will be the starting point of the new "characteristic" due to the combined action of the independent current and that induced in the armature, so that the only change occasioned by the initial "field" is the transformation of the origin of co-ordinates from O' to O.

If we examine a carefully drawn "characteristic," we shall notice that it does not materially differ from a straight line until we approach the point of saturation of the electro-magnets; and we know, moreover, that by increasing the masses of these, the point of saturation may be further removed, and the rectilinear portion of the curve lengthened out.

Let O' G, Fig. 4, be the rectilinear characteristic of a machine. On superadding a constant magnetic field, produced by a current O' O, the characteristic will, as we have seen, be represented by the portion of O' G beyond the new axis of Y, viz., F G. If D O X be the angle whose tangent represents the internal resistance of the machine, F G and O D will, in general, intersect; and, as the portion of the ordinate intercepted by these two lines represents the difference of potential e at the terminal of the machine, it follows that this difference is a very variable quantity. But we have been led to conclude that this e must be kept constant in order to distribute effectively the electrical energy of the generator to a number of machines arranged "for quantity," and Fig. 4 shows how this may be



accomplished. For, by increasing the speed of the armature, the line O' G will be displaced towards the axis of Y, and, for a certain speed of the armature, it will take the direction O' C parallel to O D. The difference of potential e will then be always equal to C B whatever the resistance C O X of the circuit may be.

We see, therefore, that we must begin by raising the speed of the machine to a certain value V'. Then if E_0 denote the electromotive force of the constant external current used in "making" the field magnets, and E the whole electromotive force $\frac{E-E_0}{I}$ will, since E and E_0 are represented by ordinates, denote the tangent of the angle which the rectilinear characteristic makes with X. For the required parallelism, this expression should be equal to the tangent of the angle denoting the internal resistance r. If it be not, we must find the velocity V' such that

$$\frac{V'}{V} \cdot \frac{E-E_0}{I} = r,$$

whence we get

$$V' = \frac{r\,V\,I}{E-E_0}.$$

The strength of the independent current and con-

The last equation may then be written

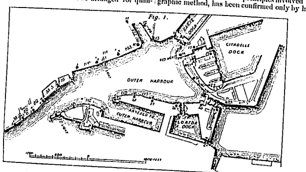
$$V' = \frac{r\,V\,I}{E - E_0},$$

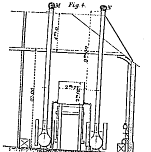
which is identical with that already found for the quantity arrangement.

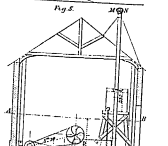
From this it follows that the speed of the armature necessary to tilt up the "characteristic" to the required parallelism is exactly the same whether the receiving machines be arranged for quantity or in series. In the former case, it will be remembered that the armature and electro-magnet circuits are separate, and that an independent current of determined strength is required to make the "field." The whole current induced in the armature is then available for useful purposes. In the second case, the field magnets are excited by a current derived from the armature, and we are thus left with only the balance for external work. The main difference between the two cases lies in the connexion or separation of the two circuits, and as this can be effected automatically, it follows that by fitting up a generator with a commutator we can use it for the distribution of electrical energy to any number of machines all of which are arranged either for quantity or in series.

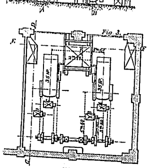
We may notice, in conclusion, that in the preceding ingenious methods and contrivances, we have compelled the electric current itself to so adjust the system as to enable us to dispense altogether with a mechanical potential-regulator.

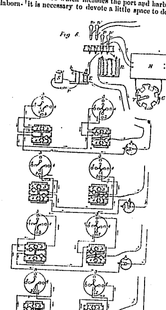
The correctness of the principles involved in the graphic method, has been confirmed only by laboratory experiments as yet. It is proposed, however, to apply them very shortly on a large scale. The results will be of much theoretical and practical interest.









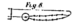


THE ELECTRIC LIGHT AT THE PORT OF HAVRE.

In a large number of tidal ports the entrance or departure of ships can be effected only twice in the twenty-four hours at the time of high water. Varying with the season the high tides occur, either both when the sun is above the horizon, or one during the day and the other at night, or both during the night. From this it results that during the period of long nights, that is to say, especially the period for bad weather, ships are often obliged to wait for several days, either for a bright night or for the next day tide, either for going in or out of port, which causes not only loss of time, and delay in commercial operations, but a serious loss of money. It is a less evil when the ship is at anchor in port, than when it is outside waiting to come in, liable at any time to damage from storm which might have been evaded if the ship could have entered harbour at once. Of course many ports do not present difficulties that render it dangerous or impossible for vessels to enter or leave on the night tides. In all cases, however, it is true that with ships, especially large steamers, the handling of which requires great caution, the responsibility of captains is very great, and a mistake easily made in the darkness may result disastrously. For a long while the chambers of commerce and the directors of ports and harbours have been occupied with the efficient lighting of entrances, a necessary complement to lighthouses and port and signal lights. This is almost impracticable with gas, which has too small a range to illuminate properly even the entrance and locks. Latterly, in many instances this has been partially done by electricity.

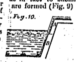
The port of Havre was the first to which a complete system of electric illumination has been applied, and a glance at the general plan shows how usefully these means of lighting could be employed. We reproduce in Fig. 1, a general plan of that part of Havre which includes the port and harbour, and it is necessary to devote a little space to describing the arrangements, in order to show clearly the services rendered by the electric installation, services that will doubtless be extended there before long. The port of Havre consists, as will be seen, of an entrance channel giving access to the outer port. This channel is 90 yards wide, and is formed of two masonry jetties. The north jetty, 1482 ft. long from the shore to the end, has a projection of 360 ft. on the ground enclosing the principal part. The projecting part exposed to the sea on two sides is constructed entirely in masonry. Beyond that on the one side two breakwaters are formed, consisting of a chamber on an inclined plane terminating on the side of the channel by a sill on which is raised a grid that allows the waves to enter the chamber, and there break their force The southern jetty, which was 787 ft. long, is to-day partly destroyed, there only remaining a length of about 160 ft. The outer port has an area of 27½ acres, with a development of 5457 ft. of quays, of which only 2276 ft. are made use of for business purposes, representing 686,000 sq. ft. of quay area, on which are distributed seventeen cranes for loading and unloading merchandise. This port is quite dry at low water; it gives access to eight floating basins, entered by locks, and there are four dry docks. The eight basins are respectively known as le Roi, la Barre, la Floride, l'Eure, la Citadelle, le Commerce, le Vauban, and le Dock. These have a total area of 131 acres, and a development of 29,356 ft. of quayage, of which 26,338 ft. are utilised, giving an area of nearly 13,000,000 square feet available for storing goods, and other purposes. The oldest of the basins is that called le Roi, which prior to 1820—an epoch at which the population of Havre was only 20,000—constituted almost the entire port. At this time the Commerce and the Barre basins were opened for navigation; the Vauban dates from 1841. But the commercial development of the port of Havre dates really from 1844, when the old

...rs are brought to each ... masonry to the level ...e wires are stripped of ...re simply coated with ... the damp. They are



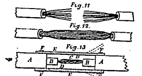
...ith six copper contacts ...ed by a piece d attached ... the bolts n n. It will ... recesses are made in ... commutator. Metal ... holes formed by the ... and electric communi-...etween the two upper ...r ones on the left, and ... In the last commutator ...itacts are in permanent ...ive lamps are identical; ...ouped two by two with ... In the sixth the four ... wire. Each of the first ...ommutator by six con-...e only. In the position ... 6, the passage of the ...d it will be seen that it ... six lamps. When they ... has only to turn the ...ch a way as to place the ...xion with the second ... No. 2 of the series are ... the man in charge sends ...amp, and introduce the ... upper contacts of the ... has been done, if any ...ndant would only have ...ontact of the two-way ...osition to secure the ... of candles. Afterwards ... insert the plug between ... the commutator, and in ...akdown, another move-...ould secure the lighting ...andles. It should be ...f the candles can be cut ...ed, a provision that is ...stances. The means are ...ur candles consecutively; ...f illumination nightly is ...f the candles burns for ... there is an ample margin ...er it sometimes happens, ...o tides during the dark ...he port twice. After the ...ll that is necessary is to ...oper positions in the com-...ving to be renewed, an ...rm in the darkness, and ...ich is the arrangement of ... Havre, and possessing ...stics, peculiar to this in-

... nature of the soil at the ... great permeability, the ...lectricité, after some pre-... to use cable conductors ... envelope of a very resist-...us in fact to submarine ...are formed (Fig. 9) of a



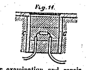
...ls of copper wire, enclosed in a sheath of rubber, over which is placed a series of protective coatings of gutta-percha, rubber cloth, and three thicknesses of paraffined hemp wound alternately in opposite directions so as to cover the joints completely; then follows a covering of galvanised iron wire, and finally a thickness of hemp. The necessity for this great precaution in protecting the conductors will be understood, when it is remembered that the cable has to pass through five locks, so that for the greater part of its length it is under water. It was necessary that the insulation should be as perfect as possible, as the same current has to feed simultaneously six candles, and consequently to possess too high a tension to be preserved except with the greatest care. Crossing the locks was one of the most delicate details of the work. All the conductors were held together by wire, and at low water they were laid from barges, and to avoid being dragged, they were held down by pig iron placed over them at frequent intervals; the two ends of the cable were raised and fixed against the sides of the lock. At the point where there was any danger of contact with the sides of vessels, they were recessed in a groove made in the masonry, and covered with cement.

At the passage of the Nôtre Dame lock the conductors are shielded behind the large cast-iron mains which convey the water and gas, and which protect them from injury. But it has happened that despite this very substantial security, this point is the only one where an interruption to the circuit has taken place. It was caused by the rupture of the water main, which damaged the cable. This injury was repaired by splicing, the only instance of the kind in the whole circuit, it having been avoided elsewhere by an arrangement to be described directly. The operation of splicing was a very delicate one, since the joints were likely to form weak spots in the system, and in this particular instance they were almost always under water. The conductors at the ends of the cable to be joined were stripped, the central wire in each was suppressed, and the strands were twisted in the manner shown in Figs. 11 to 13. Before joining the



A A ends of cable; B B, conductors stripped except the rubber envelope; C, splice; D, paraffin; E, lead tube; F fastening wire.

strands, a lead sleeve was passed over the end of one of the conductors, having about the same diameter and about triple the length of the splice. This sleeve, fastened to the cable by a wire serving, was widened at the other so as to make a bell-mouth, and melted paraffin was poured in, filling the space between the splice, the stripped cable, and the lead tube. When the paraffin was solidified, the lead tube was hammered down and fastened to the other part of the cable by wire. The operation is illustrated by Fig. 13. On all other parts of the circuit, as we have said, splicing was avoided, the length of the cables having been carefully computed beforehand and made accordingly. The circuits were so arranged that the junctions of the different cables on the same line were made at the same points, where pits were made so as to give



facilities for examination and repair. These pits were made as follows. The cables, where they are laid in the ground, have a depth of about 18 in. below the level. At the points where the ends had to be united, a pottery cylinder was placed into which the two ends were raised, having been previously stripped; the strands are then connected by a copper locking-piece. After this has been done, plaster-of-paris is poured into the cylinder, embedding the turned-up ends of the cable. When this has solidified, melted paraffin is poured in, in such a way as to enclose the junction; finally cement is added on top and made good to the top of the cylinder, which is covered over with a cast-iron plate. The object of this arrangement was not only to reduce expense but also to simplify examination, in case of loss of current, by limiting it to an exactly defined spot. The total number of these junctions in the whole system is 24. Where the cables pass under the breakwaters of the jetties as mentioned above, they are secured by iron cramps, and by staples fastened to the timber framings.

The effect produced by the 33 candles distributed as explained, and as shown on the plan, Fig. 1, can not be easily imagined. As we have said, the installation has succeeded beyond all expectation, and has been unanimously approved by the Chamber of Commerce as well as by the engineers and captains of vessels, and the pilots of the port. The utility will be soon increased by the addition of some new lights, and by raising the existing ones. It is also proposed to paint white the adjacent houses and the walls of the locks, in such a way as to transform them into reflectors, and facilitate still further the passage of ships. During the last six months the installation has been in full work and has been of great service, especially to the Transatlantic vessels, some of which are 380 ft. long, and to the Hamburg line, which is used largely for the transport of emigrants.

The whole of the work was carried out by M. G. Descamps, engineer of the Compagnie Générale d'Electricité, from the plans of M. Henry Parent, engineer-in-chief to the company, and under the control of M. Bellot, ingénieur en chef des Ponts et Chaussées, and of MM. Widmer and Delorme. We are glad to be able to give the names of all those who have taken part in this interesting installation, which is one of the most important yet undertaken in connexion with the electric light, not on account of the number of lamps, but because of the numerous difficulties that the requirements of the case and the location presented, and which have all been so fortunately overcome.

ENGINES OF S.S. "MEXICAN."

We give this week a two-page engraving containing two views of the compound engines of the s.s. Mexican, a vessel which is being built for the Union Steamship Company by Mr. James Laing, of Sunderland. The engines for the Mexican are being made by Mr. George Clark, of the Southwick Engine Works, Sunderland, and they were amongst those which were seen in progress by the members of the Institution of Mechanical Engineers during their visit to these works in August last. We shall in an early number publish further illustrations of these engines, and for the present, therefore, we postpone any detailed description.

COLD-AIR MACHINES.

To the Editor of Engineering.

Sir,—The letter signed by Mr. J. W. de Galwey in your issue of the 30th has already appeared in the pages of your contemporary *The Engineer*, and I need only say I dealt with it at length there; the experiments referred to being for the benefit of some writers in your contemporary who raised the point at issue.

I also then thanked Mr. Galwey for the information about a machine in Ireland, constructed for Mr. Shaw; but stated that the old specifications of Newton and others he referred to had been long known to me, and did not represent the machines at present in the market.

Yours, &c.,
J. J. Coleman.

45, West Nile-street, Glasgow, January 3, 1882.

THE INDIAN PUBLIC WORKS DEPARTMENT.

To the Editor of Engineering.

Sir,—Your articles in defence of the civil engineers of the Indian Public Works Department against the unfounded aspersions of the Duke of Argyll deserve our very best thanks. Will you allow one of them to ask, through you, the Council of the Institution of Civil Engineers the reason of their silence on the matter hitherto? I have heard it bitterly commented on more than once. There are by the last classified Public Works list no less than 50 members and 94 associate members of the Institution in the Public Works Department.

The Council represents the profession to us and to the world at large. Was it not therefore their bounden duty to request the present Secretary of State for India to explain the disgracefully false accusations so publicly made by his predecessor? Surely the honour of the profession demanded no less, and it is as much the duty of the Council to uphold this as to hear papers read at meetings. If not what is the Council for?

Yours faithfully,
M.I.C.E.

[Our correspondent will probably have learnt by this time that the Council of the Institution took prompt action in this matter, and that the Duke of Argyll's apology for the unfounded charge he made against the civil engineers of India, left nothing to be desired.—Ed. E.]

ELECTRIC TRANSMISSION OF POWER.

After the uncertain and somewhat contradictory reports that have been afloat as to the results obtained by M. Marcel Desprez, in his experiments on the electrical transmission of power over long distances, the record of two trials made in Paris by M. Tresca, with the co-operation of Dr. Hopkinson, will be welcomed by all who are interested in this important subject. These experiments were made under the most rigid conditions, and the results have been analysed and arranged in such a way as to show the amount of power at each point of the installation, and the loss due to each component of the apparatus. The information thus gained indicates to electricians the exact points at which the loss takes place, and further demonstrates how much of this loss may be avoided by better mechanical arrangements, and how much is inherent to this system of transmission.

The trials were made in the workshops of the Chemin de Fer du Nord on February 11 and 18, and the results were presented to the Académie des Sciences by M. Tresca in two papers, which have since been published in our contemporary *La Lumière Electrique*.

The telegraph wire by which the transmission was effected was 4 millimetres in diameter (No. 9, B.W.G.) and stretched from Paris to Bourget, and back again, a total distance of 17,000 metres (10½ miles); its resistance was 160 ohms. The two machines, the generator and the motor, were placed near together. One pole of the generator was connected to the appropriate pole of the motor through the 17,000 metres of telegraph wire, while the other two poles were connected by a short conductor. The conditions were sensibly the same as those which would have been obtained if the two machines had been placed 8500 metres apart, and connected by a double wire, constituting a main and a return lead.

The generator had its armature constructed upon a peculiar plan, devised by M. Marcel Desprez, with a double bobbin, and was wrapped with wire one millimetre in diameter (No. 19, B.W.G.) The motor was a large Gramme machine of the military type, modified for the object in view. The resistances of the two machines were 56 and 83 ohms respectively.

In each experiment the rates of revolution of both machines were determined simultaneously by means of special counters. All the electrical measurements were made by Dr. Hopkinson, F.R.S., with the apparatus of Sir William Thomson. They coincided very exactly with determinations made the preceding days by M. Desprez with his own instruments. The difference of potential between the poles of each machine was taken by a Thomson galvanometer, by aid of a supplementary resistance of 50,000 ohms. The current was measured by means of another Thomson galvanometer, through which the entire current passed. The magnets of both instruments, after having been verified in London on the 9th of February, were examined again on the 13th, on their return to Paris, without any change being discovered. Each division of the galvanometer used to determine the potential, corresponded to 50.7 volts, and each division of the current galvanometer to 0.223 ampère.

The power dynamometer was of the Morin type, and was lent by the Conservatoire des Arts et Métiers. Its indications were given in the form of a diagram. The power exerted by the motor machine was absorbed by a Prony brake, the lever of which, measured horizontally, was 0.796 metres, corresponding to a distance of 5 metres per revolution. The lever was uniformly weighted to 5 kilos., hence the work done per revolution equalled 25 kilogrammetres.

Seven successive trials were made under the above conditions; one diagram, that of the last of these experiments, was a failure. Besides these, in the eighth dynamometric determination, the work consumed in the mechanical transmission, between the dynamometer and the generator, was estimated. The speed was at that time greater than during the other trials, but as the power consumed per revolution formed the basis of the calculation, it was possible to calculate its influence readily upon each of the preceding experiments.

The following Table shows all the data obtained, and also their mean values :

TABLE I.

Number of Diagram.	Dynamometer. Mean Ordinate of Diagram.	Dynamometer. Revolutions per Minute.	Dynamometer. Work in Kilogrammetres.	Dynamometer. Work in H.P.	Current. Intensity of Current in Ampères.	Generator. E.M.F.	Generator. Revolutions per Minute.	Generator. Electric Work in H.P.	Motor. E.M.F.	Motor. Revolutions per Minute.	Motor. Electric Work in H.P.	Brake. Work on Brake in H.P.
	metres					volts.			volts.			
I.	12.87	101	500.07	6.66	2.523	1447	633	4.89	1037	418	3.50	2.32
II.	12.84	98	484.09	6.45	2.594	1324	596	4.61	936	369	3.26	2.05
III.	13.49	97	503.39	6.71	2.531	1237	608	4.19	887	384	3.01	2.13
IV.	12.48	92	441.70	5.89	2.564	1247	571	4.27	869	345	2.99	1.92
V.	13.01	87	435.43	5.80	2.564	1212	533	4.17	814	315	2.80	1.75
VI.	12.52	90	433.48	5.78	2.576	1276	580	4.41	908	363	3.14	2.01
Total	77.21	565	2798.16	37.29	15.352	7743	3541	25.56	5451	2194	18.70	12.18
Mean	12.87	94.2	466.36	6.21	2.559	1290.5	590.2	4.42	908.5	365.8	3.12	2.03
VII.	x	104	x	x	2.645	1533	699	5.47	1146	502	4.09	2.75
VIII.	0.78	112	33.6	6.45								

The mechanical work is estimated in French horse-power, of the value of 75 kilogrammetres per second, but the electrical work was calculated by Dr. Hopkinson in English horse-power, at the rate of 76 kilogrammetres per second. The experimentalists have thought it better to publish the Table as it stands than to alter Dr. Hopkinson's figures.

From a consideration of the first six experiments, which are the only ones that are complete, it is seen that out of 6.2 horse-power expended upon the shaft of the dynamometer, there were transmitted 2.03 horse-power, a return of 33.7 per cent. This result is abundantly confirmed by a comparative examination of the successive figures of each of the columns. For a mean velocity 94.2 revolutions per minute of the dynamometer, the work of the mechanical transmission, including the work of the generator when it was running idle, amounted to $0.3 \times 94.2 = 28.26$ kilogrammetres, or 0.377 horse-power, and the foregoing figure of efficiency is thus altered in the ratio of $2.01 : (6.21 - 0.38) = 34.5$ per cent. But little importance is to be attached to this correction, because it is hardly possible in actual practice to suppress this supplementary work, which must include at least the mechanical resistance of the spindle of the generator.

But it is above all in an examination of the efficiency of the individual parts of the installation that the most interesting indications are to be found. In Table II. these points are more clearly to be seen by the dissection of each of the experiments into three distinct parts.

placed parallel with the preceding, the following indications are all that are available:

Electric work of the generator... ...	4.61
Intermediate loss (by difference) ...	1.31
Electric work of the motor	3.30
Intermediate loss (by difference) ...	0.51
Actual work transmitted ...	2.79
Efficiency of the circuit...	0.711
„ „ the motor	0.845

The figure of this last efficiency differs notably from those that are contained in the general Table, but it is not too hazardous to conclude from the ratio 0.711 that the proportion of work transmitted favoured by the notable increase of speed, would not differ greatly from those which were measured directly.

Commencing with the resistances of the two machines in a state of rest it is easy to calculate the work lost in heat, and to deduce by subtraction for each machine, the supplementary work lost either by sparking or friction, or by a possible increase of resistance during working. These losses amounted to .92 horse-power for the generator and .36 horse-power for the motor. This difference is explained by the relative smallness of the work which is put in operation in the motor, and its measure, completing the facts which have been already given concerning the various losses, takes account of all the practical conditions of the trials.

In conclusion, the work actually transmitted to a distance of 8½ kilometres (5¼ miles) by an ordinary telegraphic wire of 4 mm. in diameter (9 B.W.G.) in an installation of the kind adopted by M. Desprez represents one-third of the motive power. If the resistance of the intermediate circuit be abstracted, the current remaining unchanged, the corresponding useful effect would amount, according to these calculations, to nearly one-half the motive power. The experiment, which was carried out with the greatest accuracy in all its details, has realised for the first time the transport to a great distance of 2 horse-power, and in one of these trials of 2.79 horse-power.

TABLE II.—SHOWING THE WORK MEASURED AT THE VARIOUS POINTS OF THE INSTALLATIONS.

Number of Experiment	I.	II.	III.	IV.	V.	VI.	Total.	Mean.
Motive power at dynamometer	6.66	6.45	6.71	5.89	5.80	5.78	37.29	6.21
Power lost at the generator (by difference)	1.77	1.84	2.52 ?	1.60	1.63	1.37	10.73	1.79
Electric power at terminals of generator ...	4.89	4.61	4.19	4.29	4.17	4.41	26.56	4.43
Power consumed in circuit (by difference)	1.39	1.35	1.18	1.30	1.37	1.27	7.86	1.31
Electric power at terminals of motor ...	3.50	3.26	3.01	2.99	2.80	3.14	18.70	3.12
Power lost at the motor (by difference) ...	1.18	1.21	0.88	1.07	1.05	1.13	6.52	1.09
„ transmitted to brake	2.32	2.05	2.13	1.92	1.75	2.01	12.18	2.03
Performances.								
Efficiency of generator (electric)	0.734	0.715	0.624	0.728	0.719	0.763	4.283	0.712
„ circuit (electric)	0.715	0.707	0.721	0.697	0.670	0.712	4.212	0.706
„ motor (mechanical)	0.671	0.610	0.707	0.642	0.625	0.640	3.895	0.651
„ installation	0.348	0.318	0.317	0.326	0.302	0.348	1.959	0.326

The results may be expressed in an extremely simple manner, by saying that each of the three parts of the installation gives a useful effect of about 70 per cent. The resistances of the generator, the heat there developed, the losses by the brushes, and the sparking represent an expenditure of energy equal to 30 per cent. Under the conditions of the trial the heat developed in the circuit represented 30 per cent. of the electrical energy delivered to it. Lest it should be feared that there was some unintentional communication between the two wires, they were carried upon posts all their length, and it is to be noticed that the mean intermediate loss, between the generator and the motor, is equal to 122 kilogrammetres, which corresponds to the total resistance of the circuit, which was 160 ohms. Then the resistance of the motor, including the influence of the brushes, and the sparking, absorbed also 30 per cent. of the electrical energy imparted to it. In round numbers the useful effect differed little from $0.70^3 = 0.343$.

In the data of the seventh trial, which may be

(*To be continued*).

ELECTRIC LIGHTING NOTES.

THE town of Szeged, in Hungary (70,000 inhabitants), has been partly lighted with incandescence lamps by Messrs. Ganz and Co. The first installation is in the street leading to the railway station, which has been furnished for a length of about 1000 yards with incandescence lamps of about 20 candles, spread at intervals of 40 yards. In the Place at the end of the street are placed four arc lamps.

After a sharp competition Messrs. Siemens Brothers have obtained the order for the electric lighting of the s.s. Aurania, the new boat of the Cunard Line. The success of the installations on the Arizona and the Alaska has been so decided that the Cunard Company has decided to adopt Messrs. Siemens Brothers' system in its entirety, including the rope transmission, instead of obtaining their machinery through intermediate companies, as in the case of the Servia.

A contract has been concluded with the United States Illuminating Company for lighting the great suspension bridge over the East River between Brooklyn and New York. The work will include the installation of 70 arc lamps, arranged on each side of the bridge. The power station will be placed on the Brooklyn side, and the lamps will be on two independent circuits, so that in case of a breakdown only one-half the lamps would be extinguished. The work has to be completed within two months.

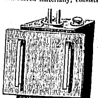
S.S. Tarawera (Union Steamship Company of New Zealand, Limited). The electric lighting plant on board this steamer, which was fitted up with the Edison system, is reported to have worked well throughout the voyage from Greenock to Melbourne. Only ten lamps (out of a total of 150) gave out during the voyage. As the loss of lamps during the first few weeks after starting an installation generally averages higher than that which occurs after the plant has been in use for a short period (owing to the weeding out of defective lamps), the result stated above may be reckoned as very satisfactory.

The Edison system appears to be progressing favourably in Paris. Among new installations there are the feather factory of M. Loddé, with 48 lamps; the glass works of M. Pochet, 20 lamps, and the artificial-flower factory of M. C. Marchais. At the Magazin du Louvre there are 60, at M. Lahure, printer, 60, and at MM. Hachette and Co., publishers, 100 incandescence Edison lamps. In Vienna two large salons of the Palace at Schönbrunn are to be lighted; in Brussels the theatre in the Park; in Germany the Royal Court Theatre of Dresden, and the Theatre Royal Munich are to be illuminated by the same system.

The American Electric and Illuminating Company of Boston, which commenced its operation in September last, is now working installations of 200 arc lamps, and has orders for 100 in addition. Its central station is situated in the basement of the Massachusetts Charitable Institution, and comprises one 150 horse-power Wheelock engine, two 50 horse-power Lawrence engines, and two rotary engines, one of 30 and one of 100 horse-power. The Thomson and Houston system of lighting is used, and the total capacity of the company's station is 1000 lamps of 2000 candles each. The *Boston Advertiser* states that there are at present over 75,000 arc lamps in use in the United States.

The advent of the Brush storage battery appears to have led to the formation of an alliance between the Brush and Swan companies in New York. There are already 18,000 Brush arc lamps in the United States, and nearly 100 companies, with a total capital of seven million dollars, have been founded in various cities and towns to furnish electric light as a legitimate business. By aid of Mr. Brush's late invention it is anticipated that most of them will be able to greatly increase their operations, and in addition to lighting the streets in the evening, they will be at work all the remaining hours charging accumulators placed in private houses and employed for feeding incandescence lamps.

In the last act of Iolanthe, at the Savoy Theatre there glows upon the heads of every peri, and also upon that of every mortal after he has "put on immortality," a brilliant star, in evidence of fairy privilege. Each star, considered materially, consists of a small



incandescence lamp of two or three candle power, connected by flexible conductors to a secondary battery attached to the back of the wearer and concealed, either by a mass of hair, or by a pair of wings. One of these batteries is shown in the accompanying view, where it will be seen to consist of a gutta-percha box,

...SSION OF POWER.
...n page 265).
...a second series of trials ...to apparatus, the only ...ed of the generator was ...to about 900 revolutions ...tions were conducted as ...xcept that the electrical ...e from the readings of ...under the control of M. ...ere made, the first having ...termination of the power ...enerator empty. Among ...nust be put aside, as the ...failed to mark, in con... of the paper, and the ...ed upon than the others ...wer, on account of the ...ling diagram.
...ons were made as follow: ...intensity. The indica..., in the circuit of the telegraph wire, oscillated 10.5 and 11 divisions of which corresponds to a ...mpères. It will be seen ...satisfactorily with the ...ements.
...differences of potential at ...nes. This difference was ...galvanometer of 56 ohms ...derived circuit from the ...ne, formed by a known ...0,000 ohms successively. ...nstrument, 1 division= ...electromotive force to be ...observation, by means of

$E = \frac{n^1}{220}(30,050)$

...act readings of this instru-

...namometer Readings.

...nal Resistance 10,000 Ohms.		Additional Resistance 30,000 Ohms.	
...tor.	Motor.	Generator.	Motor.
...0	−7.53	+11.75	−11.00
...0	−6.60	+9.60	−10.00
...0	−8.90	+13.80	−13.80
...5	−8.95	+13.90	−13.90

...riations of n and n^1, which ...n for the two machines re... for each of them a constant ...nd the verification of that ...demonstrate that the con... remained stable during the ...lucing the values of n and n^1, ...aforesaid equations, which ...values of E, the electro-...he poles of each of the two ...d.

...tromotive Force in Volts.

Motor.				Ratio.
...an.	R=10,000.	R=30,000.	Mean.	
70	1122	1411	1418	0.801
98	1160	1161	1101	0.775
78	1672	1673	1673	0.805
3	1684	1687	1687	0.798

...f measurement have produced ...most identical, they may be ...nce.
...the mechanical work. The ...d the same brake were used ...ccasion.
...trials are contained in Table V, ...o form as that based on the ... viz., Table I.
...etween the speeds of the motor ...vas as 595 : 814 = 0.743, whereas ...r exceeded 0.620 in the trials of
... values of the work represented ...ouped in such a way as to show ...e points of the transmission. ...trial is a little uncer... mean ordinate of the diagram ...gth of about two metres. The ...n running idle is much more

TABLE V.—SHOWING THE NUMERICAL DATA OBTAINED FROM ALL THE EXPERIMENTS.

Number of Diagram.	Dynamometer. Mean Ordinate of Diagram.	Dynamometer. Revolutions per Minute.	Dynamometer. Work in Kilogrammetres.	Dynamometer. Work in H.P.	Current. Intensity of Current in Ampères.	Generator. E.M.F.	Generator. Revolutions per Minute.	Generator. Electric Work in H.P.	Motor. E.M.F.	Motor. Revolutions per Minute	Motor. Electric Work in H.P.	Brake. Power Transmitted in H.P.	Brake. Efficiency.
						volts.			volts.				
VI.	15.39	127	751.92	10.025	2.687	1770	792	6.462	1418	578	5.177	3.211	0.320
VII.	15.77	111	673.12	8.978	2.687	1498	705	5.468	1161	488	4.329	2.711	0.301
IX.	15.84	138	840.93	11.212	2.687	2078	876	7.586	1673	650	6.108	3.611	0.322
XI.	15.93	138	845.70	11.274	2.687	2113	883	7.714	1686	663	6.155	3.683	0.326
Total	62.93	514	..	41.489	..	7459	3256	27.230	5938	2379	21.769	13.216	1.269
Mean	15.73	128.5	..	10.395	..	1865	814	6.808	1485	595	5.420	3.304	0.319
VIII.	x	120	x	x	2.687	1853	814	6.765	1364	620	4.980	x	x
V.	3.36	118	152.95	2.029									

TABLE VI.—SHOWING THE WORK MEASURED AT THE VARIOUS POINTS OF THE INSTALLATION.

Number of Experiment	VI.	VII.	IX.	X.	Total.	Mean.
Motive power measured at the dynamometer	10.025	8.997	11.211	11.324	41.557	10.389
Mechanical power consumed in transmission up to and including the spindle of the generator.	2.173	1.896	2.358	2.358	8.785	2.196
Mechanical power actually transmitted to the generator ..	7.852	7.101	8.853	8.966	32.772	8.193
Electrical power consumed by the resistance of the generator ..	0.549	0.549	0.549	0.549	..	0.549
Supplementary loss of power (by difference) ..	0.879	1.091	0.712	0.696	3.378	0.844
Electric power at terminals of generator ..	6.424	5.461	7.592	7.721	27.198	6.799
Power transformed to heat in the circuit ..	1.243	1.218	1.479	1.561	5.501	1.373
Electric power at terminals of motor ..	5.181	4.243	6.115	6.160	21.707	5.426
Electric power consumed by the resistance of the motor ..	0.814	0.814	0.814	0.814	..	0.814
Supplementary loss of power (by difference) ..	1.156	0.718	1.688	1.673	5.238	1.309
Mechanical power transmitted to brake ..	3.211	2.711	3.611	3.683	13.216	3.304

considerable than in the first series of trials; the belts had been taken up and were too tight. Each revolution of the dynamometer corresponded to a work of 0.0172 horse-power, whereas it was before 0.004 horse-power. From whatever it resulted this work of 2.196 horse-power included the resistances of all the straps, those of the countershaft, as well as those of the shaft of the generator and of the friction of its bearings. Even if some magnetism existed, or were produced while running empty, its resistance would also be registered. From the point of view of the calculation of the electrical work, and the successive losses which result, it was essential to work out the figures for that loss in the transmission. This reduction made from the motive power, the available power is found to be reduced to 8.193 horse-power out of 10.389, or to 78.9 per cent. of its primitive value, measured at the dynamometer. The heat which was produced, at the expense of the motive power, by the passage of the current in the generator, whose resistance at rest and cold was 56 ohms, represents a declension of work of 0.549 horse-power common to all the trials. The experiments show that there is still a supplementary loss of work between that which the generator receives and the dynamic power of the current which it gives to the circuit. That loss amounted to 0.844 horse-power on the average, and represented all that which had not been taken account of in the calculated value of the heat developed in the generator. What were the exact causes of this difference it is difficult to say; whether the resistance of the machine is greater when working with a closed than an interrupted circuit; to what extent the brushes fail to conduct the current; what is the loss by sparking; and whether counter currents are produced which augment the resistance, are questions whose solution must be deferred for the present.

The current, however, which entered the telegraph wire joining the two stations, never represented more than 6.799 horse-power, that is, 65.4 per cent. of the motive power, or 82.9 per cent. of the power imparted to the spindle of the generator. In traversing the wire of 17 kilometres, whose resistance was 160 ohms, the energy transformed into heat represented

$$\frac{2.687^2 \times 160}{g} \text{ kilogrammetres} = 1.570 \text{ H.P.}$$

The mean difference between the terminals of the generator and the motor was found to be only 1.373 horse-power; in view of the small variations of intensity, which it was impossible to measure during the course of the experiments, these two results may be considered concordant, and to them must be added the passive resistances of the shaft of the motor, of which no direct measurement could be obtained by dynamometer diagrams, as in the case of the generator.

The observations made on the motor showed that the current did not represent more than 5.424 horse-power; that is, 52.2 per cent. of the original motive power, or 66.2 per cent. of the mechanical power communicated to the shaft of the generator. The resistance of the motor, 83 ohms when at rest, corresponded to a transformation into heat of 0.828 horse-power, as is shown upon the ninth line of the Table. But this reduction is not nearly equal to the difference between the energy of the current as it leaves the generator, and the work expended in friction by the brake. This difference, which amounts to 1.309 horse-power, may be attributed to the causes alluded to above. This loss appears to have increased in a remarkable manner with the higher electromotive forces of the second series of experiments, and part of that augmentation must be attributed to sparking.

The power measured at the brake represented on an average 3.304 horse-power; that is, 31.8 per cent. of the motive power, or 40.3 per cent. of the power communicated to the spindle of the generator. The amounts of power which reappeared in the form of heat, and were necessarily lost as useful effect, can be summed up as follow:

In the generator	0.549
„ intermediate circuit	1.373
„ motor	0.814
Total	2.736

This minimum quantity of work represented by the heat is equivalent to 0.263 horse-power of mechanical power expended, or to 0.334 horse-power of work upon the shaft of the generator.

On the other hand the non-calculable losses amount to

At the generator	0.844
„ motor	1.309
Total	2.153

which form the 0.207 horse-power of total work, or 0.263 of mechanical work communicated to the shaft of the generator.

These figures may be grouped in another manner, thus:

Work of mechanical transmission ...	0.211
„ lost in heat developed by the resistances	0.263
Work lost adventitiously at the points of transference	0.207
Actual work transmitted...	0.318
Total	1.000

The third item in this list is evidently the one upon which the efforts of constructors should be concentrated, and if these causes of loss could be removed, it would be possible to approach, other things being equal, to a maximum efficiency of 50 per cent.

If the Experiments IX. and X. be submitted to the same process of examination the figures are much the same:

Work of mechanical transmission ...	0.209
„ lost in dissipated heat	0.256
„ lost at the points of transference...	0.212
„ actually transmitted	0.314
Total	1.000

90

Iron – May 23, 1884

THE DESCENT OF ELECTRIC CURRENTS INTO COAL MINES.—At a recent meeting of the members of the Manchester Geological Society, Mr. John Knowles, M.I.C.E., read a paper describing the descent of an electric current into the New Rivin Pit, one of the collieries owned by Messrs. Andrew Knowles & Sons, Limited. During a thunderstorm which took place on February 21 last, a distinct shock was felt in the workings at the New Rivin Pit, Little Lever, near Bolton. The colliery was situate close to Hall Lane, the main road between Moses Gate and Radcliffe, and about three miles from Bolton, the upcast pit being about 30 yards from the road and the downcast 50 yards. The upcast pit was 9 feet in diameter inside the brick work which rose as a chimney about 24 feet above the ground. In this pit there was no winding, but there was one pulley 5 feet in diameter, which stood without rope, to be used with a portable capstan engine in case of emergency. There were also two folding iron doors, which took up a space in the chimney 8 feet high by 5 feet wide. The pit was 97 yards deep. The downcast pit was also 9 feet in diameter and 97 yards deep, with a sump of 14 yards further. In the pit were four iron guides 1¼ inch in diameter, and two iron wire ropes between the cages; the former went into the water at the sumps, and the latter terminated just below the landing plates. There were also a bell wire of galvanised iron, and 3-inch steam pipes, which were mostly uncovered. The two cages were made of iron, a steel rope being used for one cage and an iron rope for the other. This pit was surrounded with the ordinary cast plates and rails, but there was not any connection with the chimney of the upcast shaft. There were the usual buildings about the pits, viz. engine-house, boilers, and cabins; also a chimney 6 feet square and 20 yards high, but no lightning conductor on it. At the bottom of the downcast pit there were the usual plates and rails, with the steam pipes extending to two engines on the east side and one on the west. Those going eastward were laid up a brow, with a gradient of one in three, to the Lower Three Yards Mine, and then a short distance on a level to the first engine, which wound up the down-brow in this mine. At this point there was a rise tunnel to the Lower Yard Mine, worked as a self-acting incline. The steam pipes were carried to the top of this tunnel and then on a short level to the engine at the top of a down-brow in the Yard coal, where a wire rope was used to wind the coal to that point. There was also a wire rope used in that brow to work a small pump, which forced water to the top of the incline, whence it ran to the pit. On the west side the steam pipes were laid on a level in the Lower Yard Mine to a small engine, which wound coal up a dip tunnel from the Lower Three Yards Mine. This engine had a 6-inch cylinder with 10-inch stroke, the dip tunnel being 48 yards long, with a gradient of one in five. The electric current appeared to have struck the chimney at the top of the upcast pit about 2.30 p.m. on the day named. It displaced a large quantity of brickwork, and then came down outside the chimney, striking the ground close to it and making a large hole. It then went along the ground to the cast plates at the top of the downcast pit, and it was presumed went down the steam pipes and so into the workings—on the east side going through the Yard down-brow engine and along the rope to the waggons, and on the west side passing along the pipes to the engine where the manager was standing. The strength of the current must have been very great as experienced by a waggoner seated four or five yards from the bottom of the downcast, as he stated that he saw a brilliant flash and heard a great noise, which sounded as if in the pit. He had the heel of his clog on one of the plates at the time, and felt a tingling sensation in his leg which lasted a day or two, and the sole of his clog was burnt as if hot iron had been drawn over it. Other men in the pit also experienced a sensation which they described as resembling the shock received at an electrifying machine. The manager, who was on the west side in the Lower Yard Mine at a small engine 300 yards from the pit, had his hand on the steam handle and felt a shock which numbed him for a few seconds so that he could not see or move, and afterwards was so completely prostrated by the effects of the shock that he was confined at home to bed for six days before he was able to get up and walk. From the statements which had been made by the men, it would appear that there must have been a very strong current of electricity passing down the ironwork of the pit, and it was fortunate that much of it was distributed before it reached the workmen in contact with any metal. The manager, being the nearest in direct contact, seemed to have suffered the most, as the waggoner was only connected with the plates by a wooden clog, and others at the bottom of the Lower Yard coal incline only received a shock after it had passed many means of distribution. Two other cases of a similar kind had occurred, one at the Tanfield Moor Colliery on July 12, 1880, on which a paper was read before the members of the North of England Institute of Mining and Mechanical Engineers, and the other at West Thornley Colliery on December 11, 1883, with regard to which a paper was also read before the same society. Mr. J. Dickinson said he had investigated the matter referred to by Mr. Knowles, and it had occurred to him that the flash had gone down both shafts, although it was only upon the chimney of the upcast that there were the marks of the electric current. Mr. Burrows briefly described a similar incident that had occurred at one of their collieries, and which produced the impression that the pit had "fired." Mr. Dickinson remarked that the descent of an electric current had been given as one explanation of the Risca explosion, which occurred when a violent thunderstorm was going on. In fact, some persons in the district held a very strong opinion that the explosion had been caused by a flash of lightning going down the pit.

The Iron Age – Sept. 25/8

Heat Due to Electric Currents.

An interesting paper on the heating effects of electric currents has been communicated to the Royal Society by Mr. W. H. Preece. With bare platinum wires of small diameter, the general law governing the ratio between the current strength and the diameter of the wire, when the latter is raised to a definite temperature, and where radiation is free, appears from Joule's law to be that the current should vary as the diameter × $\sqrt{\text{diameter}}$ or $c = d\sqrt{d}$. Both the results of Mr. Preece's experiments tend to show that the current varies as the diameter. Platinum wires are, however, liable to flaws which practically reduce their effective diameter. Mr. Preece has also determined the strength of currents which produce self-luminosity in wires of different kinds and sizes. These currents were measured by finding the difference of potential at the ends of a thick German-silver wire, whose resistance was .0157 ohms inserted in the circuit. The results with copper, Swedish wrought-iron, German-silver and platinum wires showed that the law $c = d\sqrt{d}$ held very well for all these wires except with those of platinum, the point of low red heat being taken as the fiducial point. The temperature of a wire which becomes self-luminous has been given by Draper as 977° F., and by Daniell as 980° F. The exception in the case of platinum may account for its exception to the law in the former experiments. Mr. Preece infers from his experiments that electric-light wires should be made large enough to avoid the possibility of heating them above normal temperatures; otherwise, points of danger are easily reached by increments of currents.

91

Engineering April 83.

THE ELECTRIC TRANSMISSION OF POWER.

ON pages 264 and 289 *ante* we gave an account of the results of two experiments in the electric transmission of power, which has been carried out in Paris by M. Tresca, with the co-operation of Dr. Hopkinson. The trials, which were made with the apparatus of M. Marcel Desprez, were described by M. Tresca to the Academie des Sciences, who appointed a commission, consisting of MM. Bertrand, Tresca, Ferd. de Lesseps, C. de Freycinet, and Cornu, to whom it assigned the task of repeating and extending the experiments, so that the accuracy of the conclusions already attained might be officially verified.

The disposition of the machines was the same as on the previous occasions, that is, two of their poles were joined by a telegraph wire 17,000 metres in length, and the other two by a short conductor of inconsiderable resistance. The results of the experiments, measured dynamometrically, are given in Table I., where it will be noticed that the tests numbered I. and II. differ so greatly from the others that there is good reason to assume that the brake became disarranged in some way. The Table, however, shows that 4½ horse-power were transmitted through a resistance of 160 ohms, while the net return was 37½ per cent. of the power expended, the gross return rising, in one instance, as high as 48 per cent. The figures appear to demonstrate that the amount of work transmitted went on increasing with the speed of the machines up to about 850 revolutions of the generator, at which point it was at a maximum. This was probably due to the construction of the machine, which suffered from excessive sparking at that velocity, and often had its commutator surrounded by a ring of fire. It was the opinion of M. Desprez that if both machines had been of the kind employed for the motor, a better return would have been attained.

Table II. gives the electric results arrived at.

The last column shows the proportion of total electromotive forces $\left(\frac{e}{E}\right)$ developed in each machine. The electric return is notably higher than the dynamometrical one, because the electrical energy created in each machine is inferior to the energy expended in the operation. If H be the coefficient of transformation for the generator, and h that for the motor at their respective speeds, then the dynamometrical return is

$$\frac{T u}{T m} = \frac{e}{E} h H$$

where Tm is the power transmitted to the generator, and Tu that obtained from the motor. The machines examined by the Commission had an efficiency of 87 and 81 per cent. respectively, which is lower than that of many dynamos, but it must be remembered that they are designed to give a very high electromotive force and but a feeble current.

The experiments show that the best returns to be obtained from this particular installation, from a gross expenditure of 9.514 horse-power at the generator is 3.572 horse-power received at the brake of the motor, or 37.5 per cent., while, considered electrically, the best return is 71.7 per cent.

TABLE I.

Number of Experiment.	Number of Revolutions per Minute.		Mechanical Power.				Dynamometrical Return.	
			Transmitted		Received at the Brake of the Motor	Transmitted per Revolution of the Generator.	Net.	Transmission deducted.
	Generator.	Motor.	By the Dynamometer Pulley.	To the Generator.				
	N.	n.	T.	T m.	T u.	—	$\frac{T u}{T}$	$\frac{T u}{T m}$
			horse-power.	horse-power.	horse-power.	horse-power.		
I.	378	101	3.838	3.290	0.578	0.00153	0.151	0.176
II.	370	88	3.854	3.331	0.489	.00105	0.127	0.147
V.	850	602	9.771	7.663	3.344	.00393	0.312	0.435
VI.	923	709	10.556	8.259	3.939	.00427	0.372	0.477
VII.	850	613	9.514	7.408	3.572	.00420	0.375	0.482
VIII.	1021	709	12.267	9.731	4.439	.00433	0.362	0.456

TABLE II.

No. of Experiment.	No. of Revolutions per Minute.		Intensity.	Difference of Potential at Terminals of		Effective Resistance of Telegraph Line.	Total Electromotive Force Developed in		Electric Return.
	Generator.	Motor.		Generator.	Motor.		Generator.	Motor.	
	N.	n.	I.	U.	u.	$\frac{U-u}{I}$	E.	e.	$\frac{e}{E}$
			ampères.	volts.	volts.	ohms	volts	volts	
I.	378	101	2.39	722	321	167	855	116	0.136
II.	370	88	2.52	745	355	155	888	138	0.155
VI.	923	709	2.52	2060	1635	150	2220	1468	0.658
VII.	850	613	2.57	1937	1470	170	2083	1258	0.604
VIII.	1020	709	2.50	2338	1994	138	2480	1779	0.717
						Mean 159.6			

NOTES.

facing the iron, and then the amount that is wasted in soldering the joints, not less than a quarter of a pound of the metal it is stated being used over one joint, and by the time the iron reaches the man at the top of a high pole or on a building it has cooled down, and has hardly retained sufficient heat to make a thorough joint, hence the slipping of these joints during contraction of the wires, more especially during winter time. Moreover the present irons are so small, they are generally made red hot when required a short distance from the centre of operation, and the wire naturally becomes brittle from overheating. Hence numerous breakdowns, leaving out the risk of fires where the iron has to be hauled up on roofs, whereas, as mentioned, this iron will retain sufficient heat to thoroughly solder eight or more joints without risk of fire. The flat or other side of the iron may be used for ordinary soldering purposes. On this side also there is a small groove, to allow of the waste solder to run into the cylinder, I C.

We understand that this iron will be made in various sizes, to suit large or small guage wires or cable work.

THE ELECTRICAL TRANSMISSION AND STORAGE OF POWER.*

By Dr. C. WILLIAM SIEMENS, F.R.S., M. Inst. C.E.

[AT the time Dr. Siemens' paper was read we gave a brief abstract of the same, and we have now the pleasure of presenting this discourse to our readers in its entirety.—EDS. ELEC. REV.]

MR. PRESIDENT, COLLEAGUES, AND GENTLEMEN,—If I interpret rightly the intention of your Council, it was not that these lectures should be what may be called popular lectures, or appeals to mere amateurs interested in the subject; nor do I understand that it was their intention that they should be strictly scientific lectures, such as would deal with ultimate laws and formulæ, or such other information as might be found in text books; but I presume the intention was that those members of your body who have given thought and study, and also attained experience in particular branches of engineering, should communicate their knowledge to their colleagues, having regard particularly to the younger members of the profession.

The general subject that has been selected for the present session is electricity—the most subtle of the forces of nature which it is the business of the civil engineer, according to the terms of our charter, to direct. The two lectures preceding this have been devoted to the action of electricity when it is a swift agent, carrying our thoughts to distances only limited by geographical bounds. The first lecture, by Mr. Preece, dealt with telegraphy; the second, by Sir Frederick Bramwell, was upon that branch of telegraphy (for so I must call it)—telephony, which accomplishes the wonderful feat of communicating speech to reasonable distances. In both cases the receiving instrument is of the most delicate nature that the ingenuity of engineers has been able to contrive for recording the small efforts of energy flowing through the wire. The task that has been assigned to me is to introduce electricity to you, still as a precise and swift agent, but as one that can moreover accomplish quantitative effects, rivalling those produced by our steam-engines, by our hydraulic accumulators, and by compressed air. It is with reference to electricity in this form that I propose to put certain experiments and explanations before you.

Electricity, as you know, is the youngest form of energy with which we are practically acquainted. Although the only available source of that energy was until lately the galvanic battery, attempts were made, from the days of Volta, at the beginning of the present century, to apply that force for the obtaining and transmitting of power. A very little consideration will convince us that all those efforts must necessarily have been futile. A pound of zinc is produced by the combustion of from 15 to 20 pounds of coal, and while a pound of coal in burning gives out 12,000 heat units, a pound of zinc in burning gives only 2,340. Thus zinc gives in burning only one-fifth of the effect in energy that coal does, and taking the cost of zinc at 50 times that of coal, it follows that the cost of energy, in the case of a galvanic battery, is, roughly speaking, 250 times greater than in a steam-boiler. Thus handicapped, it was not likely that electricity could be made available for producing powerful effects, although the attempts that were made—in ignorance of the laws of nature governing the force of electricity—were numerous.

Before entering upon the most essential part of my subject, I must mention an invention or discovery of Seebeck in 1822—that of the thermo-battery. I have here a thermo-battery in which the heating agent is gas, which we will have lighted, and you will see that from it proceeds a current, exceedingly weak, yet a current which owes its origin entirely to heat; and by it we can effect transmutation, so to speak, of heat energy into electrical energy, without any intermediate mechanism or contrivance. If alternate strips of metal, of different positions in the thermo-electrical scale, such as bismuth and antimony, are joined at the ends into couples, and one point of juncture is heated while the next is kept cool, a current is set up, flowing from the hot to the cold juncture, and the moving power of the current thus produced is proportionate to the difference of temperature between the hot juncture and the cold, and to the relative positions of the two metals in the thermo-electric scale. If this transformation could be affected without loss, we might hope that the thermo-battery would be the ultimate and most perfect solution of the problem of developing electric energy out of heat. Sir William Armstrong, in his inaugural address at York in 1881, as President of the Mechanical Section of the British Association, drew particular attention to the thermo-battery, as one of the most hopeful sources of ultimate electrical effect, and physical experimentalists should never lose sight of this interesting problem. Yet the thermo-battery has one drawback, in common with the steam-engine or any thermo-motor—that is, it is dependent, not only on the first law of thermo-dynamics, according to which heat is changed entirely into its equivalent of electricity, but also on the second law, which says that whenever such conversion of heat takes place, a certain amount of heat must descend from a point of high-potential to a point of low-potential. It is thus that our best steam-engines give in mechanical force only about one-seventh of the theoretical equivalent of the heat-energy; and it is owing to this second law of thermo-dynamics that there must be necessarily a loss of heat, by conduction in the metal strips themselves, which conducted heat must be abstracted at the cooled extremities all round, in order to keep up the extremes of temperature upon which the action of the thermo-battery depends. We will now see whether we can produce a visible effect by the current on the electro-dynamometer, an instrument the nature of which I shall have occasion to describe hereafter. The action is not great, but you see that there is a very decided deflection to this side of about 5 degrees. The battery has not been on long, or it would probably amount to 10 degrees. From measurements which I have only lately made at leisure, I find that it would require one thousand eight hundred single pairs of these strips to produce a potential sufficient to work an incandescent electric light, showing how very slight the current really is.

I now approach a subject in our lecture which is of the greatest importance. I have here the original magnet, and the original coil, which Faraday used in the year 1831—fifty-two years ago—to develop the first induction spark. In 1826, or 1827, he had already conceived the idea that when an armature was removed forcibly from a permanent magnet, the expenditure of force should give rise to a current in the wire surrounding the armature; but it took him three or four years to develop the idea. When Faraday saw the spark

* Institution of Civil Engineers, March 15th, 1883.

and was able to show it to the members of the Royal Institution, it was a red-letter day in his existence, and he even then thought that it would be a point of departure of some importance, because he said on that occasion: "Although this spark is very small, so that you can hardly perceive it, others will follow who will make this power available for very important purposes."

Now that the light is lowered, I will draw your attention to the point of the wire touching this little disk or pan, and you will distinctly observe the spark when I break the connection. This magnet is the very steel magnet which Faraday used, and at that time it was quite a giant amongst magnets.

Faraday next turned his attention to magneto-electricity, and to what was called by him the magnetic field. I have here a horse-shoe electro-magnet, with its two stems surrounded by coils of wire. If a current is passed through the coils, these extensions become magnetic poles, and if I lay a piece of cardboard upon them, and spread over it some iron-filings, you will observe that, under the influence of the electric current, they distribute themselves in a very peculiar way. Most of the iron filings you see have massed upon two spots, exactly corresponding to the two poles; and all round these spots, lines which are called the lines of magnetic force are shown by the iron filings. It is, of course, difficult, in an experiment of this sort, to show the action as completely as one can in a laboratory; I have accordingly brought some photographed cards, which are certainly very instructive. In these the result of the attraction of the poles, the outflowing lines, as it were, of force from the magnet running in all directions, are well depicted. In the one that has been reproduced, in fig. 1, the two half-circles, intensely white, are the magnetic fields of a dynamo-machine such as you see before you, and the diagram enables us to trace the intensity and direction of the magnetic action in every part of the machine.

Now if a wire forming a closed circuit was taken across these lines of force, although passing only through air (indeed it might be passing through a vacuum), it would encounter resistance due to the magnetism, and this resistance manifests itself as a current of electricity passing through the wire. I shall endeavour to make the experiment in such a way as to render this action visible to you. I have here my magnetic field, that is to say, two polar surfaces opposed to one another, and a framework wound six times round and round with wire; a single wind would do, but by winding six times I repeat the action which would take place upon the one wire sixfold, and this action I expect will be manifested upon a galvanometer-needle with which this frame is connected. I can move the frame about away from the magnetic field and no action is produced on the needle, but when I move the wires into the magnetic field, there is an action in one direction, and when I move it out again there is an action in the contrary direction. The current produced in this wire is exactly proportionate to the amount of force which I exerted, and this again is proportionate to the rapidity of the motion and to the intensity of the magnetic field. If the two poles are set very close together, and if the current exciting the electro-magnet is great, the current produced in the induction wires will be great also. Again, if I move the wires through the magnetic field with great velocity I encounter greater resistance, and I shall obtain a still greater result. In fine the mechanical power expended in passing the wires through the magnetic field is converted at once into electric power or current.

When the magneto-current had been scientifically proved, it was soon taken advantage of in the construction of the machines of Pixii, of Holmes, and of the Alliance Company, which latter machines were made successful at a very early date in lighting some of the coasts of France, and also of this country. Steel magnets were employed, between the poles of which armatures furnished with coils of insulated wire were made to rotate, when, by the inductive action thus produced, alternating currents were set up in the coils and conveyed to the electric lamp without being changed into a continuous current by means of a commutator.

The next advance upon Faraday's original conception was an armature by which the inductive action can be multiplied considerably. In the Faraday instrument the armature was separated from the magnet by lifting it away from it. In this, which is generally known as the (Werner) Siemens' armature, the coil is put upon an H piece of iron, and made to rotate in a magnetic field. There are in the magneto-machine placed on the table steel magnets superposed one above the other, and between the poles of these magnets such an armature is made to rotate with considerable velocity. You will easily perceive that each time the iron head of the armature is separated from the line of poles of the permanent magnets, *i.e.*, each time it makes a half-revolution there is a severance due to each of these magnets. Therefore, if there are eight bars, we have on the one side of the electro-magnet the joint effect of eight severances, and on the other side a similar amount of effect. So that for each half-revolution we get the result of sixteen such sparks as that shown in Faraday's experiment, and if this can be repeated at a

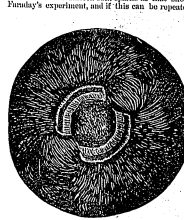


FIG. 1.—SECTION OF DYNAMO MACHINE.

very rapid rate we may get sixteen sparks perhaps ten times in a second. We will now connect the current, not with the dynamometer, because it would not be so suitable, but with one of these instruments which are generally used for exploding mines, and I will, with your permission, explode a mine. Instead of one we might have ten or twelve mine-exploders in a series. You observe a very powerful instantaneous current resulting from the action of the machine.

A further step in the development of magneto-machines was furnished by Mr. Wilde, of Manchester, by substituting for the steel magnets electro-magnets excited by the current from a separate magneto-machine furnished with the Siemens' armature. By this arrangement Mr. Wilde was able to realise much more powerful effects than could have been obtained previously.

Another form in which the Faraday or induced current manifests itself is in an induction coil, and this also represents an essential action which we should realise before going any further. In an induction coil one spiral of insulated wire is put within another, both upon an iron centre. When a bar of iron is surrounded, as in this instance, with wire, through which a current is passed, the bar becomes a magnet; and if outside the wire of the primary coil, as it is called, fine wire is wound, a current is induced in the secondary coil which is of high potential, or tension, according to the number of turns which the

94

95

For No 1, see page 80 - Crystal Palace Exposition

FACTS NOT GENERALLY KNOWN CONCERNING ELECTRICAL INVENTION.

By J. S. Beeman, M.S.T.E.

The history of the transmission of electric energy by high-tensioned currents, its storage and distribution, is very interesting, as showing the development of an idea which has for long exercised a certain fascination for practical men, viz., the transfer of the energy of waste natural sources of force to localities where it can be utilised. As these localities may be situated at a considerable distance from the source of force, the capital invested in the collecting, transmitting, and distributing apparatus must of necessity be the ruling factor in the case from a commercial point of view, and therefore the economy to be effected by the application of some system for storing the energy and changing its tension to such as is found by experience to be the most expedient, is of great importance. Having in view the improvements in secondary batteries which have already been published, and those which we have still a right to expect, the day may not be far distant when the ideas that have been promulgated regarding such a system, applied to the distribution of electricity, will take concrete form. The various steps by which it has attained its present position, and been brought into the ranks of practically applied natural sciences, form the subject of this article. One of the earliest notices formulating such a design appeared in an article in the *Chemical News* in the year 1862, and ran as follows:—"Sitting by the seashore a few days since, we could not help noticing the vast reservoir of mechanical power existing in the ocean. We do not refer to the noisy dash of the waves as they break upon the beach, but to the infinitely mightier although silent and progressive energy exerted in the gradual rise and fall of the tides. By means of appropriate machinery connected with this tidal movement, any kind of work could be readily performed. Water could be pumped or air compressed to any desired extent, so as to accumulate power for future use, or for transport to distant stations. Light of surpassing splendour could be generated by means of magneto-electric machines; and with a very little extension of ingenuity, every lighthouse on the coast could be illuminated with sun-like brilliancy and with absolutely no expenditure of fuel; the very same mechanical power of the ocean, which in its brute force would dash the helpless vessel to pieces against the rocks, being bound and coerced like the genii in Eastern tales, and transformed by man's intellect into a luminous beacon to warn the mariner against the approach of danger." This idea of utilising the tidal power was, in 1871, actually embodied in a patent by Ferdinando Tommasi, for the working of which it was proposed to form a company. The apparatus, called the flux-motor, was a machine worked by the action of the tides, by which compressed air was to be delivered to customers through a network of pipes, on lines somewhat similar to those employed for the supply of gas. The idea was certainly somewhat unique, but, as far as can be ascertained, has never been practically tried; had it been carried to a practical commercial issue we should by this time have been in possession of a very cheap source of power for the production of electric energy. The possible application of this great natural force, by enclosing tidal waters just before the ebb sets in, and working motors through their release, has, however, been shown, in most cases, to be probably less remunerative than the utilisation of the land so enclosed for other purposes. In 1877 public attention was drawn to this question by the late Sir W. Siemens in his opening presidential address to the Iron and Steel Institute. He then stated that the energy of the Falls of Niagara might be made available by the then known mechanical means—though undoubtedly in a very wasteful manner—saying, to quote his own words, "Time will probably reveal to us effectual means of carrying power to great distances, but I cannot refrain from alluding to one which is, in my opinion, worthy of consideration—namely, the electrical conductor. Suppose water power to be employed to give motion to a dynamo-electrical machine, a very powerful electrical current will be the result, which may be carried to a great distance through a large metallic conductor, and then be made to impart motion to electro-magnetic engines, and ignite the carbon points of electric lamps, or to effect the separation of metals from their combinations. A copper rod, 3in. in diameter, would be capable of transmitting 1000-horse power a distance of, say, thirty miles; an amount sufficient to supply a quarter of a million candle-power, which would suffice to illuminate a moderately sized town." It is of historical interest that in the following year—1878—Sir Wm. Armstrong practically applied this method for the utilisation of natural forces in lighting his house at Craigside during the night, and working his lathe and saw bench during the day, by power transmitted through a wire from a waterfall nearly a mile distant from his mansion. In October, 1878, Mr. St. George Lane Fox patented his system for electric distribution by means of secondary batteries, and, as far as information is obtainable, this is the first public mention of secondary batteries being employed in such a system, although, as has been shown in a previous article, they had been patented at an earlier date as regulators to the circuit. Mr. Lane Fox's system is an extension of the idea of regulation, and it is worthy of passing note that at this period high-tensioned current dynamos, such as we are now accustomed to—the Brush, for instance—were practically unknown, the Brush patent not then having been published in this country. In November of the same year, a French engineer patented an invention, entitled "Improved means of Transmitting Electricity to Great Distances." Although his views and ideas were erroneous, the patent is interesting as showing that inventive talent was directed towards the subject of this paper, and because of the crude ideas contained in it as to the character of dynamic electricity. In December, 1878, Edison patented a system showing duplicate sets of batteries, one set being in the discharging circuit whilst the other could be in the charging circuit—there was practically no difference of tension in the two circuits. An interesting part in the patent was the apparatus whereby the sets of batteries, when fully charged, were cut out of the charging circuit; this was effected by utilising the gas given off to lift a diaphragm which actuated a switch or contact breaker. In May, 1879, Sir William Thomson gave evidence before the Select Committee of the House of Commons on lighting by electricity, saying, in reference to the utilisation of the energy of the Falls of Niagara for the purpose of generating electricity, and in answer to question No. 1799, "There is no limit to the application of it on a general scale. It might do all the work that can be done by steam engines;" he qualified this, and explained how it could be done in a later part of his evidence, by stating, in answer to question No. 1803, that the current sent along the wire would be used to turn electro-magneto machines, which current would be produced by magneto-electric machines. In October, 1879, Luke took out a patent for Houston and Thomson, wherein they showed means by which the tension of the discharging circuit might be raised far in excess of the tension of the current produced by the generator, this being accomplished by charging the batteries in sections and discharging them in series. The special feature of the patent bearing on one subject is contained in the twenty-second claim, and is the method described of bringing a dynamo-electric machine into circuit with a storage battery by first bringing the machine to its normal condition of working by the interposition in its circuit of, first, a normal working resistance, and afterwards of the secondary battery. In March, 1881, Professor Perry, whilst lecturing at the Society of Arts, said that for the future development of the transmission and distribution of electric energy it would be necessary to use electric machines of great electro-motive force. During the lecture, and afterwards in the discussion, reference was made to Professor Ayrton's paper read at the British Association meeting, held the previous year at Sheffield, wherein he pointed out, in a full and comprehensive way, how the energy of the Falls of Niagara might, theoretically speaking, be conveyed to New York along a single ordinary telegraph wire. The system, which was based on theoretical grounds only, and was dependent on exceptionally good insulation, was explained thus: Only a small amount of current would be conveyed along the wire, but it would have an enormous potential; and although the difference of potential between the ends of the telegraph wire would be nearly *nil*, yet the difference of potential at all points along the route, between the line wire and the earth, would be extremely large, so that much energy could be put in at the generating place—viz., Niagara—and a nearly equal amount would be delivered at the motor place—viz., New York. Thus, through the current being so very small the waste of energy in electric friction would be very slight. In April St. George Lane Fox, when lecturing before the Society of Telegraph Engineers, carried the system a step further by expounding a scheme whereby the energy transmitted under high potentials could be safely and usefully applied. He is reported to have used the following words:—"Electricity could be conveyed from a very great distance at an enormous electro-motive force, which electro-motive force could be reduced to any extent by means of a system of condensers, or of secondary batteries, and a suitable arrangement of commutators working automatically, so as to suit the requirements for distribution." Mr. Crompton, during the discussion, said: "As to the use of the secondary or reservoir batteries to act as a store of electrical energy, it is one of those things much talked of, but never yet practically carried out. M. de Meritens told me a few days since that a secondary battery had been recently brought out in France, which gave surprising results; five or six times as much energy can be stored in it as in the Planté battery." About May 16th appeared a letter in the *Times*, announcing the arrival of the above secondary battery, called, after its inventor, the Faure accumulator. On May 18th, Mr. Alexander Siemens lectured at the Society of Arts upon "Electric Railways and Transmission of Power by Electricity." He described a number of ways in which high potential currents could be utilised. He drew attention to large central stations fitted with powerful steam engines and dynamos supplying current to secondary batteries which would keep the electric energy stored until required for use. On June 6th appeared the celebrated letter of Sir William Thomson anent the Faure secondary battery, in which he stated that "the Faure accumulator always kept charged from the engine by the house supply wire, with a proper automatic stop to check the supply when the accumulator is full, will be always ready at any hour of the day or night to give whatever light is required." On the 9th he further wrote, when alluding to credit due to the late Sir William Siemens as the originator of the idea of utilising the Niagara Falls as the natural and proper chief motor for the whole of the North American Continent, "Under practically realisable conditions of intensity, a copper wire of ½in. diameter would suffice to take 26,500-horse power from water-wheels driven by the Fall—losing only 20 per cent. on the way—to yield 21,000-horse power at a distance of 300 British statute miles; the prime cost of the copper amounting to £60,000, or less than £3 per horse-power actually yielded at the distant station." Early in September he, when delivering his opening address as president of the Physical Science Section of the British Association at the York meeting, went still further, and pointed out that through the introduction of accumulators much smaller conductors could be used than were anticipated by the late Sir William Siemens in 1877, and, further, that the necessarily high potential current employed to transmit the current long distances could be converted at its centre of distribution into such a low potential current as should be desired for the several purposes at the points of consumption of the electric energy. He went into fuller details regarding the contents of the letter alluded to above, stating that until he heard of Faure's invention he could only think of step-down dynamos at a main receiving station, to take the energy direct from the electric main with its 64,000 volts, and supply it by secondary 200 volt dynamos through proper distributing wires to the houses and factories and other places, where it could be used for every suitable purpose requiring power. Now the thing could be done much more economically and with much greater facility and regularity by keeping, say, 40,000 secondary battery cells always being charged direct from the supply main, and applying a methodical system of removing sets of 100, and placing them on the town supply circuits, while other sets of 100 were being regularly introduced into the great battery that is being charged. He further described and showed an automatic apparatus which he had designed and constructed to break and make the circuit between the battery and the dynamo. On the 24th of September, Duprez and Carpentier obtained a patent, wherein was described a system very similar, but, of course, giving more definite details of apparatus to be employed than did Sir William Thomson in the address referred to above. They referred to an automatic galvanometer which actuated a commutator or switch, thus causing the connection of the discharging circuit to be always in contact with a very constant supply of electricity. In November Professor Sylvanus Thompson, at a lecture at the Society of Arts, stated that we had in the tidal basin of the Avon enough energy to light Bristol, and in the channel of the Severn there was sufficient power—if only one-tenth were conserved in accumulators—to drive every loom spindle and axle in Great Britain. By this time the inventive public was thoroughly aroused, and the records of the Patent-office show that the details of the working out of the above system has received great attention. Nothing new has, however, been shown affecting the principle. Last month news reached this country that the Bell Telephone Company has two wires connected with the Niagara Falls, by means of which the Exchange at Buffalo has recently been operated. As an experiment, a generator was placed on the paper mills of Quimby and Co., at Niagara Falls, and the machinery connected with twenty miles of wire, the result being a success. The various attempts that have been made in this and other countries, notably France, with systems worked on the lines herein set forth, are practical evidence of the value of the foresighted idea of the late Sir William Siemens.

Iron — Oct. 10, 1884

THE DISTRIBUTION OF ELECTRICITY.

We have from time to time recorded with satisfaction the progress made by the Gaulard-Gibbs method of distributing electrical energy for the production of light and power by means of secondary generators, which system was first described and illustrated in IRON for April 27, 1883. Since that date we have seen it successfully applied on the Metropolitan Railway, where for five months five stations were lighted over a circuit of 15 miles. That installation has now been greatly exceeded by one in connection with the Turin Exhibition, and in which the Gaulard-Gibbs system stands out both prominently and successfully. Before describing this new installation, we may premise that electrical apparatus forms an important feature in the Turin Exhibition. There are in the electrical section several exhibits of the greatest interest, which are shown by firms or companies who have already done good service to science and industry. The Italian Edison Company, of Milan, may be mentioned as exhibiting much that is interesting and excellent. Messrs. Sautter Lemonnier & Co., of Paris, and Messrs. Siemens, of Berlin, stand out conspicuously, but it is the English installation which is the great novelty, and, we may add, the great success of the Turin Exhibition. This, we need hardly say, is the Gaulard-Gibbs system of electrical distribution, which is exhibited by the National Company for the Distribution of Electricity by Secondary Generators, and whose offices are at 18, Warwick Street, Regent Street, London. The Italian government, together with the city of Turin, have offered a prize of 15,000 francs, or £600, for the most important improvement in that department of electrical science, which so closely affects so many branches of industry, namely, the transport of electrical energy over a great distance. The Gaulard-Gibbs system has been in competition for the prize, and has succeeded in carrying off a remarkable share of honours. By this system electrical energy has been transported, and applied to lighting under practical and economical conditions over a much greater distance than has hitherto been done by anyone. The motive power of the National Company and their dynamo (an alternating current machine by Messrs. Siemens Brothers, of London) of 60 horse-power, and supplying a current of 3,000 volts and 10 ampères, being installed within the exhibition, the company undertook to transport electrical energy as far as the railway station of Lanzo, a pretty little town at the foot of the Alps, and at the entrance of the valley of the Stura. The undertaking was a bold one, necessitating complicated details of installation both tedious and difficult. But the great importance of the demonstration was universally realised, as well as its wide interest for a progressive and industrial country, rich in hydraulic power and poor in fuel such as Italy, and everyone sought to aid M. Gaulard in the demonstration which, on behalf of his company, he went to make. The Italian government, the executive commiitee of the exhibition, the railway company of La Haute Italie and that of Turin-Ciriè-Lanzo, the administration of the state telegraphs, the Turin and Lanzo municipalities, all lent their valuable aid, and it must be added to the honour of science that valuable assistance was rendered by electricians who were the first to applaud the progress realised by one of their confrères.

By this installation we have the unprecedented fact of electrical energy furnished by a Siemens machine being transmitted to a distance of 40 kilometres, or 25 miles, from the machine along a single conductor, which forms, consequently, a circuit of twice that length, electrical currents of varying potential being developed at the extremity as well as at several other points of the circuit. This conductor, which was placed at the disposal of M. Gaulard by M. Mouchel, of Paris, is a simple Mouchel bronze wire of 3½ millimetres, or ⅛ inch, in diameter, costing £10 per kilometre, or a little over £16 per mile. This conductor is entirely without insulating covering of any description; and it is worthy of remark that, even in this condition, the heaviest rain does not interfere with the passage of the current. This fact has been thoroughly proved, for the first experiment was conducted during a tropical downpour. The conductor is attached to ordinary insulators on the telegraph posts of the railways of La Haute Italie and of Turin-Ciriè-Lanzo. The wire is placed below the telegraph wires, and in returning by the same posts forms a circuit 80 kilometres, or 50 miles, in length, which is metallically closed with the terminals of the dynamo machine at the exhibition. It should be observed that, to keep the conductor at a certain height from the ground, it was found necessary to place the outgoing and returning portions of the conducting wire near together, the distance separating them being only from 20 to 25 centimetres, or 7·874 to 9·842 inches. This primary conductor established, M. Gaulard placed at different points of the circuit secondary generators, the secondary currents from which serve to light glow and arc lamps of various systems, thereby demonstrating with what facility he can arrive at, not only the transmission, but the distribution of electrical energy. In the exhibition building itself, secondary generators of different sizes and patterns supply currents for Siemens and Sun arc lamps, and for Bernstein and Swan glow lamps, the intensity of the light being regulated at will. The kiosque of the *Figaro* newspaper, situated in the park of Valentino, is brilliantly illuminated by a cluster of five Bernstein lamps, fed by a small secondary generator. The station of Turin (one of the termini of the Turin-Ciriè-Lanzo Railway, and which is distant from the dynamo machine in the exhibition 10 kilometres, or 6¼ miles, in consequence of the detour the circuit has to make in following the telegraph posts) is splendidly lighted with eighty-two Edison lamps, which the Italian Edison Company have fitted up at their own expense. These lamps are fed by a secondary generator of four columns, with energy to spare; another small column lights a Siemens arc lamp outside the station. The stations of Venaria, Reale, and Ciriè are lighted by Siemens and Cruto lamps. Lastly, the station of Lanzo, distant 32 kilometres, or 20 miles, from that of Turin, is lighted by Swan and Bernstein glow lamps, and by Sun and Siemens arc lamps distributed tastefully over the interior and exterior of the station, and fed by several columns of secondary generators. This point marks the entire length of the little line which it is contemplated to transform into an electric railway, and in doing so to utilise the ample water-power in its neighbourhood.

This installation, complete in all its details, and thoroughly demonstrating the value of the principles advanced by M. Gaulard, and of the apparatus which he has constructed for applying them, was inaugurated on September 29 by the international jury of the electrical section of the Turin Exhibition, and will continue to work on stated days until the end of the present month. That the jury consists of men well calculated to thoroughly test the merits of the system may be gathered from the fact that amongst them are—M. Tresca, member of the Académie des Sciénces of Paris, director of the Conservatoire des Arts et Métiers, vice-president of the Société Internationale des Electriciens; M Wartmann, recteur de l'Université de Genève; Professor Voit, of Munich; Professor Kittler, of Darmstadt; Professor Ferraris, of the Polytechnique of Turin; Commandant Parent, of the Italian Navy; Professor Cossa, of the Ecole des Ingénieurs of Turin; Professor Roiti, of the Ecole Supérieure of Florence; Professor Ferrini, of the Ecole des Ingénieurs of Milan; Professor Webber, of Zurich, Ingénieur Candillero, of Turin, president of the Ecoles Professionnelles; and Captain Pescetto, of the Génie Militaire Italien. Professor Ferraris, the organiser and president of the electrical section, was unanimously chosen by his Italian and foreign colleagues to preside, M. Tresca having been nominated honorary president. It may be mentioned that Professors Voit and Kittler were charged with the duty of taking electrical measurements at the Munich and Vienna electrical

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exhibitions. In entering upon the work of adjudicating the high prize offered by the government of Italy and the municipality of Turin, the jury commenced by taking electrical measurements by the most exact scientific methods of the effective return obtained from the secondary generators, a question which has already given rise to much discussion, but which has been determined in London by a report of Dr. John Hopkinson. The jury employed the electrometer of Muscart, which is recommended by the highest electrical authorities in Paris. The effective return established by the jury is 90 per cent., which is even higher than that given by Dr. Hopkinson, and this is attributable to the perfected construction of the secondary generators now employed by Messrs. Gaulard and Gibbs.

To celebrate the advent of the electric light in the Alpine town of Lanzo, and transmitted, too, all the way from Turin, a brilliant fête was organised by the directors of the Turin-Cirié-Lanzo Railway and by the manufacturers of the valley of the Stura, over which the chairman of the Bank of Turin presided. A special train arrived at Lanzo about seven o'clock on the evening of September 29, conveying the jury and several notabilities of Turin, amongst them being the Count de Sambüy, syndic of Turin and senator; Commander Villa, president of the executive committee of the Turin Exhibition, a member of parliament and formerly minister of justice; the chairman of the Turin-Cirié-Lanzo Railway, and the rector of Turin University. The guests were received on their arrival at Lanzo by the syndic of that town, the manager of the railway, and several of the most enterprising manufacturers of the valley, amongst whom may be mentioned MM. Remmert Brothers, M. Bona, M. Cardolle, and M. Martiny. With them was the well-known engineer of Milan, M. H. Bollinger, who has erected so many engineering works in the country about Lanzo and in other parts of Piedmont, as well as in Lombardy and Tuscany. A banquet was prepared in the restaurant of the station, and, at the moment of the guests sitting down, M. Gaulard caused the glow lamps to be lighted, and the room was splendidly illuminated. Thus the almost unknown little town of Lanzo witnessed this new advance in conquering science. It is satisfactory to us to be able to state on good authority, though the official announcement has not yet been made, that, as a result of their investigations, the jury have awarded the National Company for the Distribution of Electricity by Secondary Generators the first prize at the Turin Exhibition, which includes £400—out of the £600—placed at their disposal for prizes in the electrical department. Watching as we have, with interest the progress of the system devised by Messrs. Gaulard and Gibbs, we cannot but congratulate them on this excellent result. In the history of the development of electricity and of the progress made in its practical application to everyday wants, the demonstration of Lanzo will certainly always stand out in bold relief.

Iron — Nov. 14, 1883.

THE DISTRIBUTION OF ELECTRICITY.

It is now nearly three years since a vigorous impulse was given to the question of electric lighting. Numerous systems more or less ingenious, for the production and consumption of electricity have been designed. The public, attracted by the real advantages this system of lighting offers, has liberally responded to the invitations made by the several companies which have in some instances somewhat hastily promised the full advantages offered by electricity as an illuminating agent. This wide-spread impulse has necessarily resulted in some remarkable improvements in the art of producing and consuming electrical currents. Further the wonderful process of transforming mechanical power into electricity, and *vice versâ*, has caused the labours of numerous scientists and *savants* to be directed towards the attainment of the means of carrying out this process by the transmission of natural forces and their consequent utilisation. Nevertheless, many false impressions have been produced, and considerable capital has been swallowed up by companies which have no practical vitality, as well as by speculation. But although the production and the consumption of electricity have been rendered possible, the laws which regulate the distribution of electrical currents have presented a problem which hitherto would appear to have remained without practical solution. It is very certain that if the employment of gas had necessitated the manufacture of this illuminating agent on the premises of consumers, its use would have been considerably restricted. In like manner the hitherto existing necessity of placing on or near the premises of consumers the dynamo machines necessary for the production of electricity has considerably cooled the enthusiasm shown by the public in the first moment of excitement.

In our issue of April 27 last, in discussing the recent results obtained by M. Marcel Deprez, and by the secondary generators exhibited by Messrs. Gaulard & Gibbs at the Westminster Aquarium, we defined the conditions under which the solution of the problem of the distribution of electricity could alone be solved. These were—Firstly, that the economical mechanical production of electric currents which, wherever possible, should be produced by utilising natural forces. Secondly, the distribution over great distances, not of an electrical current, but of electrical energy, which is a very different matter, for every given current has special properties, and consumers should not be limited to the employment of special apparatus adapted to the given current, for this would be to discourage improvements in such apparatus. Thirdly, the distribution of electrical energy must be effected without permanent danger to consumers, and as far as possible to an unlimited extent. Lastly, the consumer should be able to transform this electrical energy into currents of every kind, and consequently adapted to every purpose already known or that may hereafter be discovered, amongst the former being lighting by incandescence and by arc voltaic, chemical processes, such as electro-plating, and furnishing motive power. We have now to direct attention to the fact that in principle the secondary generators of Messrs. Gaulard & Gibbs fulfil all these conditions, and it is gratifying to find that after so short an interval our anticipations have been realised. Whilst the path followed by M. Marcel Deprez has led to no further results as regards himself, the National Company for the Distribution of Electricity by Secondary Generators, whose offices are at No. 18, Warwick Street, Regent Street, London, has practically applied its Gaulard-Gibbs system of distribution by means of a single cable twenty-five kilometres in length and four millimetres or one-sixth of an inch in diameter passing through the several stations of the Metropolitan Railway, and enabling the secondary generation of electrical currents at Notting Hill Gate, Edgware Road, Gower Street, King's Cross, and Aldgate. At each of these stations a secondary generator acts under the influence of the movement of the primary alternating current which traverses the primary circuit, metallically closed on the generating dynamo machine, transforming a part of the energy into electrical currents of different kinds which are employed at each station for feeding incandescent and arc lamps, and at one station, we understand, power also. We recently announced the thorough and practical success of this enterprise.

We need not here repeat the theoretical considerations which have been fully discussed in our columns. We wish simply to place before our readers particulars of the apparatus employed by Messrs. Gaulard and Gibbs in the different stations of the Metropolitan Railway, and of which a perspective view is given on page 520 of our present issue. These secondary generators are composed of sixteen vertical and parallel columns placed between two platforms of wood, to which they are individually attached by means of four iron bolts. Each column is formed of a hollow cardboard cylinder 2 inches in diameter, upon which is rolled in two layers of superposed spirals, a cable composed of a central copper wire, No. 8, B. W. G., covered with a double layer of paraffined cotton. Around this central wire are placed, in parallel order and completely enveloping it, six cables individually composed of eight copper wires, No. 26, B. W. G., and similarly insulated by a double layer of paraffined cotton. This arrangement has been adopted by the inventors in order to avoid the inductive reaction which would occur in the spirals of the primary circuit if they were placed next to one another. The columns, in groups of four, are arranged so that the terminals of their inductor are brought to the commutator placed in front of the apparatus, the object of which is to direct the primary current by one or more of these groups of columns. The terminals of the secondary wires are themselves conducted to four circular commutators of identical construction placed on the side of the apparatus, the object of which is to couple these terminals by means of a simple handle either in parallel order or end to end. The individual ends of each column may, by means of these commutators, be connected separately or in groups to the apparatus of consumption, whether lamps or otherwise, which they are destined to feed. A bundle of iron wire fills the centre of the columns, and its magnetic action is regulated by the introduction of brass cylinders which may be seen in our engraving emerging from the upper platform, the object being to graduate easily the intensity of the secondary current, and consequently the intensity of the lamps. This movement of the brass cylinders is obtained by means of four circular handles on the side of the apparatus just below the upper platform.

A striking characteristic of this apparatus is that, although traversed by currents of the highest potential, every metallic part may be touched without producing the least shock. The management of the secondary generators is so simple that the company has been able, since the commencement of their working, to leave the apparatus, when once adjusted, in the hands of the unexperienced employés of the Metropolitan Railway. The generating machinery, which is located at the Edgware Road Station, consists of a steam engine of 25 horse-power running at 120 revolutions per minute, and supplied with steam from a Cornish boiler at 60 lb. pressure per square inch. The engine drives through counter shafting a Siemens W° alternating current dynamo machine running at 600 revolutions per minute, and excited by a small Siemens dynamo running at 1,000 revolutions per minute, the large dynamo giving 10,000 alterations per minute. The primary wire is led from the large dynamo to the secondary generator, after traversing which it is led out of the station and along the course of the line at the side of the tunnel to Notting Hill Gate Station, whence it returns to Aldgate, and thence is led back to Edgware Road, a total length of fifteen miles, including bends and turnings at stations. In the arc lamps Jablochkoff candles are used, while the incandescence lamps are those of Swan, the latter being fitted in the ordinary station lamps. This is a disadvantage, inasmuch as the frames of the lanterns, which are globular and in sections, cast shadows on the platforms. In other respects the light is very satisfactory, and although the stations do not present the brilliant appearance of those on other lines in which the arc light alone is used, and which is sometimes dazzling, there is a mellow light cast around ample for all practical purposes, and presenting a pleasant contrast to that of the gas at the stations on the Metropolitan Railway not yet electrically lighted.

It has been practically demonstrated that the loss occasioned by the transformation of energy into light by this system does not exceed 10 per cent. We need hardly point out how highly creditable this is to the Gaulard-Gibbs secondary generators. In view of the facts before us we cannot doubt that this system is destined to render important service in the economy of life. To give some idea of its possible development we may mention that it is intended to light by it the entire length of the Suez Canal by means of lamps placed on its banks and along its course through the lakes which it traverses, the whole being fed by a single cable about 200 miles in length, along which will circulate a current produced at one central station. In fact, in the Gaulard-Gibbs system we have the solution of a very important problem in electric lighting practically demonstrated.

Iron Age, Oct. 16, 84.

The Greatest Electrical Problem Unsolved.—Mr. Thomas A. Edison, having recently been asked what progress he was making toward obtaining electricity direct from the combustion of coal, instead of having to get it by first producing heat, then by heat steam-power, and finally electricity from the steam-power, said: "I have been working away at it for some months, and have got to the point where an apparantly insurmountable obstacle confronts me. Working at the problem now seems to be very much like driving a ship straight for the face of a precipice, and when you come to grief picking yourself up and trying it again to-morrow. There is an opening in the barrier somewhere, and some lucky man will find it. I have got far enough to know that the thing is possible. I can get quite a current now directly from the combustion of fuel. Jablochkoff tried his hand at the same thing some years ago, and so did some Germans, but the results were laboratory curiosities only. I give myself five years to work at it, and shall think myself lucky if I succeed in that time. The unscientific world has no conception of what such a discovery would mean. It would put an end to boilers and steam engines; it would make power about one tenth as cheap as it is now; it would enable a steamship to cross the Atlantic at a nominal cost; it would enable every poor man to run his own carriage. It would revolutionize the industrial world."

Eng. Mech. + World of Science – Feb. 6/85.

around;* the planets whilst viewing their satellites, especially those of *Jupiter* in transit; portions of the moon, the details thus shown being sometimes very striking; sunspots or their nuclei, no diagonal being needed if the observer screws up the shutters very close before looking through the telescope; searching for comets or examining nebulæ and clusters.† As no clock is required for this instrument, and as all the shutters are at right angles to their neighbours, position angles can be very shrewdly calculated. To do this let the major star run along the edge of one or other shutter by turning the whole instrument on its axis, and bring a neighbouring shutter into the field. As the ordinary circular field is now reduced to an arc of 90°, the pos. angle can much easier be guessed.

Due thanks must be accorded to Mr. Mason, the optician, who resides in my neighbourhood, for his great ingenuity and patience in perfecting many manufacturing details in this contrivance, and to Mr. Wray, jun., who especially designed the deep positive eyepieces suitable to my requirements.

THE DISTRIBUTION OF ELECTRICITY.

THE first of a series of three lectures on this subject was delivered on Monday evening in the rooms of the Society of Arts, John-street, Adelphi, by Professor George Forbes, M.A., F.R.S.E. There was a large attendance, and great interest was manifested in the lecture, Mr. Forbes's remarks being several times cheered.

Professor Forbes said that when he was first asked to give this course of lectures on the "Distribution of Electricity" he thought it would be an interesting thing in a general and somewhat popular manner to give a description of the different schemes which had been proposed for lighting large installations and central station lighting, and to simply treat what had already been written in a general sort of manner. But as soon as he began to go into the questions at all, he felt it would be losing an opportunity for doing something which would be far more useful, and that was to talk on the subject from a more technical point of view than that which he had originally thought of, and to discuss somewhat fully these different systems and explain the defects of each and what were the relative merits of them, and really go into the question in a more thorough manner than anyone had found it worth his while up to the present time to attempt in these different problems. That, then, was the scheme he had before him in the course of those lectures. They all knew the different systems that had been proposed for lighting; they knew how the arc lights had been distributed in series, and how incandescent lamps had been put up, the multiple arc lamp on large stations, and more especially they were aware of what had been done in America. A great many eminent engineers had, doubtless, attacked the problem from the very beginning; but very few had written or published anything on the subject. It might be that, having expended a large amount of time in research, they were glad enough to remain possessors of the knowledge they had gained. In some cases only a special system had been marked out, and in very few cases had all the systems been relatively compared and pursued so as to bring out the most economical systems possible. Besides these two systems—the series system and the multiple arc system—they were aware that the latter was subdivided into a large number of different ways of distribution. They had all heard of the network system—a system with mains and lines of centres of distribution. So they had another one, which was called a multiple series system, which had been used to a certain extent very successfully, but which had some radical defects in it which had prevented its general adoption. At the same time it must be said that many distinguished engineers believed that in the future there might be a possibility of rendering this multiple series system efficacious, and of removing the difficulties which were in the way. The objection to the ordinary multiple system—where all the lamps were connected on to two massive mains, or a number of massive mains which were so connected as to make two massive mains; the objection to that system was the enormous cost of conductors. During the past few months there had been several committees started with a view of influencing the Board of Trade to take action in removing some of the restrictions in the Electric Lighting Act of 1882, which had proved such a hindrance to the progress of electric lighting. But besides that difficulty there was the fact that the Electric Lighting Act was simply unworkable, as every unprejudiced person must admit. There was another fact which had largely hindered electric lighting, and that was the enormous cost of mains. Not only that, but the multiple arc system introduced another serious expense. It became essential with such large mains to have rather a central station, with the engine in the centre of the district which was being supplied. In thickly populated districts, such as would be necessary in manufacturing the light on the multiple arc system, it was very difficult to get a site for the engine and dynamos, and it had been acknowledged by those who had undertaken to work the system in London to be one of the serious objections to the multiple arc system. It was of the utmost importance that engineers should devote their energies to the most economical system possible, whether that system be the multiple arc or the multiple series, or any of the modifications which had been proposed. At the present moment there were thousands of people in the city who were anxiously waiting to have the electric light supplied to their houses, but they were prevented from having it partly on account of the fact of the expense in the outlay, and partly by the gas monopolists and the assistance which the gas monopolists had received from the Electric Lighting Act of 1882. That would not much longer be maintained, he thought they could safely trust, and in that case they must be prepared as engineers with most economical means of laying down thick mains, so as to make electric lighting then a possibility in an economical and financial way. The question of the production of electricity was one on which he need say but little. At the present time electricity was produced by dynamo-machines, and that was by far the cheapest way, and there was no immediate prospect of any other system being introduced which was more economical. The question of primary batteries might be completely laid aside. There was no prospect that any primary battery would be rendered an economical means of producing electricity. It was true if it was possible to consume carbon in the form of coal or charcoal by oxidisation instead of consuming zinc they might have some economical battery which might compete with the dynamo. In 1880 he (Mr. Forbes) was engaged in making a number of experiments in that direction, but owing to an unfortunate circumstance they were discontinued; but many people had taken up the subject, and every now and then they heard prospects of something being done; but at the present moment they were very far from it, and before such a thing was done they would require something that would be entitled to rank as a real and original discovery—a discovery which did not come to them at the bidding, a discovery which was more often made in the laboratory of the patient investigator rather than in the workshop of the speculative inventor. Secondary batteries which were being supplied with their charge from dynamos might be looked upon as a means of supply rather than as a means of production of electricity. The same might be said of secondary generators, which had attracted considerable attention during the last year or two. He would now come to the problem before them—namely, the problem of the distribution and supply of electricity—but before attacking the problem directly he would take a general survey of the comparisons between electricity and gas in that respect. The production of gas was a far more complicated operation than the production of electricity. It was a somewhat complicated mechanical laboratory experiment produced on a large manufacturing industrial scale; but the distillation of the gas from the coal, and subsequent treatment by scrubbers, condensers, and lime purifiers previous to its introduction through a meter into the gas-holder and its supply to the service pipe, was a far more difficult operation than the similar problem in the case of electricity. When, however, they came to supply, the gas and electricity problems resembled each other a great deal. Gas must be supplied in pipes at a certain pressure, the size of the pipes must be regulated by the quantity of gas that was to pass through them, and the quantity of gas flowing through them must be so regulated that the pressure at the point of supply —namely, the burners—must not vary to any great extent. In all these points they had an analogue to gas in electricity. He should use the word "pressure" in speaking of electricity because it was used as a Parliamentary term, and it was a very convenient, and really, he believed, a scientific term—a pressure on any point to indicate the

* In using this instrument, the observer must bear in mind that it takes an appreciable time for the eye to recover the effect of the previous glare of the bright star; for that purpose it is well, I find, to keep the bright object some while behind a shutter before attempting to dismiss the field as barren. After a steady gaze a small star near α Sagittæ was observed Sept. 12, distinctly with the occulter, but *not visible* with my aperture (10in.) whilst employing ordinary means. We judged its P.A. 180. Mr. Burnham wrote to the ENGLISH MECHANIC some weeks after to say he had discovered it with the great instrument he uses. He judged P.A. 180·5 with his micrometer.

Iron. Aug. 1884

AN ELECTRIC TORPEDO-BOAT.

ELECTRICITY has been called in to render the dreaded torpedo-boat still more formidable. An American, Professor Tuck, has built an electric submarine torpedo-boat, which looks at a little distance very much as if it had been constructed by laying a large row-boat upside down on top of another large row-boat, fastening them together and painting them both sea green. The shell of the new boat is of iron. The boat is 30 feet long, is ballasted with lead, so as to sink to the water's edge, and her displacement is 20 tons. In the centre of what may be called the deck is sunk a well hole. By a simple air lock arrangement, it affords a passage between the interior and exterior of the vessel, even when the vessel is wholly under water. It is also the captain's look-out station, and is capped with a dome of heavy glass, so that, if he chooses, he can exclude the water and stand in the pit with his head and shoulders above the top of the boat, or he can leave the glass off and stand there in a diving suit. Close to his hand is a signalling steering apparatus, which transmits his orders to the helmsman down below. The boat has three rudders, one an ordinary vertical rudder at the stern, and the other two horizontal blades on the port and starboard quarters. These last help to govern the boat's movements up and down. To sink her, water is pumped into her compartments; to raise her, air is pumped in, and the water is forced out. Compressed air is stored aboard in 6-inch pipes. There is also an apparatus for reoxygenating air that has already been breathed. Moreover, there is a simple arrangement by which the ends of two rubber tubes can be floated up to the surface of the water and opened to the supply of fresh air up there. An electric motor, driven by force from storage batteries, runs the propeller. The interior, which is arranged for a crew of four or five men, is lighted by incandescent lamps. An indicator shows the distance of the boat beneath the surface. The estimated speed of the boat under water is eight knots. The torpedoes are to be carried outside the vessel, one at the prow and one at the stern. They are to be held there in iron cylindrical sheaths by electro-magnets, which will release them when the current is cut off. They are ballasted with cork, and, after placing one of them, the torpedo-boat retires to a distance, unreeling as it goes two wires, by which, at a proper distance, the torpedo is fired. On a recent trial near the Delamater Ironworks, New York, a crew of three men went aboard her, and a test was made of the electric engine. It drove the boat several miles up and down the river at a speed of ten knots, when she answered her rudder well. She will soon be tried under water. The lead ballast proved insufficient to sink the boat below the water.

Iron Nov. 1884.

ELECTRICITY AND HEALTH.—Sir Frederick Abel, chairman of the council of the Society of Arts, delivered the opening address of the session on November 19. He dealt principally with electricity and the recent Health Exhibition, and commenced his address with a tribute to the memory of Sir William Siemens, who, the speaker remarked, "had he been present, would have rejoiced to bear testimony to the continued steady progress made during the past year in the application of the electric light." The recent Health Exhibition, the chairman continued, was an instance of this, for during the whole of that exhibition over 5,000 glow lamps and 334 arc lights, yielding a candle-power light of 375,000, were worked with a total expenditure of only 1,180 tons of coal; whilst other electric light installations, upon a much less extensive scale than at South Kensington, but still of considerable magnitude, had come into operation during the year. The application of the light in small quantities to private houses had been the subject of many experiments by well-known electricians, and considering that the glow lamp was only in the fifth year of its existence, there was every reason to be very hopeful of its future development in the direction of permanence and of the consequent cheapening of domestic applications of the electric light. After a glance at the development of electricity for military purposes, Professor Abel referred to the attempts to utilise the agent as a motor, alluding, en passant, to the Siemens electric railway at the Paris Exhibition, the line between the Vienna Exhibition and the Praterstern, the Portrush and Giant's Causeway Railway, the Brighton Electric Railway, and several experimental lines in America. The result of recent trials seemed to foreshadow a future for the employment of electricity as the motive power, not merely for small pleasure craft, but for small vessels in which silent progression is a desideratum sufficiently important to counterbalance the defect due to the limited period during which the motive power could be maintained; and as to the transmission of heavy weights by electricity, the public would shortly see a system in application at Millwall, devised by Professor Jenkin, for moving goods trucks by telpher lines suspended as telegraph wires now are. A considerable portion of the address was devoted to a review of the effects likely to result to the public from the Health Exhibition—"effects," said Professor Abel, "which cannot fail to prove fruitful of great benefit to the country." Sir Frederick admitted the mixed character of the collection, but, speaking generally, he expressed the opinion that it was replete with instruction and interest to the masses, and even to the most educated, whilst the conferences added much to that instructiveness. The sanitary and insanitary houses erected side by side in the grounds emphasised the increasing importance of the comparatively new profession of the sanitary engineer, and with regard to smoke abatement, a comparison of the collection at the Smoke Abatement Exhibition of two years ago and the Health Exhibition showed that there was no single instance in which makers had not made an effort to achieve an advance, either in the extent to which the escape of smoke and the wasteful consumption of fuel were avoided and ventilation secured in the warming of a room, or in simplicity of construction or arrangement of an already efficient stove. After a reference to the advantages, in this connection, of liquid fuel, Professor Abel passed to the consideration of the adulteration of food, and the benefits derived from the recent legislation, and in the course of some remarks on water supply he pointed out the disadvantages of the deep-well system, and expressed the opinion that our hope for a radical improvement in the water supply of London lay rather in the application of some simple, expeditious, cheap and effective mode of chemical treatment to supplies from sources now in use previous to their filtration than in a complete change of the source of supply. The address concluded with an approving reference to the steps now being taken in the promotion of technical education.

Character of article Ed

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NIAGARA FALLS CONSIDERED AS A SOURCE OF ELECTRICAL ENERGY.

THE first suggestion of the possible employment of Niagara Falls as a source of electrical energy, and the distribution of this energy in the shape of light and power, is due to C. W. Siemens. It was a large suggestion; and it took root speedily in what may be termed 'cosmical minds.' The way, however, to its fulfilment, has not been made plain to business enterprise. The most noteworthy remarks upon the subject were made by Sir William Thomson in 1881, at the York meeting of the British association. His remarks and calculations were in substance as follows: With the idea of bringing the energy of Niagara Falls to Montreal, Boston, New York, and Philadelphia, a total electromotive force produced by the dynamo-machines at the falls was taken at 80,000 volts. This was between a good earth connection at the falls, and one end of a solid copper wire of half an inch in diameter, and three hundred statute miles in length. The resistance of the circuit was so arranged that there should be an electromotive force of 64,000 volts at the remote end, between the wire and the earth connection. The calculations showed that a current of 240 webers

not reached even the perfection which systems of electrical lighting have attained.

JOHN TROWBRIDGE.

Railway News
April 23/85

When that eminent electrician, Sir Wm. Thomson, was in this country some few years since, he was much interested in the examination of Niagara Falls, not as most tourists are interested—from idle curiosity—but from a belief entertained by him that the day would come when the tremendous powers generated there and running to waste would be utilized in running the mills, if not the railroads, through the State of New York. He had no sooner made the suggestion, when the illuminati, as is their wont when any one broaches an original idea, set up a howl of derision. They insisted that there was no reason to believe that anything of the kind would ever be accomplished; it was a purely chimerical idea, the product of a diseased mind. Then they went on to estimate the dimensions of a copper conductor required to transmit electrical energy one mile, increasing the diameter as they progressed until a few miles having been traversed, it was seen that the interest in the money expended for copper would alone amount to more than could be hoped for from the sale of the power transmitted from the great waterfall.

But while these purely ornamental scientists were trying to prove that the project was visionary, many practical electricians knowing Prof. Thomson's reputation for accuracy of statement, set to work to see what could be done in this direction. The progress these men or some of them have made is extraordinary, to say the least. Short lines of electrical railroads were among the first products of their exertions. Some of these were operated by electricity generated by coupling up a steam-engine and a dynamo at a central station and transmitting the energy along the line of the road while others, following Thomson's plan, were operated by electrical energy gathered on the banks of running streams. The best exponent of this system is found in the electric railway running between Portrush and Bush Mills in Ireland, and such success has been had in the operation of this road that it was recently extended eight miles.

The city of Rochester, New York, has for some time been lighted by electricity gathered on the banks of the Genesee River, the power being transmitted in a somewhat similar manner to that suggested by Prof. Thompson; and there are electric plants now in operation—a very large one in New York—which transmits not only light but also power to run shafting, and this over an ordinary copper conductor.

But what concerns us most and what led us to bring the subject before the readers of the RAILWAY NEWS, is the series of extraordinary experiments now being made in Paris by M. Marcel Deprez, in the transmission of electrical energy. Two years ago last March, Deprez, working in the railway shops of the *Chemin de Fer du Nord* in Paris, astonished the scientific world by transmitting twenty horse-power ten miles over an ordinary telegraph wire, and ten horse-power twenty miles, sustaining a loss in both instances, while *in transitu*, of a trifle more than fifty per cent. Considering that where power costs nothing at its place of production, a loss of even fifty per cent. is of little consequence. This was a wonderful achievement, and even the illuminati who had come "to scoff remained to pray."

At the Exposition at Munich, Deprez repeated his experiment, and again at Grenoble about a year ago, where he collected power from a running stream ten miles from the city and operated the shafting of a mill with it. Quite recently, however, Deprez has made some even more valuable discoveries in the transmission of electrical energy; showing that short lines of railroad running from a common center, as in the case with a great city, can readily be run by electricity brought to this common center from a running stream miles away, or from the mouth of a coal-pit where fuel is cheap.

There is a promise in the future in this direction that we wot not of.

London – Iron Trade
May 2/85

In the current number of the *Fortnightly Review* there appears an interesting article on "Recent Progress in Electricity," by Mr. Julius Maier. The article is instructive not only to persons directly interested in electricity, but to all those who have interest or stake in any modern industry. It may fairly be said that there is scarcely any trade on which the increasing application of electricity to practical purposes has no influence. Electric lighting is looked upon as an entirely new discovery, and it is not generally known that the electric light was employed for the purposes of illumination as early as the middle of the eighteenth century. Up to our own days, however, the electric light, though interesting as a scientific experiment in the lecture room, was not employed for practical purposes, owing to the vast amount of elements in the galvanic battery needed for its production. The new and practical era of electric lighting was heralded by the discovery of the principle of the dynamo-machine by Faraday, in 1830. The first really successful dynamo-machine was constructed by Gramme, in 1870, and since then progress towards perfection has been rapid, though perfection has by no means been obtained as yet. The serious objection to the introduction of electric lighting into general use is its cost of production. Even at the present day, it cannot compete with gas in cheapness. With the present system of converting heat into work by means of the steam engine, loss is entailed not only in the conversion of heat into work, but also in the transmission of the work thus obtained to the dynamo machine. Another principle is that of the thermo-electric battery. The defect in these batteries was the low standard of electro-motive force obtained. These are the only two systems at present discovered, though Mr. Julius Maier points out that there is no reason why some investigator may not be enabled to apply solar heat to the production of electricity. The other important element in electric lighting is the lamp. Of these, two species are in vogue, the arc and the incandescent lamps. Of these, the arc seems to have a future before it for lighting public buildings and thoroughfares, while the incandescent lamp seems destined, when perfected, to perform the task of domestic lighting. One of the most important applications of electric lighting has been to collieries, and it is to be hoped that ere long an Act of Parliament will compel owners to adopt the electric light in their mines. The importance of such a step will be realised on reflecting that in 1880 four hundred and ninety persons were killed by mine explosions in Great Britain. Mr. Maier further draws attention to the application of electricity to the transmission of sound in the now familiar telephone, and of energy as foreshadowed in the experiments made by Mr. Deprez, in 1882 and 1883. It was discovered by Mr. Deprez, that energy might be transmitted to a long distance with a loss of from 50 to 60 per cent. of original motive power. Further applications of electricity are found in the electric boiler safety apparatus of Mr. Richard Schwarzkopff, of Berlin, an invention whereby a boiler may be secured against danger arising from over-heating, excessive steam pressure, and want of water. Dr. Boudet has successfully applied electricity to medical purposes in his pulsometer, cardiaphone and myophones, the two latter for articulation of the heart and muscles, respectively. Though the public interest is at present centred more in the electric light, that is by no means the only new application of electricity which our days have seen, and it may be safely predicted that in no long time we shall be dependent on electricity for well-nigh all the ordinary appliances of every-day life.

Mail & Express
May 4/85

Electricity and Boiler Explosions.

Two terrific boiler explosions yesterday—one in the Tremont Hotel, Galveston, and the other in a sawmill a few miles from Wilkesbarre—caused the loss of five lives and serious injury to several persons, of whom some may not recover. In neither the hotel nor the mill could any satisfactory substitute for steam be found, perhaps, but the explosions direct attention to the advantage of introducing electricity in place of steam in all the buildings of cities where small engines are now used. Electricity is cheaper than steam where less than ten-horse power is required, and its safety is a much more important consideration. The transmission of power by wires under the streets will permit the removal of thousands of small steam boilers from buildings in this city, and the substitution of a dynamo for every engine of less than ten-horse power would promote both convenience and safety. It is asserted by electricians that the substitution would be advantageous even where more power than that of a ten-horse engine is used, and it is not improbable that a great change will be effected in this direction within a few years. Where large engines are used their management can always be entrusted to an expert, and statutory provision should be made to require this to be done; but the fact that electricity is cheaper than steam where small engines are employed will be sufficient to effect the desired change in establishments of this class as soon as the electricians supply the desired facilities. For heating purposes steam will always be extensively employed, probably; but experience has demonstrated the advantage of using steam from pipes in the street, rather than from a boiler in the basement.

N. Y. Tribune
May 2, 1885

Electric invention is by no means at an end. On the contrary it is more active than ever. It is being directed, however, rather to the application of electricity than to the discovery of new forces or powers. Electric lighting is in itself possible of world-wide application, but methods of the use of electricity in light may be wholly revolutionised at any time. George W. Stockley, of Cleveland, secretary of the Brush Electric Light Company, said the other day: "There is nothing especially new in the electric light world. It is settling down into a staple business. It has never been a speculative business with us. Those companies which pushed into speculative channels have nearly all burst up. The storage battery is not being pushed into the general market, and will not be until further changes are made in it. The trouble is that it requires more skill and intelligence to operate it than a sewing machine or a furnace, and the ordinary run of people will not give it the necessary care. The Pennsylvania Railroad Company is using the storage battery to light cars between New-York and Philadelphia, and has no trouble in its operation. The effort is being made to make a battery that any one can manage."

Menlo Park Scrapbook, Cat. 1051

No. 35. "Electric Lamp"

This scrapbook contains clippings about electric lamps. It covers the years 1879-1886, but most of the material is for 1879. The spine is labeled "Vacuum Pump--Tube--Radiometer--Elect. Lamp." There are 144 numbered pages.

Blank pages not filmed: 100-144.

1051

Electric Lamps.

[ITEM FOUND IN BOOK]

September 20, 1879.]

Mining & Sci Press

New Electric Mining Lamps.

A late number of the *Colliery Guardian* gives a long account of Andre's electric mining lamp, claiming its great desirability in mining operations, sub-aqueous works, and in factories where explosive agents are dealt with.

The light is enclosed in a strong glass cylinder, open only at its lower end, which rests in an air-tight seating upon the base of the lamp. By this means the atmosphere is securely excluded, and explosions of fire-damp certainly prevented. The cylinder is protected by rods on the outside; the lamp is constructed to be suspended from these rods, and the latter are utilized to pass the electric current in to the carbons. Being thus complete in itself, the lamp, when not in action, may be easily carried about from place to place, and suspended at any point required. The lamp consists essentially of four small carbon rods or pencils, enclosed in a series of vertical tubes. A light weight in each of these tubes above the carbon rod forces the latter down as its lower end is consumed. This weight is not heavy enough to break the point of the carbon, even when the point has become very fine, so that no unpleasant flickering occurs as the carbon descends, and no waste is occasioned. The arrangement of the carbon rods and the weights in tubes obviates the necessity for the strings required in other electric lamps working on the same principle of incandescence. The lower ends of the carbons rests upon discs of copper, which constitute the negative poles. The metal being incombustible, only one pole, the positive, is burned away. When the current is impeded by the accumulation of silicious dust from impurities in the carbon the disc turns slightly, and the point of the carbon sweeps the impediment away; and should the carbon rod fail to descend, by sticking in the tube, the disc rises and breaks it away from its point of contact.

The glass cylinder being air-tight, the combustion of the carbon is retarded through lack of oxygen, and finally ceases altogether. Practically, however, a slow waste occurs, due, perhaps, to oxygen occluded in the carbon, or possibly by the disintegrating action of the electric current. When the first carbon rod has been consumed, or if from any other cause it becomes extinguished from an interruption of the circuit, the current passes automatically to the second of the series. This rod is then slowly consumed, like the latter portion of the first. From the second, the current passes in like manner automatically to the third of the series, and from this again to the fourth. The total duration of the four carbons, which are each 9 inches in length, varies from 500 to 600 hours, according to the strength of current used.

There is no risk of the lamp being extinguished, because, in case of an interruption, the automatic action of the commutator switches the current from one carbon to the next in the series. The intensity of the light is about 75 candles. The light is regarded of great importance, in consequence of its superiority and the non-vitiating and non-heating of the atmosphere of the mine. It also works well under water, in works where caissons are used.

Edison's Discovery.

Mining & Sci Press Sept 20 1879

Mr. Edison has not yet revealed any additions to his knowledge of the use of electricity for illumination, but his paper on the treatment of platinum wire, read at the session of the American Association for the Advancement of Science at Saratoga, is almost as interesting as a discussion of the electric light would have been. Platinum, made incandescent by a hydrogen flame or by an electric current, wastes away or burns until nothing is left. This prevents its use for illuminating purposes. He found this to be caused, not by volatilization, a sgenerally understood, but by detrition, the currents of gas rubbing off fine particles. He prevented this by coating the wire with oxide of magnesium.

By further experiments Mr. Edison supplemented Dr. John W. Draper's discovery that platinum wire in a Bunsen flame becomes disintegrated. He states in his paper the fact that all metals have air spaces in them, and that these interstices are the origin of the cracks which become visible through a microscope after incandescence, and to the naked eye in platinum if a wire is stretched between clamp posts. These being the conditions, Mr. Edison put his platinum under the receiver of a powerful air-pump, and by alternately subjecting it to the action of a vacuum and sending an electric current through it to aid the expulsion of air by warmth, he produced a wire in which "no cracks were visible" by the microscope. "The wire had become as white as silver, and had a polish which could not be given it by any other means. The wire had a less diameter than before treatment, and it was exceedingly difficult to melt in the oxyhydrogen flame. As compared with untreated platinum, it was found that it was as hard as the steel wire used in pianos, and that it could not be annealed at any temperature."

Mr. Edison adds: "My experiments with many metals treated by this process have proved to my satisfaction, and I have no hesitation in stating that what is known as annealing metals to make them soft and pliable is nothing more than the cracking of the metal. In every case where a hard drawn wire has been annealed a powerful microscope revealed myriads of cracks in the metal."

Further experiments showed that a very much higher illuminating power could be obtained at a much less expenditure of force than in the original platinum. He has made, in fact, a new kind of platinum, and other metals, by the same process, are transformed in the same manner.

ANDRE'S ELECTRIC MINING LAMP.—A short time ago, the inventor of this important aid to the safe working of coal mines, explained its construction and working in a very perspicuous and exhaustive manner to an influential meeting at the offices of the British Electric Light Company, Parliament Street. Mr. Andre showed the perfect adaptability of his lamp to the lighting of fiery collieries and mines generally. The atmosphere being securely excluded from the light, the risk of explosion, with its fearfully disastrous effects, is entirely avoided, and this end is attained advantageously and economically, for the light remitted is of great power, and the cost far less than that of safety lamps or candles. The Duke of Sutherland, Professor Keats, and Mr. Easton, C.E., who were present, highly commended the design of the lamp as thoroughly practical in all its details. His Grace, on taking leave of Mr. Andre, expressed his satisfaction at the success attained, and remarked that the lamp had a great future before it. The lamp exhibited will burn 600 hours in a mine without being touched, four carbons being thrown into light automatically one after another. There are now good grounds for hoping that the terrible calamities of fire damp explosions may be averted. It may be added that the lamp is applicable to all mining operations, and particularly to sub-aqueous engineering works.

2 Engineering Sept 26 1879

MR. EDISON'S LAST DISCOVERY.

WHENEVER the prognostications of sanguine newspapers concerning Mr. Edison's electric light were falsified, it was said that Mr. Edison was not responsible for that which he had not himself said; at last he has spoken himself, and that of very wonderful discoveries indeed in a paper "On the Phenomena of Heating Metal in Vacuo by the Electric Current," read before the American Association at Saratoga Springs. The substance of his discovery is that by exhausting air or something else from platinum while at a high heat its durability is enormously augmented, as well as its power of giving out light. If a short length of platinum wire, one-thousandth of an inch in diameter, be held in the flame of a Bunsen burner, at some part it will fuse, and a piece of the wire will be bent at an angle by the action of the globule of melted platinum; in some cases there are several globules formed simultaneously, and the wire assumes a zigzag shape. With a wire four-thousandths of an inch in diameter this effect does not take place, as the temperature cannot be raised to equal that of the smaller wire, owing to the increased radiating surface and mass. "After heating, if the wire be examined under a microscope, that part of the surface which has been incandescent will be found covered with innumerable cracks. If the wire be placed between clamping posts, and heated to incandescence for twenty minutes, by the passage of an electric current, the cracks will be so enlarged as to be seen with the naked eye; the wire under the microscope presents a shrunken appearance, and is full of deep cracks." If the current is continued for several hours these effects will so increase that the wire will fall to pieces. Mr. Edison states that the cause of the shrinking and cracking of the wire is due entirely to the expansion of the air in the mechanical and physical pores of the platinum and the contraction upon the escape of the air, and that by eliminating the air with the aid of syringe pumps he has succeeded in producing "a metal in a state hitherto unknown and which is absolutely staple at a temperature where nearly all substances melt or are consumed—a metal which, although originally soft and pliable, becomes as homogeneous as glass and as rigid as steel. When wound in the form of a spiral is as springy and elastic when at the most dazzling incandescence as when cold, and which cannot be annealed by any process now commonly known." This is not all, Mr. Edison goes on to state that by the increased capacity of platinum to withstand high temperature, he is able to employ small radiating surfaces, and thus reduce the energy required per candle light. "I can now obtain eight separate jets, each giving out an absolutely steady light, and equal to sixteen standard candles, or a total of 128 candles, by the expenditure of 30,000 foot-pounds of energy, or less than one-horse power. The most astounding statement of all is, however, contained in the following passage:—"As a matter of curiosity, I have made spirals of other metals, and excluded the air from them in the manner stated. Common iron wire may be made to give a light greater than platinum not treated; the iron becomes as hard as steel, and just as elastic. Nickel is far more refractory than iron. Steel wire used in pianos becomes decarbonised, but remains hard and assumes the colour of silver. Aluminium melts only at a white heat." This means that the fusing points of the metals named is enormously increased by heating them slowly to very high temperatures in vacuo. Thus, for example, aluminium in its ordinary condition melts at a full red heat. Assertions so remarkable and so publicly made will not be suffered to pass unquestioned. It is extremely desirable that the inquiry should be taken up in this country, and pushed to its limits.

Arloing

La Correspondance Scientifique 30 Sept 1879

La Bougie Jablochkoff

La Société Générale d'Electricité (procédé Jablochkoff) vient d'obtenir une récompense bien méritée, après plus d'une année de luttes et d'expériences heureuses. Le concours international de l'Exposition des Pays-Bas, qui s'est tenu à Arnheim, lui a décerné une médaille d'or et une mention honorable pour les procédés Jablochkoff.

Cet éclatant succès donne une actualité toute particulière à une notice très intéressante et très instructive que la Société Générale d'Electricité vient de publier, notice qui répond si bien aux attaques et aux objections qui sont faites relativement à l'emploi de la bougie Jablochkoff. Mettre sous les yeux de nos lecteurs les quelques lignes de cette notice, c'est répondre victorieusement à ces attaques et à ces objections :

Le prix d'installation d'un bec de gaz étant de 100 francs, et celui d'un foyer électrique de 1,600 francs, on voit que l'installation d'un foyer électrique, dans le cas où elle revient le plus cher par suite de l'emploi d'un moteur spécial, ne coûte pas plus que celle de 16 becs de gaz. Donc, toutes les fois qu'un foyer électrique remplacera 16 becs de gaz, l'installation ne coûtera pas plus cher, bien que l'intensité lumineuse soit *supérieure* à celle des 16 becs.

Quant au prix de consommation, voici les conclusions de la notice :

D'après les résultats indiqués ci-dessus, on voit que 126 becs de gaz sont remplacés avec avantage par 6 foyers électriques brûlant à nu et donnant une lumière supérieure et une économie de 34 pour cent.

Il en résulte qu'en réalité, au point de vue de la dépense, un foyer électrique ne coûte pas plus que 8, 3 becs de gaz, en donnant une lumière supérieure.

Les globes opalins dont les foyers sont ordinairement environnés absorbant environ 1/3 de la lumière produite, on doit admettre que toutes les fois que 10 à 11 becs de gaz sont compris dans la zone d'éclairement d'un foyer électrique, on pourra les remplacer par un foyer électrique donnant une puissance éclairante supérieure sans augmentation de dépense.

En rapprochant ce résultat de celui qui a été trouvé plus haut, on voit que lorsque 16 becs de gaz seront remplacés par un foyer électrique, on aura égalité de prix d'installation et économie de consommation, avec une quantité de lumière plusieurs fois supérieure.

L'économie qui résulte de l'emploi de la lumière des bougies électriques substituées au gaz pour l'éclairage des espaces où le nombre des becs est déjà considérable n'est donc pas discutable.

D'ailleurs, outre cet avantage capital, cet éclairage présente les qualités suivantes :

1° Il conserve les couleurs et permet de différencier les teintes les plus voisines, ce qui serait impossible à la lumière du gaz. Dans toutes les industries où l'on doit se rendre compte de la qualité des

as fast as he could, and reached a solid standing-ground, but not before perceiving that the guide, who walked behind him, had sunk up to the middle in the sand, and indeed soon disappeared. All the slope sank with increasing swiftness, swelling out at the bottom and opening out to give forth a stream of mud of at least ten metres in height, which shot like a wild torrent across the plateau, and precipitated itself towards the Val de Bove. Immediately all the moving sand, to more than thirty metres in height, was diluted and drawn along, as were also the stones and blocks it contained, and which rolled over each other pell-mell. Fortunately they succeeded in extricating the guide, covered with mud, torn and bruised.

Seeking the origin of these eruptions of mud, M. de Saussure observes first that they take place in the neighbourhood of the central cone of Etna, and that they all escape from the foot of the cone and the very inclined slopes which support it. They proceed then exclusively from the water stored in the beds of ashes. These causes seem to account for this mass of water. 1. The hot vapours. The cone seems almost exclusively composed of ashes and movable stones, and during the eruption an enormous mass of vapour must have traversed it. There are, moreover, numerous fumeroles in the upper part. These vapours have been condensed, all the more readily that they have encrusted the mantle of snow which envelops the summit of the mountain. 2. The melting of this snow, determined less by the fall of ashes on the surface than by the heat which radiates from the interior and the vapours which traverse the porous mass of the cone. 3. The abundant vapours falling from the cloud of vapours projected by the crater. The two first causes are the most important; the last has most especially given rise to surface streams, the traces of which are apparent. The water gradually collecting in excess in the lower parts of the cone, ends by forming these enormous deposits, which, at a given moment, yielding to their weight, cause an eruption to the outside, turning over and diluting the beds of ashes which oppose its exit.

In a communication to us M. de Saussure gives an analysis of the little mud-heaps which have projected through the snow. They are composed of a grey powder formed of pozzolana (spongy amorphous silicates), white, grey, and black (augite), mixed with (*b*) amorphous sulphur (yellow and orange coloured); (*c*) calcium sulphate (hydrated) in numerous well-defined small crystals; (*d*) sodium and potassium sulphate; (*e*) calcium and potassium chloride; (*f*) perchloride of iron and oxychloride of iron; (*g*) indication of copper salts.

The crystals are all of alabaster, and so wet that they can only have been formed after the eruption of the mud in drying. There is no crystallised silica nor feldspar. The sulphur in the mud is curious to observe. It must have condensed out of the eruptive vapours which formed the water to make the mud by mixing with old ashes under the snow, and by their expansion driven small quantities of that mud through the snow. This mud, when heated, evaporates sulphur, sulphurous and sulphuric acid, some perchloride of iron, and some hydrochloric acid.

THE ACTION OF HEAT IN VACUO ON METALS[1]

Nature Oct 2 1879

IN the course of my experiments on electric lighting I have developed some striking phenomena arising from the heating of metals by flames and by the electric current, especially wires of platinum, and platinum alloyed with iridium. These experiments are in progress.

The first fact observed was that platinum lost weight when heated in a flame of hydrogen, that the metal coloured the flame green, and that these two results continued until the whole of the platinum in contact with the flame had disappeared. A platinum wire four-thousandths of an inch in diameter, and weighing 306 mgrms., was bunched together and suspended in a hydrogen flame. It lost weight at the rate of a fraction less than 1 mgrm. per hour as long as it was suspended in the flame. When a platinum wire is stretched between two clamping posts, and arranged to pass through a hydrogen flame, it is coloured a light green; but when the temperature of the wire is raised above that of the flame, by passing a current through it, the flame is coloured a deep green. To ascertain the diminution in the weight of a platinum wire when heated by the electric current, I placed between two clamping posts a wire five-thousandths of an inch in diameter, and weighing 266 mgrms. This wire, after it was brought to incandescence for twenty minutes by the current, lost 1 mgrm. The same wire was then raised to incandescence for twenty minutes it gave a loss of 3 mgrms. Afterwards it was kept incandescent for one hour and ten minutes, at which time it weighed 258 mgrms.—a total loss of 8 mgrms. Another wire, weighing 343 mgrms., was kept moderately incandescent for nine consecutive hours, after which it weighed 301 mgrms., showing a total loss of 42 mgrms. A platinum wire twenty-thousandths of an inch in diameter was wound in the form of a spiral one-eighth of an inch in diameter and one-half an inch in length. The two ends of the spiral were secured to clamping posts, and the whole apparatus was covered with a glass shade $2\frac{1}{2}$ inches in diameter and 3 inches high. Upon bringing the spiral to incandescence for twenty minutes that part of the globe in line with the sides of the spiral became slightly darkened; in five hours the deposit became so thick that the incandescent spiral could not be seen through the deposit. This film, which was most perfect, consisted of platinum, and I have no doubt but that large plates of glass might be coated economically by placing them on each side of a large sheet of platinum, kept incandescent by the electric current. This loss in weight, together with the deposit upon the glass, presented a very serious obstacle to the use of metallic wires for giving light by incandescence, but this was easily surmounted after the cause was ascertained. I coated the wire forming the spiral with the oxide of magnesium, by dusting upon it finely powdered acetate of magnesium: while incandescent the salt was decomposed by the heat, and there remained a strongly adherent coating of the oxide. This spiral so coated was covered with a glass shade, and brought to incandescence for several minutes; but instead of a deposit of platinum upon the glass, there was a deposit of the oxide of magnesia. From this and other experiments I became convinced that this effect was due to the washing action of the air upon the spiral; that the loss of weight in and the coloration of the hydrogen flame were also due to the wearing away of the surface of the platina to the attrition produced by the impact of the stream of gases upon the highly incandescent surface, and not to volatilisation, as commonly understood; and I venture to say, although I have not tried the experiment, that metallic sodium cannot be volatilised in high vacua by the heat derived from incandescent platinum; any effect that may be produced will be due to the washing action of the residual air. After the experiment last described I placed a spiral of platinum in the receiver of a common air-pump, and arranged it in such a manner that the current could pass through it, while the receiver was exhausted. At a pressure of 2 millimetres the spiral was kept at incandescence for two hours before the deposit was sufficient to become visible. In another experiment, at a higher exhaustion, it required five hours before a deposit became visible. In a sealed glass bulb, exhausted by a Sprengel pump to a point where a quarter of an inch spark from an induction-coil would not pass between points 1 millimetre apart, was placed a spiral, the connecting wires passing through the glass. This spiral has been kept at the most dazzling incandescence for hours without the slightest deposit becoming visible.

I will now describe other and far more important phenomena observed in my experiments. If a short length of platinum wire, one-thousandth of an inch in diameter be held in the flame of a Bunsen burner, at some part it will fuse, and a piece of the wire will be bent at an angle by the action of the globule of melted platinum; in some cases there are several globules formed simultaneously, and the wire assumes a zigzag shape. With a wire four-thousandths of an inch in diameter this effect does not take place, as the temperature cannot be raised to equal that of the smaller wire, owing to the increased radiating surface and mass. After heating if the wire be examined under a microscope, that part of the surface which has been incandescent will be found covered with innumerable cracks. If the wire be placed between clamping posts, and heated to incandescence for twenty minutes, by the passage of an electric current, the cracks will be so enlarged as to be seen with the naked eye; the wire, under the microscope, presents a shrunken appearance, and is full of deep cracks. If the current is continued for several hours these effects will so increase that the wire will fall to pieces. This disintegration has been noticed in platina long subjected to the action of a flame by Prof. John W. Draper. The failure of the process of lighting invented by the French chemist Tessie du Motay, who raised sheets of platinum to incandescence by

[1] A Paper read by Mr. T. A. Edison before the American Association for the Advancement of Science; Saratoga Meeting.

4

NEW FORM OF REYNIER'S ELECTRIC LAMP.

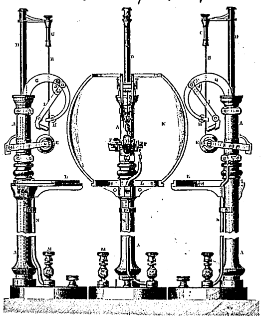
In 1878 Mr. E. Reynier observed the advantages presented by the effects of incandescence for the simple production and division of the electric light, and conceived the idea of uniting these effects with those of the voltaic arc. He therefore arranged the carbons, according to the Lodyguine system, so that it would burn at the point and furnish a small center of combustion at the point of contact. A small voltaic arc was thus produced.

Sc. Am. Sept 27 1879

In this lamp a slender rod of carbon is placed above a fixed and massive contact, either of carbon or metal, and is held in a vertical position by a heavy carbon holder. The carbon holder, by means of its weight, gradually pushes the carbon rod downward to replace the parts burned away. Cinders will collect at the point of contact if the ordinary carbons are used, but these cinders are thrown off by the rotation of the carbon disk. With this apparatus Mr. Reynier illuminated five lamps with a current from thirty Bunsen elements, and maintained the light in one of the lamps for more than a quarter of an hour with a secondary battery of three Planté elements.

Fig. 1 is a side view of the lamp without globe. Fig. 2 is a front elevation with section of globe and support. Fig. 3 is an elevation of the other side. A is the hollow supporting column with base; B is a slender carbon rod fitted to the socket, C, and retained by a screw. The vertical rod, D, supports the carbon rod, B, and slides in the column, A, on friction rollers. The carbon disk or cylinder, E, upon which the end of the carbon, B, rests, is supported in a forked arm, F. The carbon slides between the two cheeks of the curved guide, G. There is a small wheel, H, at the end of the guide, G, against which the carbon rod, B, rests, and an inclined lever, I, is pressed by the spring, J, against the carbon rod, and acts as a brake. A glass globe, K, covers the whole.

Mr. Reynier has made several models of his lamps. The last has a Carré carbon about 0·08 of an inch in diameter, held by a heavy carbon holder, which slides in a hollow column, and is provided with four friction rollers. The carbon rod rests on a carbon cylinder pivoted to a vertical arm of the column. A guide piece, provided with a brake, holds the carbon rod, and through this guide the current passes into the carbon rod, and from thence to the carbon cylinder, and returns to the battery. The point of contact is not directly over the center of the cylinder, but a little to one side, so that the cinders cannot accumulate.



REYNIER'S ELECTRIC LAMP.

¾ bar, 2½ inches at a cut. It has an open back, and will admit a plate 14 inches wide, and of course any length. The opening in the bed is 7x9 inches; stroke of slide 1⅛ inch; adjustment of slide 1⅛ inch. It weighs about 1,200 lbs., and

523. ELECTRIC LIGHT, J. T. and W. R. Bousfield.—Dated 10th February, 1879. 6d.

Engineer Oct 3 1879

A rotating armature is used made in the form of a drum, and composed of longitudinal sections secured in place by end plates, which are mounted on the armature spindle. These sections consist of segmental armatures, the core of which is preferably /—/ shaped in cross section, the flanges being set radially, and the induction coils laid longitudinally round the core. Or the sectional armatures may be made by coiling insulated wires on flat bars lengthwise in such manner that when placed together the periphery of the drum would present to the exciting magnets an unbroken surface of copper coils; the cores would, as in the former case, be connected magnetically. The Second part relates to holding and feeding, say, the positive carbon in an electric lamp. The carbon is held in a grooved holder, through which, when no current is passing, it slides freely until it touches the negative electrode. When the current passes the carbon is gripped tightly in its holder.

5-6

… seule lampe. L'expérience

NOUVELLE LAMPE ÉLECTRIQUE

A INCANDESCENCE (SYSTÈME REYNIER).

On se souvient que le principe des lampes Reynier consiste à maintenir incandescente une mince baguette de carbone, par le passage d'un courant électrique qui la traverse sur une partie limitée de sa longueur, entre un *contact en bout* sur lequel elle bute, et un *contact latéral* dans lequel elle glisse en progressant.

Nous avons montré aux lecteurs de *la Nature*[1] les diverses dispositions successivement imaginées par l'inventeur pour mettre en pratique ce principe original.

Continuant à perfectionner son système, M. Reynier vient de réaliser un nouveau *bec* électrique plus simple encore que ses précédents dispositifs, et qui va sans doute faire entrer les lampes à incandescence dans l'éclairage courant. Ce nouveau bec est représenté figure 1.

La Nature 27 Sept 1879

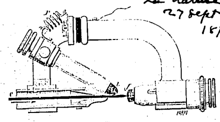


Fig. 1.

Le charbon C, poussé dans le sens de la flèche par un mécanisme quelconque, bute sur le *contact en bout* B; le *contact latéral* L, monté à l'extrémité d'un levier, s'appuie sur le charbon par le tirage d'un ressort *r* et limite entre *i* et *j* l'incandescence de la baguette.

Le contact en bout B est monté dans un porte-contact fixé à baïonnette dans la douille intérieure du bec. Pour introduire le charbon dans la lampe, on retire ce porte-contact, qui laisse libre l'orifice du tube; on pousse le charbon dans ce tube, puis on remet en place le contact en bout : et l'appareil est prêt à fonctionner.

L'incandescence, avons-nous dit, se manifeste entre *i* et *j* sur une longueur qu'on peut faire varier entre 4 et 8 millimètres. La lumière obtenue est de cinq à vingt becs Carcel par foyer, selon l'intensité du courant électrique et la longueur d'incandescence qu'on s'est donnée. Avec une pile de huit éléments Bunsen plats (modèle Ruhmkorff), on produit une lumière équivalente à douze becs Carcel environ. Quand on fonctionne avec des machines magnéto-électriques, on peut produire, par cheval-vapeur, de trois à cinq foyers valant chacun huit à quatorze becs, ce qui fait un rendement de trente à quarante becs Carcel par force de cheval.

Étant donné le bec, il était aisé de l'adapter à des lampes de formes diverses. M. Reynier a fait des appareils marchant de haut en bas par l'action d'un contrepoids ou d'une poussée hydrostatique, un modèle à barillet fonctionnant dans toutes les positions et un appareil suspendu, le plus simple de tous : c'est celui que nous représentons figure 2.

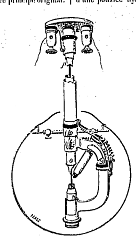


Fig. 2.

Ici, la progression du charbon est obtenue par la descente du cylindre *p*, qui pèse directement sur la tête du charbon.

SUR L'EMPLOI

DES PILES HYDRO-ÉLECTRIQUES

ET DES LAMPES REYNIER

POUR L'ÉCLAIRAGE DOMESTIQUE.

Nos nouvelles lampes électriques à incandescence, devenues simples, commodes et sûres, peuvent fournir de trois à cinq foyers par cheval-vapeur. Ces appareils trouveront donc un débouché important dans les usines et les grands établissements pourvus d'un moteur; car tout en fournissant un fractionnement plus grand qu'aucun autre système, les nouveaux foyers conservent un rendement photométrique assez satisfaisant (30 à 40 becs Carcel par cheval); de sorte qu'ils réalisent sur le gaz une économie sensible, en offrant des qualités de blancheur, de fixité, de salubrité, etc., qui en font un éclairage de luxe.

En dehors de ces applications, nos lampes à incandescence pourraient prendre place dans les in-

[1] Voy. table des matières des précédents volumes.

6

7

CHRONIQUE DES PROGRÈS DE LA LUMIÈRE ÉLECTRIQUE

Electricite
20 Aug 1879

Les expériences sur la lumière électrique ont obtenu un tel succès à Londres que le Bureau métropolitain des travaux publics s'est décidé à conserver les bougies Jablochkoff pendant une nouvelle période de six mois et à en augmenter le nombre d'une façon notable.

En effet, aux soixante bougies qui éclairent les quais de la Tamise, depuis le pont de Westminster jusqu'au pont de Blackfriar, viendront s'ajouter vingt autres qui illumineront le pont de Waterloo et la grande avenue Northumberland, allant du quai de la Tamise à la place Trafalgar.

Les amis du gaz sont consternés, car ils voient arriver flamboyante la grande nuit où les bougies Jablochkoff accapareront cette grande place, assiégeront le Parlement et, s'avançant par Regent Street, marcheront à la conquête du parc qui est le rendez-vous de la fashion universelle.

Pavillon des Halles Centrales illuminé par la lumière Jablochkoff

Cette éclatante victoire justifie nos assertions cent fois répétées et explique les attaques dont elles peuvent avoir été l'objet. Elle nous permet de ne point tenir compte des démentis qui pourront nous être adressés, pas plus que de ceux qui l'ont déjà été.

Elle prouve combien nous étions heureusement inspirés en avertissant, au commencement de ces expériences, les actionnaires du gaz du danger de les laisser commencer, car l'électricité est du nombre de ces ennemis qu'il faut étouffer dans le berceau, écraser dans l'œuf, étrangler au moment où ils se présentent.

Nous sera-t-il permis d'ajouter que le grand succès définitif obtenu à Londres est dû à l'innovation que nous avons réclamée depuis longtemps : la suppression des opales et leur remplacement par des globes à peu près transparents.

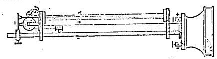
Toutefois, nous négligerions une occasion presque unique de mettre en évidence un grand fait général, si nous omettions de faire comprendre la nature des hésitations de la Compagnie générale d'Electricité.

Il fallait, en effet, faire l'éducation de l'œil du public, qui se serait plaint d'être inondé de clarté, si on lui avait montré dans les premiers temps la lumière Jablochkoff sans être atténuée.

Il serait arrivé quelque chose d'analogue à la combustion spontanée dont périt Sémélé, lorsque Jupiter eut la faiblesse de se rendre à ses prières et de se

Lampe électrique à incandescence système Ernest Arnould

M. E. Arnould nous a mis à même de faire connaître à nos lecteurs le dessin de la lampe électrique dont nous avons parlé dans notre précédent numéro.



A charbon de 1 ou 2 millimètres de diamètre.
B poulie faisant monter le charbon à l'aide du poids C.
D tronc de cône en charbon ou en métal contre lequel vient buter la baguette de charbon A.

Nous pouvons ajouter à ce que nous avons dit de cette lampe que son auteur a obtenu une lumière fixe et régulière pendant 6 heures, en employant 6 éléments Bunsen de 0 m. 20 centim. de haut.

Electricity July 1879

ENGINEERING.

FRIDAY, OCTOBER 10, 1879.

THE PHYSICAL ALTERATION OF METALS.

AT the meeting of the American Association for the Advancement of Science which has recently been held at Saratoga an announcement was made by Mr. Thomas Alva Edison of a discovery made by him, which, from its interesting nature and the probable value of its application, is quite equal to, if it does not surpass, the many discoveries and inventions that he has already given to the world. The public, more especially that portion of it interested in the development of the electric light, have for some months been expecting great things from Mr. Edison, as it has been a matter prfectly well known that he has throughout the whole of this year been devoting himself to the solution of the great problem of the day—the application of electricity to economical illumination—and Mr. Edison and his accomplished work are too well known for much doubt to exist as to important results accruing from a research to which he was with all his exceptional resources directing so much attention.

When it was announced a few months ago that Mr. Edison was experimenting with an alloy of iridium and platinum, and with each metal separately, for the production of the light-giving portion of an incandescence electric lamp, it was with considerable truth surmised that the former metal was too difficult to obtain in the first instance, and too refractory to work in the next, and the latter substance, besides being difficult to get, was too liable to destruction by fusion to render very promising the practical and commercial success on any extended scale of the employment of those metals in the then known distribution of them, and with their then understood physical character. Mr. Edison, so far from being blind to these difficulties, which would have been stumbling-blocks to less energetic investigators, set himself to search for fresh and more plentiful sources of supply of these precious metals by which they would become less precious, and at the same time to prosecute a research into the phenomena taking place when these metals were rendered incandescent under different physical conditions. If report from the other side of the Atlantic speak the truth, the search which Mr. Edison set on foot for new sources of supply has met with very considerable success, and of the successful results of his own experiments on the physical aspect of the question no further proof is needed than his very remarkable and interesting paper which was read before the American Association, and which must give to the Saratoga meeting a special historical feature.

Observing that a platinum wire heated to incandescence in a hydrogen flame gave to the latter a greenish tinge, at the same time losing its own weight, Mr. Edison made some careful quantitative measurements to ascertain the nature and extent of the loss sustained by the platinum. He took a bundle of platinum wire four-thousandths of an inch in diameter, and suspended it in a hydrogen flame. Before the experiment the platinum weighed 306 milligrammes (about 4¾ grains), and during its period of incandescence it lost weight at the rate of about one milligramme (.015 grain) per hour. Mr. Edison also noticed that a platinum wire within a hydrogen flame produced upon that flame different effects when deriving its temperature of incandescence solely from the flame itself, and when superheated from an external source; thus a platinum wire glowing with incandescence within a hydrogen flame by which it was heated, imparted to it a pale green colour, but when a current of electricity was passed through it so as to heat it above the temperature of the flame, the latter assumed a much deeper tone of green, and it would seem from this that the depth of colour is in some way connected with the amount of platinum being thrown off per unit of time, in other words, with the rate at which it is losing its weight under the conditions in which it is placed. In one experiment a platinum wire weighing 343 milligrammes (nearly 5.3 grains) was maintained for nine hours in an incandescent state, at the end of which time it was found to have lost no less than 42 milligrammes in weight (.65 grains); and when a spiral ⅜ in. in diameter and ½ in. in length composed of fine platinum wire was enclosed within a small glass shade and maintained in a state of incandescence for twenty minutes by the passage through it of an electric current, it was found that the inner surface of the glass shade became slightly coated with metallic platinum, and that after five hours of such treatment the deposit became so thick as to be perfectly opaque to the light emitted by the incandescent spiral, and Mr. Edison states his conviction that by a process founded on this phenomenon, large plates of glass might be coated with pure metallic platinum as reflecting surfaces with great economy by placing between them a sheet of platinum rendered incandescent by the passage through it of an electric current. Mr. Edison's explanation of the physical cause of this phenomenon is very interesting, and we cannot do better than present it to our readers in Mr. Edison's own words. "From this and other experiments," he says, "I became convinced that this effect was due to the wasting action of the air upon the spiral; that the loss of weight in and the coloration of the hydrogen flame were also due to the wearing away of the surface of the platinum by the attrition produced by the impact of the stream of gases upon the highly incandescent surface, and not to volatilisation as commonly understood." And the author in his paper goes on to describe a series of experiments in support of this theory, in which no such wearing away or diminution of weight was produced when the spiral was enclosed in a bulb which was exhausted by means of a Sprengel pump to such a degree that the discharge spark from an induction coil would not strike across a distance of one millimetre; in this experiment the spiral was maintained at the most dazzling incandescence for several hours without the slightest deposit being formed upon the surface of the glass envelope.

It is very interesting in turning over the pages of the history of the progress of science during the last half century to observe the different aspects with which different philosophers at different periods regarded certain facts of science, certain substances, and certain phenomena connected with them, how in their different views they seemed to arrive at different results; but as the observations of other investigators approaching the subject from different directions came to be recorded, and the great oneness and harmony of nature asserted itself in the human mind, things the most apparently opposite united their forces to support the truth, proving only that the conditions were the only agents in opposition, that the different positions assigned to the same phenomena by different observers were the result of a sort of mental parallax, and that Nature could not in these or anything else be divided against herself. Want of space will not permit us in this place to enter into the researches which bear more or less upon Mr. Edison's recent discoveries made by previous investigators, but the names of Döbereiner, of St. Claire Deville, of Troost, of Faraday, and of Graham, will recall a multitude of researches bearing on the occlusion and dispersion of hydrogen gas by certain metallic substances, more especially platinum, palladium, iridium, and certain other of the tetrad metals, under various physical conditions. It was found by Professor Graham that platinum, whether in the form of wire or of foil, is capable of absorbing when at a low red heat nearly four times its volume of hydrogen (measured cold), and that palladium foil condenses more than six hundred times its volume of hydrogen at a temperature below that of boiling water, and that in the spongy state platinum absorbs 1½ times its volume of hydrogen, and palladium nearly one hundred times.* Thus hydrogen so occluded at comparatively low temperatures, and at ordinary pressures, is driven out again, when the metal which has absorbed it is subjected to the action of heat and to a diminution of pressure, and Mr. Crookes in some of his beautiful experiments has taken advantage of these phenomena for varying the internal pressure within his exhausted vessels without having to use the Sprengel exhauster. The facts recorded by Mr. Edison of the diminution of weight in metallic wires when rendered incandescent at ordinary pressures are enhanced in interest by comparing them with the researches of the pioneers in the science of the subject to whom we have alluded; and the modification of the phenomena when atmospheric pressure is removed, and when the same experiments are conducted in high vacua taken in conjunction with Mr. Edison's explanation of it, adds very great interest to the recent researches of Mr. Crookes upon radiant matter, for while the last-named investigator has shown how, by the impact of gaseous molecules upon the vanes of a mill, mechanical motion may be imparted to them, and by the concentration of the streams of such molecules upon a small area the most intense heat may be produced, Mr. Edison has shown that these molecules, infinitesimally minute as they are, are so thoroughly material in nature that their friction on the surface of the heated platinum is sufficient to rub away its substance, transporting its particles to another place in a manner analogous to the action of the very interesting sand-blast process of Mr. Tighlman, for the cutting and engraving of stone, glass, and other hard substances.

From these experiments, which form the subject of the first part of his paper, Mr. Edison was led to undertake a minute examination of the structure of the substance of wires of platinum and other metals before and after being subjected to incandescence. In the course of this examination he found that the effect of incandescence upon wires experimented upon was to produce all over their surface innumerable cracks, and when the incandescence was maintained for twenty minutes these fissures became so enlarged as to be visible to the naked eye, and when still further continued for several hours the cracks united and the wire fell to pieces, and Mr. Edison points out that a somewhat similar phenomenon had been noticed by Professor Draper in platinum plates which had for a long time been subjected to the action of flame. A number of experiments made by Mr. Edison have led him to the conclusion that this cracking up of the surface of the metal is due entirely to the occluded gases imprisoned within its mechanical and physical pores becoming expanded and driven out under the action of heat, these gases first separating the molecules of the metal, then tearing their way through it to the surface, and escaping by the cracks and fissures so produced, a sort of microscopical volcanic action going on within the metal, producing miniature "earthquakes" and fissures on its surface out of which the heated gases are emitted. By heating spirals of platinum wire gradually by means of a transmitted electric current of periodical increasing strength, and within a chamber exhausted to a pressure of two millimetres, the gaseous bodies contained within their substance were gently withdrawn; and, by allowing the metal in the interval, between each increase of

* Philosophical Transactions, 1866.

temperature to cool down, a series of expirations of air from its surface took place alternating with a closing up and welding again together of the mi- nute fissures through which the gentle heating *in vacuo* had enabled the gases to escape. The pores of the metal thus became converted into an infinite number of what might be called molecular valves opening outwards whenever subjected to the gaseous pressure from within caused by the action of heat, but closing and welding up again with increased density at each alternate cooling. By continu- ing this very simple operation Mr. Edison has been able so completely to change the physical character of the metals subjected to the process, that he may almost be said to have produced new substances altogether, for he has done what is almost the same thing, he has produced metals in a state such as has never been known before, increasing their hardness and density to an extraordinary de- gree and raising their points of fusion so high that they are perfectly unaffected in temperatures at which most substances would be melted or consumed and very many would be volatilised. Most persons are aware that when a spiral of platinum wire is heated to a bright incandescence it softens and loses its elastic or rigid character, but it has been reserved for Mr. Edison to discover that when the same spiral is subjected to this alternate gradual heating and cooling in an exhausted chamber it becomes as homogeneous as glass and as rigid as steel, and its melting point is so enormously raised that a fine spiral so treated is, at a temperature at which it is glowing with an incandescence of dazzling brilliancy, as springy and elastic as when cold, and cannot be annealed by any known process.

The great value of Mr. Edison's discovery, as far as the electric light is concerned, lies in the power which it places in the hands of the metallurgist of raising the fusion point of platinum and of other metals beyond the reach of destruction by the trans- mission of the electric current, and if we understand Mr. Edison's experiments correctly, it is almost im- possible to overrate the value of their results to the development of the science of electric illumination and more immediately to that branch of the subject which deals with lighting by incandescence. The hitherto insurmountable difficulty in the way of illumination by incandescence has been the low fusion point of those metals which can be obtained commercially, and when obtained which can be worked, and our readers will remember that a few months ago* Mr. Edison included in a patent a large number of most ingenious devices for protect- ing a platinum spiral from destruction by its own incandescence, and there have been devices suggested and patents applied for, almost without number, for bringing about the same result. The fact, however, remained that platinum in its normal condition is when sufficiently incandescent to be useful for illumination purposes in a highly delicate state of unstable equili- brium, a delicately poised balance, so to speak, be- tween extinction from cooling on the one hand, and destruction from fusion on the other, and none of the very pretty protectors, so far as we have been able to learn, have been found to work satisfactorily in practice. Recourse was next had to using a sub- stance possessing a still higher fusion point, and this was found in the metal iridium, but this is both difficult to get, and, therefore, very costly, and still more difficult to work into wire. Mr. Edison has, however, met with some considerable suc- cess, as have the Anglo-American Electric Light Company, in the employment of an alloy of platinum with iridium, an alloy which combines, to a certain degree, the refractibility of the one metal with the malleability of the other; and, as such, gave some- what promising results, but for the reason stated above, it could hardly have come into very general application. Here then comes in the great value of Mr. Edison's new discovery, for he can, speaking *incandescently* (and by that we do not mean talking the language of a red-hot republican, but speaking from the point of view of the requirements of in- candescence), make a spiral in platinum and convert it when so made into iridium, or more correctly speaking, he can make his light-giving portion of platinum, which is easily drawn and manipulated; and when so made he can confer upon it a fusion point higher than the purest iridium, and without any fear of fusing it or of affecting its rigidity.

Mr. Edison has actually produced by his process spirals of platinum wire which could be raised by the passage of the electric current to such a high temperature without fusion, that their incandescence gave out a light of 25 standard candles, while the same coils not treated by the process gave a maxi- mum light of but four candles at their point of destruction by fusion. One spiral which had been submitted to the vacuum heating process more gradually, and for a longer period, produced a light of thirty candles, and the surface of all the wires so treated was in all cases free from roughnesses or cracks of any kind, presenting a brilliantly polished surface; they were as hard as the steel used for pianoforte wires, and by no process could they be annealed.

When we state that by preparing spirals in a Sprengel vacuum very slowly, and allowing a great many alternate heatings and coolings to take place, Mr. Edison has produced a light-giving body, whose total radiating surface is only $\frac{1}{32}$ in., which emits a light of eight standard candles, and that without the treatment the same spiral could hardly have produced one candle's light without fusion, and that he has thereby been enabled to produce eight lights, each of 16-candle power, or 128 candles in all, by the expenditure of less than one horse power, we have, we think, said enough to show the great importance of Mr. Edison's discovery to the single application of electric lighting, and it would be unreasonable to suppose that it has not still wider and more important applications. We shall on an early occasion refer again to this interesting subject, and to its probable bearing upon other branches of the science of illumi- nation by electricity.

* See ENGINEERING, vol. xxvii., page 160.

STEEL RAILS.

We publish elsewhere in the present issue (*vide* page 292) a letter from Mr. C. P. Sandberg, on a subject which is of particular interest just now, when there is some prospect of a revival in our steel trade, and when every item of saving in the cost of manufacture of steel rails has a special importance. The object of Mr. Sandberg's letter is to direct attention to the injury which steel rails now not unfrequently receive in the process of straightening cold, and to suggest a remedy in the shape of an arrangement of rolls by which rails are straightened while hot as they leave the saw, this plan having already been brought into use in America with very satisfactory results. It must be understood that Mr. Sandberg's remarks refer particularly to flange rails—rails of the double-headed or bull-headed sections being much less liable to injury from the ordinary process of straightening.

There can be no doubt that as Mr. Sandberg points out, fractures of steel rails sometimes occur which can only be explained by the supposition that the metal has received local injury, and the suggestion that such injuries are largely due to mal-treatment during the cold straightening process is a very plausible one. There can also be no doubt that it is the occurrence of such fractures as have just been referred to that has had an important influence in lead- ing engineers to increase the severity of their tests, until it has been rendered impossible for these tests to be satisfied without using a steel which is softer than is desirable as far as the power of resisting wear and tear is concerned. If, therefore, a cause of local injuries can be removed, a direct benefit will be obtained not only by the rail maker, but also by the rail user, who will be enabled to frame his specification so as to obtain harder rails than he feels justified in using under present conditions.

Altogether the subject is, as we have said, one of much importance, and we are glad that Mr. Sand- berg has drawn attention to it. No doubt there are many of our readers who have had special experience in the matter referred to, and we shall be glad to make public any facts which they may be able to lay before us. The time has, also, we think, arrived when the subject of the best standard tests for rails of different weights and sections might be discussed with advantage. The tests now prescribed by dif- ferent engineers, differ greatly in severity, and it would be of much interest to know how far these different tests are justified by the results obtained. On the one hand an insufficiently severe test may lead to the passing of rails of defective quality, while on the other, an unduly severe test tends to the supply of rails which are too soft to give the best results as regards wear, and, moreover, unneces- sarily increases the first cost. Steel rails have now been sufficiently long in use for a great number of facts to have been collected respecting the endurance and trustworthiness of rails made under systems of testing, and those who are in possession of such facts would do great good by making them public. It is indeed only by the interchange of such ex- perience that real progress can be insured, and for this reason we shall have much pleasure in throwing our columns open to the publication of such data as we have referred to.

LOCOMOTIVE CRANK AXLES.

On the Correct Shape and Dimensions of the Crank Arms in Locomotive Crank Axles.

By J. J. Birckel.

That crank axles are made to be broken is a dictum which will hold good, as long as the inside cylinder engine with its undoubted advantages finds an ad- vocate. Yet if cheapness of material and economy of labour in the process of manufacture have made the renewal of crank axles a matter of comparatively little moment, this is no reason why we should not endeavour to ascertain whether some neglected point in the proportions of such axles does not, in a great measure, account for their liability to fracture, and if we detect such a fault to remedy it accordingly.

It is well known that these fractures occur most frequently in the neck of the crank, and sometimes partly through the neck and partly through the arm; both cases are illustrated by the accompanying sketches, Figs. 1 and 2 (see opposite page) and the author has it on the authority of one of the oldest locomotive engineers of the United Kingdom, that a partial fracture takes place first, after which the axle continues to do duty very often for a consider- able time without any apparent increase of frac- ture before being finally disabled. A curious phenomenon like this demands a rational explana- tion, and this explanation can be none other but the following, namely, that the axle has established for itself, by this partial fracture, the conditions of flexibility which it requires to possess, in order to live and to do its work.

The author believes that the main point on which are based his recent researches on slide bars (see ENGINEERING, page 95 *ante*) will enable him to show that without a considerable amount of flexibility in the crank arms the axle is hopelessly doomed to break.

It has been shown in the paper on slide bars just referred to, that the shock to the bars due to the lateral displacement of the wheels corresponds to a pressure equal at least to double the weight of the wheels and axle with all the parts that move side- ways along with them, that shock being communi- cated to the bars by means of the connecting rod.

It follows, by Newton's principle, that the axle meets with an equal resistance to its lateral displace- ment, and as the mass $\frac{w}{g}$ (w being the weight of the wheels and axle with all the parts moving along with them laterally) has acquired its lateral momentum prior to the shock $2w$ taking place, and as that momentum can only be destroyed by lateral displacement, it follows that unless the crank arms can yield by their own structural flexi- bility, some molecular disruption must take place to permit of this lateral displacement.

If, for instance, in the accompanying Figs. 3 and 5, we assume the retarding force $2w$ to act in the di- rection of the arrow in the centre line of the neck of the crank, the part of the moving mass lying to the left of it will, by virtue of its acquired momentum, move in the opposite direction, and if nw be the weight of that portion, v its initial velocity of lateral displacement, and v_1 that velocity after the shock, we shall have

$$2we = \tfrac{1}{2}\frac{nw}{g}(v^2 - v_1^2) \quad . \quad . \quad (1)$$

e being the space through which the retarding force $2w$ has been acting, or in other words, the space through which the portion nw has been able to move relatively to the portion lying to the right of the crank, either by the structural flexibility of the arms, or by the accidental flexibility due to partial fracture.

From equation (1) above we make

$$e = \frac{n}{4g}(v^2 - v_1^2) \quad . \quad . \quad . \quad (2)$$

and as $(v^2 - v_1^2)$ is, to our certain knowledge, a quantity having a real, though unknown value, we know also that e has a real though unknown value, or more precisely, we know that the crank-fork must have opened by a certain amount, either through the structural flexibility of the arms, or through partial molecular disruption in or near the neck of the crank, and to avoid this latter con- tingency the arms ought to be made as flexible as possible.

Passing now to the consideration of the strains on the body of a crank axle, it is to be observed

June 25 '79 Sc. Am

THE KRUPP ELECTRIC LAMP.

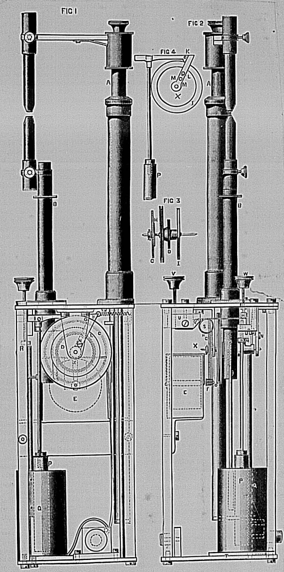
Herr von Krupp, of Essen, has recently patented an invention for "Improvements in Electric Light Apparatus." The main object of the invention is to regulate automatically the position of the carbons of an electric lamp "in a simpler manner than heretofore, without abandoning the generally acknowledged conditions on which the precision of motion of the single parts depends." The invention includes the application of a brake appliance for the automatic regulation of the distance between the two carbon points. A fan or fly revolves in quicksilver, or other liquid, for the purpose of regulating the motion of the carbon holder, this part of the apparatus being designed as a substitute for clock-work. A magnetic coil with iron casing and iron bottom is employed in connection with the motion of the brake appliance.

Fig. 1, in the engraving, which we take from *Engineering*, is a side elevation, and Fig. 2 a front elevation of the lamp, in which A is the holder for the upper positive carbon, and B the holder for the lower negative carbon. The upper holder, A, is suspended from the disk or pulley, C, by means of a jointed chain or wire, the lower holder, B, being similarly attached to a disk or pulley, D, the latter disk being just half the size of the former. The chains or wires are so passed round the pulleys that when the holder, A, descends a certain distance by its weight, the other holder, B, ascends to half the distance. Accordingly the electric arc formed between the carbon points occupies a fixed position. As the weight of the upper holder, A, must not be too small, because its motion would then be easily influenced by dust and dirt, it is necessary to have an appliance for retarding and regulating its course or travel. For this purpose a fly or fan, E, is applied, which revolves in mercury or other liquid. On the spindle of this fly there is a pinion, F, which gears with a tooth wheel, G, on the spindle, X, of the chain pulleys, C and D. In order that the fly, E, by the insertion of a fresh carbon should not have to revolve backward, the toothed wheel, G, is fitted with a pawl wheel, H.

The setting and regulating of the proper distance between the carbon points is effected in the following manner: On the same spindle, X, as the pulleys, C and D, and tooth wheel, G, there is a disk, I, as shown in the separate view, Fig. 3. Fig. 4 is a separate view of a brake of a peculiar form acting on this disk, I. The brake consists of two parts, K and M, which are jointed together at L. The lower part, M, can turn on the spindle, X, and has a hole, M^1, in which is inserted a small peg, N, Figs. 1 and 2. The peg, N, has much play in the hole, and the backward motion of the brake is limited thereby. O is a brake block on the upper part, K, of the brake; P is the keeper for an electro-magnetic coil, Q. This keeper is by a brass rod suspended from the other end of the part, K.

When the lamp is in action the keeper, P, is drawn into the coil, Q, whereby the brake block, O is pressed against the disk, I, turning the latter in its further movement downward, that is, so far as the set screw, R, Fig. 1, will allow. Thus, the upper carbon point will be raised, and the lower carbon point lowered, and the electric arc then makes its appearance. The carbon points now gradually consume away, the current becomes weaker, and its effect on the electro-magnet, Q, is lessened. The brake, K, supported by the spring, S—the action of which can be suitably regulated in proportion to the strength of the current by means of the lever, U, and set screw, V—and by the weight of the carbon holder, moves slowly back. The brake disk, I, is thereby enabled to turn forward, and the carbon points can approach each other. When this movement has proceeded as far as the brake disk, I, moved back before, then the lower part of the brake comes to bear against the peg, N. By the further weakening of the current, the brake will now turn in its joint at L, the brake block, O, releases the disk, I, and the carbon points move toward each other, whereby the current is strengthened and the brake is again applied to the disk, I, either simply to hold it when the carbon points are in their right position, or to pull it back when the carbon points are too close together. When inserting new carbons, the brake is fixed by the set screw, W, and the work is arrested thereby. The electro-magnetic coil, Q, rests on the bed plate, T, of the lamp, and is surrounded by an iron casing, whereby its power of attraction for the keeper is increased.

The fixed position of the arc provides for keeping the light in the center of a concave reflector. Where this is not required, the lamp may be simplified by leaving out the moving parts for the lower carbon holder, making it fixed instead of movable. The lamp thus devised has been employed by Herr von Krupp in portions of his great factory at Essen, in Germany, and the results have been so satisfactory that the light is being extended to other parts of the establishment.



KRUPP'S ELECTRIC LAMP.

1.14

THE TEMPERATURE OF THE CARBON POINTS IN THE ELECTRIC LAMP.

Engineering Oct 31 1879

Early in the development of the electric light a difference was observed in the appearance of the two carbon terminals. The positive was blunt and hollowed out in the centre; the negative was conical, pointed, and covered with the particles disintegrated from the positive. This, together with the difference of brilliancy noticed when the image of the carbons was projected on a screen, led to the same conclusion, viz., a difference of temperature between the incandescent points.

In 1844, Foucault and Fizeau wrote a paper upon this subject in which they described the general phenomena, but gave no data from which the heat condition of the two poles could be inferred. It was not until 1862 that any careful measurements were made. In that year, the late M. Becquerel made a series of experiments on the temperature of the positive carbon. The current was supplied by a battery of 80 middle-size Bunsen cells, and the temperature was taken at the moment the light flashed forth. M. Becquerel concluded that this temperature was not constant, but that it varied between the limits of 2070 deg. C. and 2100 deg. C. Unfortunately an assumption was made by the French physicist which has since been disproved, and hence the above figures have not been generally accepted.

It may be remarked that this determination is beset with considerable practical difficulties. The radiating surface must be small, a mere slice of the glowing carbons, and yet it must be measured with great accuracy. M. Rosetti, an Italian physicist, who has been following up the work begun by the late Professor Henry and Father Secchi on the temperature of the various parts of the solar disc, has recently applied his method to this electric problem. He has found that the temperature of the incandescent carbons, at the moment of ignition, is not the same throughout and is effected by a variety of circumstances, *e.g.*, the thickness of the terminals, the number of cells in the battery, the way in which they are coupled together, and the time they have been charged.

Thus in one series of experiments, the temperature of the positive terminal was found to be 2980 deg. C. By using a thinner terminal, it rose to 3065 deg. C.; and by changing this for a third of still smaller dimension, it reached 3136 deg. C.

The effect of the number of cells in the battery on the temperature is shown in the following Table:

Number of Cells.	Temperature.
80	2781 deg. C.
70	2536 "
60	2331 "
50	2190 "

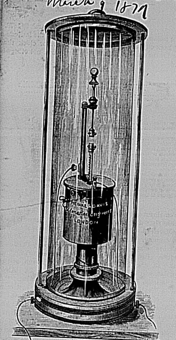
Foucault showed photometrically that the light produced by a battery of 80 Bunsen cells lost one-third of its intensity in less than three hours. Hence M. Rosetti was obliged to make a large number of determinations including all the varying conditions above mentioned before he could arrive at any very definite conclusion. In every case, however, he found the temperature of the positive pole higher than that of the negative; and, summing up his experiments, he concludes that the temperature of the positive carbon point cannot be less than 3200 deg. C. whilst that of the negative is at least 2500 deg. C.

15

SUBMARINE ILLUMINATION.

The conditions to be observed in the construction of lamps for giving light under water are many and difficult. Such lamps, like those used in an explosive atmosphere, must of course be isolated from the surrounding medium. There is also the additional requisite that, for a given degree of illu-

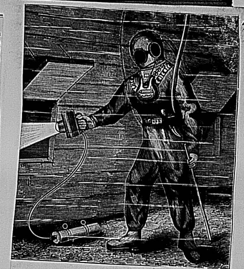
March 9 1877



ELECTRIC SUBMARINE LAMP.

mination, a greater intensity of light is needed to pierce the denser fluid. It is evident that there are strong objections against the use of ordinary gas or oil lamps for submarine illumination. They require an extra pump for their air supply, as much hose as the diver, and also as many men to attend to them; so that, for a necessarily feeble illuminating power, not only is the first cost considerable, but the working expenses are heavy and continuous. The cumbrous attachments are also a drawback.

Two modes of overcoming these difficulties are shown in the accompanying engravings. In one apparatus, that of Messrs. Heinke & Davis, the problem is solved by the aid of electricity. This light will burn below water without any air whatever; and it is stated by *Iron* that when the parts of the lamp are screwed together no further attention is required. The upper illustration on this page shows the construction of this apparatus. The strength of the electric light allows the substitution of a glass cylinder for the usual bull's eye lens and reflector, and thus a uniformly diffused light is produced. The cylinder is fitted to a segmental ring, and can be removed by turning it to the extent of one eighth of the circumference. The lamp is made of polished brass, the top and bottom portions being connected together by strong brass rods. A plate of lead at the bottom gives the necessary weight to balance displacement, and also causes the lamp to sink and remain steady when placed on the bottom. The lamp may be burnt continuously or intermittently, as required by the nature of the work; the carbons are usually arranged so as to last about four hours without renewal. Electricity is supplied by a battery of from twenty to forty Bunsen's elements, according to the intensity of light required. The bottom of the lamp is fitted with stuffing boxes, by means of which the wires connecting the lamp with the battery may be connected or disconnected at will, without the necessity of severing the wires. The total weight of this lamp, which gives a light equal to 20,000 normal candles, is about 60 lbs. It may be used independently of surface connection.



OXY-CARBON SUBMARINE LAMP.

Another plan is that of Messrs. Barnett & Foster, who use the system represented in the lower engraving. The light consists simply of the flame of a spirit lamp, urged by a jet of pure oxygen, compressed in a wrought iron bottle to about thirty atmospheres; and when one remembers what brilliant coruscations are produced by incandescent charcoal plunged in oxygen, it will readily be conceived that such a light is exceedingly powerful. This arrangement possesses the advantage of being entirely self-contained, dispensing with all pipes and connections from the surface. Exit valves are provided for the gaseous products of combustion, and the oxygen receiver is fitted with a rope, by which a diver can sling it on his back and walk about with it easily. The ordinary supply of materials will furnish a brilliant light for four hours.

14/16

Edison und das elektrische Licht.

(Für den "Techniker" von Ernst Gundlach.)

Der Techniker [illegible] 1879

Das Edison'sche Princip des Zweigstroms.

Unter den Erfindern auf dem Gebiete der Elektricität nimmt Thomas A. Edison entschieden einen hervorragenden Rang ein. Wir brauchen nur auf seine zahlreichen Erfindungen für Verbesserungen der telegraphischen Duplex- und Quadruplex-Gegensprech-Apparate, auf seine elektrische Feder, auf sein elektro-chemisches (lautsprechendes) Telephon und auf seine elektrischen Messinstrumente, wie das Mikrophon und den Mikrotasimeter, und schliesslich auf seinen zwar praktisch werthlosen, aber bedeutend ausposaunten Phonographen und andere Erfindungen hinzuweisen. Seitdem nun der berühmte Erfinder von Menlo Park in dieser Weise die Aufmerksamkeit der ganzen civilisirten Welt auf sich lenkte, konnte es nicht fehlen, dass auch auf verwandten Gebiete, wie dem des elektrischen Lichtes, resp. der praktischen Einführung desselben — die gleichzeitig und überall mit grösstem Eifer angestrebt wurde und noch wird — Edison für den Auserwählten angesehen wurde, der das grosse Problem endlich zur glücklichen Lösung bringen werde. Kein Wunder, dass die ersten Nachrichten über wirklich von Edison auch auf diesem Gebiete gemachte Studien und Experimente und deren angeblich wahrhaft grossartige Resultate sofort überall unbedingten Glauben fanden. Edison hatte — so hiess es — die Erfindung gemacht, das elektrische Licht auf den Strassen, in Theatern, Privatwohnungen, kurz, überall einzuführen, wo überhaupt künstliche Beleuchtung gebraucht wird. Die Gas-Compagnien bekamen eine Gänsehaut und die Oelquellen verloren die Lust, weiter zu springen. Illustrirte Journale brachten bereits Abbildungen von mit Edison'schem Lichte beleuchteten Privaträumen und alle Welt identificirte bereits das elektrische Licht mit Edison und liess alle übrigen Erfinder auf diesem Gebiete fast unbeachtet.

Obgleich nun mittlerweile nach und nach die Details der Edison'schen Projecte und Erfindungen durch Veröffentlichung seiner Patente der allgemeinen Beurtheilung zugänglich gemacht worden sind, so haben sich der Autoritätsglaube und die sanguinischen Hoffnungen dennoch bis heute in so hohem Grade aufrecht erhalten, dass eine ernste kritische Prüfung der bis jetzt bekannten Edison'schen Erfindungen im Gebiete der elektrischen Beleuchtung wohl nicht mehr als angemessen erscheinen dürfte.

Die Basis des Edison'schen Projectes ist die sogenannte "Theilung" des elektrischen Stromes, zu dem Zwecke, um eine *grosse* Anzahl Lichtherde von entsprechend *mässiger* Leuchtkraft von einer gemeinschaftlichen (centralen) Elektricitätsquelle aus zu speisen und vermittelst verbindender Leitungsdrähte auf *grosse* Räume (ganze Städte) zu vertheilen.

Alle *vor* Edison gemachten Versuche dieser Art stimmen ausnahmslos darin überein, dass die betreffenden Lichtapparate oder Lampen sämmtlich in *eine* und *dieselbe* Stromleitung *hintereinander* eingeschaltet wurden und dass also der an einer Centralstelle erzeugte, starke elektrische Strom z. B. von einer Strassenlaterne zur anderen, durch den, alle Laternen verbindenden Leitungsdraht gehen musste. Diese Versuche hatten den grossen Uebelstand, dass eine etwaige Unterbrechung der ganzen Leitung an irgend einer Stelle derselben, sei es ein Fehler an der Lampe selbst, oder das durch irgend einen Zufall etwa herbeigeführte Zerreissen des Drahtes, *das sofortige Erlöschen sämmtlicher Lichtherde* zur Folge hatte. Ebenso theilte sich jede Unregelmässigkeit in dem Funktioniren einer Lampe allen anderen mit, so dass dieselben gewissermaassen einen fortwährenden Kampf gegen einander führten.

Edison's Project beseitigte nun diesen Uebelstand durch Anwendung des — an und für sich durchaus nicht neuen — Princips des sogenannten *Zweigstromes*, indem er z. B. einen *starken* Hauptleitungsdraht durch die Strassen zieht und an diesem überall da, wo eine Lampe durch einen Strom für das Licht gespeist werden soll, einen *dünneren* Nebendraht abzweigt, der nach der betreffenden Lampe geleitet und dann wieder nach dem Hauptdrahte, in geringer Entfernung von der ersten Verbindungsstelle, zurückgeführt wird. Ein solcher Nebendraht nimmt von dem Hauptdraht einen geringen Theil seines elektrischen Stromes für sich in Anspruch. Die Stärke dieser Ableitung, resp. die dadurch verursachte Schwächung des Hauptstromes, richtet sich sowohl nach dem Verhältniss der *Dicke* des Nebendrahtes zu der des Hauptdrahtes, wie auch nach der *Länge* des Nebendrahtes zu der *Länge* des zwischen den beiden Verbindungspunkten liegenden Hauptdrahtes, d. h. je dünner und länger der Nebendraht im Vergleich zum Hauptdraht ist, desto schwächer der in den Nebendraht abgeleitete Strom, resp. desto geringer der Verlust des Hauptstromes.

Es leuchtet hiernach ein, dass man durch entsprechende Drahtdicke und Länge dem für die Lampen bestimmten Strom eine beliebige Stärke geben, und ferner, dass eine etwaige Unterbrechung des Zusammenhanges des Nebendrahtes nur die eine einzige Lampe erlöschen machen, auf die übrigen Lampen aber nur den höchst unbedeutenden, sogar *wohlthätigen* Einfluss ausüben kann, dass der, so lange von dem nun unterbrochenen Nebendrahte absorbirt gewesene Stromtheil sofort dem Hauptdrahte zurück gegeben wird.

Die erforderliche Sicherheit, welche die frühere Methode entbehrte und desshalb ihre Concurrenz mit der Gasbeleuchtung unmöglich machte, ist also in dem Edison'sche Project vollständig garantirt, und so sollte man meinen, dass der praktischen Verwendung desselben Nichts mehr im Wege stehe, nachdem Edison auch die *andere* Hauptbedingung — eine zweckmässige *Lampe* — bereits zur vollständigen Befriedigung gelöst zu haben scheint!

Dies ist jedoch leider nicht so; vielmehr stellen sich der praktischen Anwendung dieser Methode noch andere Schwierigkeiten und Hindernisse entgegen, die selbst Edison nicht richtig gewürdigt zu haben scheint.

Wir wollen versuchen, diese Hindernisse hier näher zu beleuchten und ihre Bedeutung uns klar zu machen.

Der elektrische Telegraph und seine äussere Einrichtung, seine hunderte von Meilen langen Leitungsdrähte, durch die uns mit der grössten Zuverlässigkeit Nachrichten aller Art übermittelt werden etc., ist uns etwas so Alltägliches geworden, dass wir aus den uns entgegentretenden Erscheinungen und Umständen naturgemäss die Meinung bilden, dass der elektrische Strom durch den *längsten* Draht ohne alles Hinderniss hindurch gehe, und, gleichviel, ob *eine* oder *hundert* Meilen lang, in unbeeinträchtigter Stärke am entfernten Ziele anlange.

Diese sehr allgemein verbreitete, jedoch durchaus falsche Vorstellung von der Fähigkeit des elektrischen Stromes hat schon so manchen sonst tüchtigen Menschen verleitet, all' seine Habe und Arbeitskraft der eingebildeten Erfindung einer sogenannten elektro-magnetischen Kraftmaschine zu opfern, um dann die Enttäuschung zu erleben, dass seine Maschine, anstatt die erwartete grosse Kraft zu entwickeln, sich nicht rückt und rührt!

Der elektrische Telegraph verdankt seine Existenz zum grössten Theil dem Umstande, dass ein *äusserst schwacher Strom* seinem Zwecke vollständig genügt!

Wäre ein nur einigermaassen kräftiger Strom erforderlich, um die betreffenden Apparate in Thätigkeit zu setzen, so würde, durch diesen Umstand allein, die Anwendbarkeit des Telegraphen ganz ausserordentlich in Frage gestellt werden, denn entweder müsste dann der Draht, der jetzt hunderte von Meilen lang sein darf, auf eine ganz geringe Entfernung, vielleicht bis auf eine einzige Meile, reducirt werden, oder er müsste eine enorme Dicke, oder der Krafterzeuger (Batterie) eine enorme Kraft haben.

Der verhältnissmässig starke Strom aber, den eine Telegraphen-Batterie in einem *kurzen* Draht, etwa nur 100 Fuss lang, zu erzeugen vermag, wird in dem viele Meilen langen Draht durch den um soviel Mal vergrösserten *Widerstand* desselben so ausserordentlich geschwächt, dass, weit entfernt, den Telegraphen-Apparat direct in Thätigkeit setzen zu können, ein besonderer, äusserst empfindlicher Apparat, das Relais, an der Empfangs-Station angewendet werden muss, um eine zweite, dort aufgestellte Lokal-Batterie zur Unterstützung einzuschalten, die dann erst den eigentlichen Telegraphen-Apparat in Thätigkeit setzt.

Noch klarer dürfte uns die Bedeutung des Widerstandes der Drahtleitung durch folgende Beispiele werden.

Leitet man z. B. durch einen *starken* Kupferdraht, der etwa 1/8 Zoll dick, und hundert Fuss lang sei, einen starken Strom einer Batterie von 10 Zellen, und controllirt die Stromstärke vermittelst eines eingeschalteten Galvanometers; verlängert man dann den Draht um das Doppelte, also auf zweihundert Fuss, so zeigt das Galvanometer eine Schwächung des Stromes an, die jedoch nicht bedeutend ist, und, je nach dem Verhältniss der Batterie zur Dicke des Leitungsdrahtes, vielleicht höchstens 1/4 beträgt, so dass noch etwa 3/4 oder noch mehr der ursprünglichen Stromstärke übrig bleibt.

Da nun die Vermehrung der Zellen der Batterie auch eine entsprechende Verstärkung der Stromerzeugung zur Folge hat, so sollte man erwarten, dass im vorliegenden Falle eine Zellenvermehrung um 1/4, also auf 13 statt 10, die durch die Drahtverlängerung verursachte Stromschwächung von 1/4 wieder zur ursprünglichen Stärke herstellen müsse. Dies tritt jedoch nicht ein, sondern die volle Stromstärke wird im vorliegenden Falle erst dann wieder hergestellt sein, wenn auch die Zahl der Zellen *verdoppelt* ist, also 20 beträgt!

Gehen wir wieder zurück und lassen es bei der ursprünglichen Zellenzahl 10, versuchen dagegen den Stromverlust durch entsprechende *Verdickung* der Leitung auszugleichen und verstärken zu diesem Zwecke *den* Theil der Drahtleitung, durch welchen die Stromschwächung verursacht wurde, nämlich einhundert Fuss der ganzen Leitung, während wir die ersten hundert Fuss in ihrer ursprünglichen Dicke belassen. Verstärken wir die hinzugekommenen hundert Fuss z. B. durch einen zweiten Draht von gleicher Länge und Dicke, den wir neben denselben legen und mit ihm von einem Ende bis zum anderen leitend verbinden, so zeigt uns das Galvanometer eine Zunahme der Stromstärke an. Obgleich nun diese Verstärkung nicht bedeutend ist, so sollten wir nach diesem Erfolge doch erwarten, dass durch fortgesetzte Verstärkung dieser einhundert Fuss endlich der Punkt erreicht werden müsste, wo die ursprüngliche Stromstärke wieder eintritt. Dies ist jedoch nicht so. Der Strom kommt zwar der ursprünglichen Stärke immer näher und näher, je mehr die zweiten hundert Fuss verstärkt werden, kann diese aber *niemals ganz erreichen*, selbst wenn die Leitung armesdick oder noch dicker würde!

Nur wenn auch gleichzeitig die erste Hälfte der Drahtlänge verdickt wird, kann die ursprüngliche Stromstärke wieder erhalten werden.

Haben wir nun aus diesen Beispielen eine klare Vorstelluug von der Bedeutung des Widerstandes gewonnen, der dem elektrischen Strome durch die Beschaffenheit der Drahtleitung geboten wird, so bedürften wir nur noch einiger praktischer Versuche zur Feststellung des positiven Werthes dieses Widerstandes, um uns die grossen Schwierigkeiten klar zu machen, die der Fortleitung eines *starken* elektrischen Stromes durch eine Drahtleitung von mehreren oder vielen tausend Fuss Länge entgegenstehen. Und in der That ist eine *enorme* Drahtdicke und gleichzeitig ein enorm starker Stromerzeuger dazu erforderlich!

Nun hat aber Edison's Zweigstrom-Project neben den Eingangs beschriebenen Vorzügen den grossen Fehler, dass nicht allein nicht der volle vorhandene Strom, sondern sogar nur ein *sehr geringer Theil* desselben für die Lichterzeugung verwendet werden kann. Ist der Hauptstrom nicht so stark, dass der für die Lichterzeugung in einer Lampe erforderliche Stromtheil fast verschwindend klein gegen denselben ist, so würde — falls nicht eine grosse Regelmässigkeit in der gleichzeitigen Thätigkeit einer bestimmten Anzahl Lampen stattfindet — die Beeinflussung des Hauptstromes, die wieder reactiv auf die einzelnen Lampenströme wirkt, so bedeutend sein, dass die sonst höchst sinnreiche Vorrichtung zur Regulirung der Stromstärke in der Edison'schen Lampe mit glühender Platinaspirale (siehe "Techniker" No 14) sich als *unzureichend* erweist, und das Licht ein Mal zu schwach und das andere Mal zu stark wäre, so dass der Platinadraht dennoch zum Schmelzen und die Thätigkeit der Lampe dadurch zum Stillstande gebracht würde.

Aber selbst um das Edison'sche Glüh-Licht hervorzubringen, resp. die Platinaspirale hinreichend zu erglühen, ist schon ein *ziemlich starker* elektrischer Strom erforderlich!

Edison ist nicht der Erste, der den Versuch gemacht hat, den elektrischen Strom zur Beleuchtung in ausgedehntem Maassstabe und auf grosse Entfernungen zu benützen. Aber seine Vorgänger (Lontin, Gramme etc.) waren ihm darin *überlegen*, dass sie wenigstens den wegen der grossen Circulationslänge höchst kostbaren Strom in seiner *vollen Stärke* für ihre Lichterzeugung ausbeuteten. Alle solche Versuche scheiterten aber dennoch an den grossen Schwierigkeiten der Hervorbringung eines genügend starken elektrischen Stromes auf grosse Entfernungen, resp. der unverhältnissmässigen Kostspieligkeit desselben. Einen wie grossen Rückschritt macht daher Edison mit seinem Zweigstrom-Project, welches unter Umständen vielleicht noch *weniger als den hundertsten Theil* des vorhandenen Stromes für die Lichterzeugung verwendbar werden lässt!

17

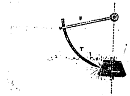
14/18

In der That muss daher die praktische Ausführbarkeit dieses Projects, wenigstens im grösseren Maassstabe, für *absolut unmöglich* angesehen werden, und so lange es Herrn Edison nicht gelingt, dieses Haupthinderniss zu beseitigen, werden seine in grösserem Maassstabe auszuführenden Versuche von vollständigem Fehlschlage begleitet sein. Thatsache ist, dass die seit Jahr und Tag versprochene elektrische Beleuchtung von Menlo Park bis dato noch nicht stattgefunden hat. In unserer nächsten Nummer werden wir nun Edison's Neuerungen auf dem Gebiete der dynamo-elektrischen Maschinen, sowie seine Glühlicht-Lampen des Näheren beleuchten und den Nachweis zu liefern suchen, dass er, mit Ausnahme mehrerer sinnreichen Lampen-Constructionen, in Bezug auf Strom-Maschinen, soweit diese jetzt bekannt sind, ein glänzendes Fiasco gemacht hat.

119

LAMPE VARLEY

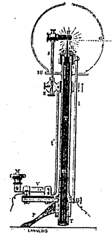
La lampe Varley, brevetée en 1876, se compose d'un crayon en charbon de cornue, de forme bizarre, reposant sur un galet qui est animé d'un mouvement de rotation dans le sens indiqué par la flèche. Le charbon rectiligne presse par son poids en proportion de son usure.



V. Levier pivotant auquel est attaché le charbon T.
T. Charbon positif en forme de demi-cercle venant butter par son propre poids contre le charbon N.
N. Charbon négatif servant de buttée et animé d'un mouvement rectiligne.

LAMPE DUCRETET

La lampe Ducretet, dont nous donnons plus bas la description, réalise le principe du système Werdermann d'une façon ingénieuse, mais prévue, à ce qu'on nous dit, dans un des brevets de l'inventeur.



SYSTÈME DUCRETET A FLOTTEUR DE MERCURE

Le chapeau B, métallique, qui sert de guide aux crayons G, est *isolé* du tube T, soit par un espace libre, soit par l'interposition d'une enveloppe concentrique de corps mauvais conducteurs de la chaleur, bois, terre cuite, verre, etc.; espace représenté en I sur la figure ci-contre première. Le chapeau métallique B est mis en *communication avec la partie inférieure* du tube T par un gros fil conducteur *t*. Les guides métalliques fixés sur le chapeau B sont mobiles et dépendent du diamètre des crayons qu'on emploie.

Par suite de l'action répulsive de deux portions consécutives d'un même courant, mais surtout par suite *du contact imparfait* du crayon G contre le bloc H (de charbon de cornue), il se produit un très-petit arc, puis (comme dans toutes les lampes électriques) le crayon rougit sur une certaine longueur que limite le contact métallique du chapeau B. Le crayon s'use au fur et à mesure de sa combustion, constamment amené au point d'appui H par la poussée du mercure. — La chaleur intense du crayon se communique de suite au chapeau métallique B, puis trouve un écoulement rapide par le conducteur métallique *t* qui y est fixé. Le calorique tend donc à arriver, par l'intermédiaire de ce conducteur *t*, à la partie inférieure du tube métallique T et à chauffer le mercure.

L'énergie du calorique développé est d'autant plus grande que le charbon qui flotte est le petit charbon qui se brûle et que le gros est celui qui sert de butoir.

La difficulté de se débarrasser de la chaleur est fort gênante. C'est une des raisons qui empêcheront probablement cet appareil de sortir du laboratoire, où sa place est marquée d'avance comme beaucoup d'appareils sortis des ateliers de cet habile ingénieur.

14 20 2

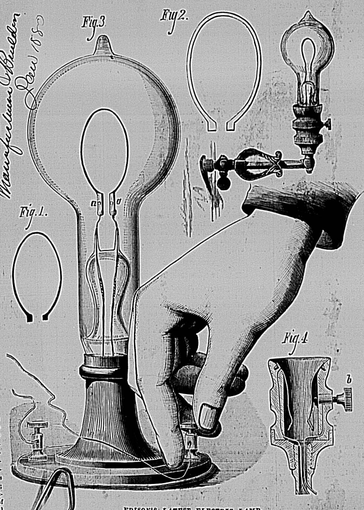
Manufacturer & Builder Jan 1880

The Electric Lamp of Edison.

We take pleasure in representing on this page the form of lamp which Mr. Edison's researches have led him at last to adopt. It appears that he soon found that the electric arc, so called, (which is the intensely luminous spark that flashes through the air between two carbon points placed close together), does not satisfy the requirements, and this for several reasons: 1st. It is altogether too intense for domestic use. 2d. It is not adapted for subdivision, as proved by the many futile attempts to accomplish this. 3d. It is difficult to keep it steady, as proved by all the different devices applied to the electric lamps, with and without regulating clock-work, none of which thus far have fully met the requirements.

Mr. Edison discards these lamps altogether, and first [illegible] platinum, [illegible] brought by the electric current to the state of incandescence in which it gives a light that, while strong enough for illumination, is at the same time not so intense as to produce a disagreeable glare, as is the case with the ordinary electric light thus far used. But the use of platinum, or some platinum alloy, which is subsequently used, involves great expense, as it belongs to the rare metals; while the manufacture of millions of lamps, which will be needed to supply the demand when once the electric light is introduced, would certainly raise the price of that scarce and already too expensive material. Therefore, he published some time ago a request to miners, asking them to give attention to the finding of more platinum. This appeal resulted in showing that, if needed, more platinum would be forthcoming, as was proved by an exhibition of results made at the close of the recent meeting of the American Association for the Advancement of Science, at Saratoga, N. Y., where Prof. Forsyth Barker, of Philadelphia, explained a large number of samples, which showed that in this case the demand could be supplied, even if it increased very far above the present limits, which are very contracted, as this precious metal is not suitable for ornaments, being by no means a handsome looking metal, (which makes gold and silver so attractive); neither is it used for coin, although Russia introduced some such coin several years ago. It is only used for those scientific and manufacturing purposes where its place cannot be supplied by anything else, hence the limited demand never stimulated increased production.

Now, however, Mr. Edison discards the incandescent platinum altogether, and uses nothing but carbon, which certainly is cheap and abundant enough; but he places it in a vacuum in order to prevent its combustion, which certainly would follow in the air, and that very rapidly too, as at the temperature required to make substances emit light, the affinity of carbon for atmospheric oxy



EDISON'S LATEST ELECTRIC LAMP.

Dec 21, 1879 NY Herald

EDISON'S LIGHT.

The Great Inventor's Triumph in Electric Illumination.

A SCRAP OF PAPER.

It Makes a Light, Without Gas or Flame, Cheaper Than Oil.

TRANSFORMED IN THE FURNACE.

Complete Details of the Perfected Carbon Lamp.

FIFTEEN MONTHS OF TOIL.

Story of His Tireless Experiments with Lamps, Burners and Generators.

SUCCESS IN A COTTON THREAD.

The Wizard's Byplay, with Bodily Pain and Gold "Tailings."

HISTORY OF ELECTRIC LIGHTING.

The near approach of the first public exhibition of Edison's long looked for electric light, announced to take place on New Year's Eve at Menlo Park, on which occasion that place will be illuminated with the new light, has revived public interest in the great inventor's work, and throughout the civilized world scientists and people generally are anxiously awaiting the result. From the beginning of his experiments in electric lighting to the present time Mr. Edison has kept his laboratory guardedly closed, and no authoritative account (except that published in the HERALD some months ago relating to his first patent) of any of the important steps of his progress has been made public—a course of procedure the inventor found absolutely necessary for his own protection. The HERALD is now, however, enabled to present to its readers a full and accurate account of his work from its inception to its completion.

A LIGHTED PAPER.

Edison's electric light, incredible as it may appear, is produced from a little piece of paper—a tiny strip of paper that a breath would blow away. Through this little strip of paper is passed an electric current, and the result is a bright, beautiful light, like the mellow sunset of an Italian autumn.

"But paper instantly burns, even under the trifling heat of a tallow candle!" exclaims the sceptic, "and how, then, can it withstand the fierce heat of an electric current?" Very true, but Edison makes the little piece of paper more infusible than platinum, more durable than granite. And this involves no complicated process. The paper is merely baked in an oven until all its elements have passed away except its carbon framework. The latter is then placed in a glass globe connected with the wires leading to the electricity producing machine, and the air exhausted from the globe. Then the apparatus is ready to give out a light that produces no deleterious gases, no smoke, no offensive odors—a light without flame, without danger, requiring no matches to ignite, giving out but little heat, vitiating no air, and free from all flickering; a light that is a little globe of sunshine, a veritable Aladdin's lamp. And this light, the inventor claims, can be produced cheaper than that from the cheapest oil. Were it not for the phonograph, the quadruplex telegraph, the telephone and the various other remarkable productions of the great inventor the world might well hesitate to accept his assurance that such a beneficent result had been obtained, but, as it is, his past achievements in science are sufficient guarantee that his claims are not without foundation, even though for months past the press of Europe and America has teemed with dissertations and expositions from learned scientists ridiculing Edison and showing that it was impossible for him to achieve that which he has undertaken.

HIS FIRST ATTENTION TO ELECTRIC LIGHTING.

When Edison began his experiments in September, 1878, he had just returned from the inspiring scenery of the Rocky Mountains, where he had been enjoying a little recreation after several months of hard labor. He was ripe for fields and enterprises new. A visit to a Connecticut factory where an electric light was used concentrated his thoughts on the subject of lighting by electricity, and he determined to attack the problem. Previous to this time, although he had roamed broadcast over the domain of electricity, wresting from it, as is well known, many of its hidden secrets, Edison had scarcely thought of the subtle fluid in connection with practical illumination. Now, however, he bent all his energies on the subject, and was soon deep in the bewildering intricacies of subdivision, magneto currents, resistance laws and the various other branches going to make up a system of lighting by electricity. The task before the young inventor was divisible into two parts.

First—The producing of a pure, steady and reliable light from electricity; and

Second—Producing it so cheaply that it could compete with gas for general illumination.

HE CHOOSES INCANDESCENCE.

Of the two systems before him—viz., voltaic arc and the incandescence system, Edison chose the latter as his field of operations. Prominent among the difficulties incident to incandescent lighting, it will be remembered, was the liability of the platinum (when that metal was used) to melt under the intense heat of the electric current, and the liability of the carbon, when that was employed, to gradually become dissipated under the combined action of gases and the electric current.

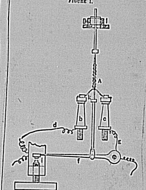
THE PLATINUM LIGHT.

As between platinum and carbon as the substance to be made incandescent, Edison took up platinum and devoted first his attention to the obtaining of some device to prevent the platinum from melting under the intense heat of the electric current. An ingenious and simple contrivance met the requirement. He arranged a small lever, about three inches long, so that the expansion of the platinum (caused by the heat) beyond a certain degree would close it, such closing making a new passage for the electric current and cutting it off from the incandescent platinum. When the latter contracted, as it did the moment the heat was lessened, the lever returned to its normal position and allowed the electric current to again pass through the platinum. By this device the inventor hoped to be able to keep the incandescent platinum always below its melting point. The contrivance is described in his first patent as follows:—

THE FIRST LIGHT.

"Electric lights have been produced by a coil or strip of platinum or other metal that requires a high temperature to melt, the electric current rendering the same incandescent. In all such lights there is danger of the metal melting. My improvement is made for regulating the electric current automatically passing through such incandescent conductor, and preventing its temperature rising to the melting point, thus producing a reliable electric light."

FIGURE 1.



"Fig. 1 shows one form of the device. The incandescent metal is in the form of a double spiral A, the two ends terminating upon the posts b, c, to which the conductors d, E, are connected. A circuit closing lever, f, is introduced in the electric circuit, the points of contact being at i, and there is a platina, or similar wire, k, connected with the lever, f, to the headpiece or other support, l. The current from a magneto machine is connected with the wires E and d. The current then flows from E to the post, c, thence around the platinum spiral to b, and is carried off by the wire, d. Now, when the rod, k, of platinum becomes heated to too great intensity its expansion closes the lever, f, and the current then passes from E, through f, and not through the spiral at all. In this way the lever cuts off the current every time the heat becomes too intense."

Numerous other devices of a similar character were tried and for a while they all worked satisfactorily, but the inventor finally discovered that the constant expansion of the platinum rod k and its pressure upon the lever f bent it so that it became unreliable and it was, therefore, abandoned.

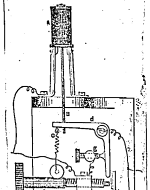
THE SECOND PLATINUM LAMP.

The next regulator was in the form of a diaphragm, which cut off the electric current from the platinum every time the diaphragm was pressed outward beyond a fixed limit by the heated air. The regulation thus produced was so rapid that the eye could not perceive any diminution in the strength of the current. But this also was inadequate in many respects. The next important modification in the light was the substitution for the platinum spiral of finely divided platinum incorporated with non-conducting material. When the electric current was passed through the combination the platinum particles became incandescent and the non-conducting material incorporated with them became luminous and increased the brilliancy. One advantage by this form not previously attained was that a very weak electric current produced a good light.

THE BOBBIN LAMP.

After this followed a device for obtaining more light-giving surface, the platinum being wound in the form of a small bobbin, first having been coated with a non-conducting coating that was not injured by the heat. With this arrangement a new form of regulator was used. The lamp at this stage is shown in figure 2.

FIGURE 2.



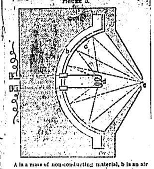
A is the incandescent bobbin, between the coils of which is a coating of magnesia. The top of the bobbin has a metallic cap connected to the lever, d. A spring, C, draws the rod, B, downward with considerable pressure, and this, of course, places pressure on the top of the bobbin, thus keeping the wire in contact with the upper end of the coil. The bobbin, A, expands as a whole by the heat and draws the rod, B, upward. This brings the lever attached upward and allows the lever, E, to come in contact with the screw, F, permitting the current to find a passage other than that afforded by the incandescent material.

The inventor next followed with a new regulator and a meter for measuring the amount of electricity used; also an automatic switch connecting the regulator with the wires leading to the machine for generating the electric current.

THE REFLECTOR LAMP.

The next was a unique idea, making the platinum give the light as it were by proxy. By means of a reflector he concentrated the heat rays of the platinum upon a piece of zircon, causing the latter to become luminous. Figure 3 shows the apparatus.

FIGURE 3.

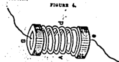


A is a mass of non-conducting material, b is an air space, c is a polished reflector of copper coated with gold, d is a platinum-iridium spiral, which becomes heated by the passage of the electric current through it, E is a thin piece of zircon that receives the heat rays thrown off by the reflector, C, which heat rays bring up the zircon, E, to vivid incandescence, making it give out a light much more brilliant than the light of the platinum spiral, C. With this form Mr. Edison tried numerous experiments, and from time to time made many alterations and improvements, but eventually the apparatus was placed in the category of non-successes.

ANOTHER SPIRAL.

Realizing from the first the necessity of the light giving substance offering much resistance to the passage of the electric current—a necessity in extensive subdivision of the light—the inventor throughout his experiments kept a close watch for substances and forms that gave suitable resistances. In figure 4 is shown a form of lamp disconnected from the regulating apparatus, which largely embodied the above requirement and for a time gave good results.

FIGURE 4.



A is a spiral of carbon with two large ends, B, e, connecting with the wires leading to the machine for generating the current. This device was tried for several weeks, but did not, as a whole, give satisfaction.

EVERY MAN HIS OWN ELECTRIC LIGHTER.

Branching off from the line of investigation he had been previously following Mr. Edison at this time began experimenting with a view to having the light produced locally—i. e., arranging for each householder to become his own manufacturer of light, thus dispensing with mains and central stations. The apparatus which he used for this purpose is shown in figure 5:—

FIGURE 5.

It is an induction coil such as are used by peripatetic showmen at fairs and other places when they give electric shocks to inquiring sightseers at so much per shock. It is operated by two cells of battery, B, and wires lead from it to the glass tubing, T, from which the air has previously been extracted, and the passage of the electric current through the tubing gives out a light. This plan is analogous to what is known as the Geisler tube arrangement, the difference being in the form of the tube and the extreme smallness of the bore and also in the degree of vacuum produced. Mr. Edison succeeded by this arrangement in obtaining a light of several candle power with a moderately powerful induction coil. The light, however, was not the one sought after so persistently by the inventor, and so it took its place in that part of his laboratory occupied by inventions not in use.

OSMIUM-IRIDIUM.

Once more Mr. Edison made a departure. He moulded powdered metallic oxides in the form of sticks and subjected them to a very high temperature. In this connection he obtained very fine results from the native alloy of osmium-iridium called iridosmine, which alloy he used in the form of a powder enclosed in a tube of zircon. The electric current passing through the same brought it to a beautiful incandescence.

CARBON AND PLATINUM.

The inventor's next important move was the adoption of carbon in connection with platinum as the substances to be made incandescent. He caused a slender rod of carbon to rest upon another of platinum, the inferiority of contact between the two at their point of meeting producing a resistance to the passage of the electric current and causing the carbon to become highly incandescent, while the platinum attained only a dull red heat. The carbon rod was kept pressing upon the platinum by a weight ingeniously arranged. A dozen or more forms of this lamp were made; but, after all, the inventor was obliged to return to platinum as the substance most suitable, all things considered, for being made incandescent. For two months he worked at platinum day and night, only to find that platinum, as he had been using it, was entirely worthless for incandescent lighting. To many experimenters this would have proved a discouragement perhaps fatal, but it had the effect only of increasing Edison's determination.

THE CRACKS IN PLATINUM.

After scores of new experiments he arrived at the true causes of the defects and hastened to apply the remedy. I have found, he writes, that when wires or sheets of platinum, iridium or other metallic conductors of electricity that fuse at a high temperature are exposed to a high temperature near their melting point in air for several hours by passing a current of electricity through them and then are allowed to cool, the metal is found to be ruptured, and under the microscope there are revealed myriads of cracks in various directions, many of which reach nearly to the centre of the wire. I have also discovered that, contrary to the received notion, platinum or platinum and iridium alloy loses weight when exposed to the heat of a candle; that even heated air causes it to lose weight; that the loss is so great a hydrogen flame is tinged green. After a time the metal falls to pieces; hence wire or sheets of platinum or platinum and iridium alloy as now known in commerce are useless for giving light by incandescence—

First—Because the loss of weight makes it expensive and unreliable and causes the burner to be rapidly destroyed.

Second—Because its electrical resistance changes by loss in weight, and its light-giving power for the total surface is greatly reduced by the cracks or ruptures.

The melting point also is determined by the weakest spot of the metal.

PLATIN[illegible]

By my invention or discovery I am able to prevent the deterioration of the platinum or its alloys by cutting off or intercepting the atmospheric action. A spiral wire or other forms of platinum is placed in a glass tube or bulb, with the wire near its ends passing through and sealed in the glass, and the air is exhausted from the glass. The platinum wires of the spiral are then connected to a magneto-electric machine or battery, the current of which can be controlled by the addition of resistance. Sufficient current is allowed to pass through the wire to bring it to about 150 degrees Fahrenheit. It is then allowed to remain at this temperature for ten or fifteen minutes. While thus heated both the air and gases confined in the metal are expelled by the heat, or withdrawn by the vacuum action.

While this air or the gases are passing out of the metal the mercury pump is kept continually working.

After the expiration of about fifteen minutes the current passing through the metal is augmented so that its temperature will be about 300 deg. Fahrenheit, and it is allowed to remain at this temperature for another ten or fifteen minutes.

The mercury pump is to be worked continuously and the temperature of the spiral raised at intervals of ten or fifteen minutes until it attains vivid incandescence and the glass is contracted where it has passed to the pump and melted together.

BRILLIANT RESULTS.

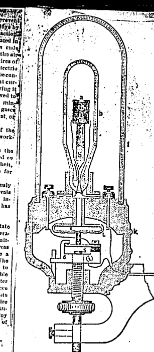
The wire is now in a perfect vacuum and in a state heretofore unknown, for it may have its temperature raised to a most dazzling incandescence, emitting a light of twenty-five standard candles, whereas before treatment the same radiating surface gave a light of only about three standard candles. The wires after being thus free from gases are found to have a polish exceeding that of silver and obtainable by no other means. No cracks can be seen even after the spiral has been raised suddenly to incandescence many times by the current, and the most delicate balance fails to show any loss of weight in the wire even after it is burning for many hours continuously. I have further discovered that if an alloy of platinum and iridium is coated with the oxide of magnesia and subjected to the vacuum process described, a combination takes place between the metal and the oxide, giving the former remarkable properties. With a spiral having a radiating surface of 3-16 of an inch light equal to that given by forty standard candles may be obtained, whereas the same spiral, not coated by my process, would melt before giving a light of four candles. The effect of the oxide of magnesia is to harden the wire to a surprising extent and render it more refractory. A spiral made of this wire is elastic and springy when at high incandescence. I have found that chemically pure iron and nickel drawn in wires and subjected to the vacuum process may be made to give a light equalling that of platinum in the open air. Carbon sticks also may be freed from air in this manner and be brought to a temperature where the carbon becomes pasty and on cooling it is homogeneous and hard.

THE FIRST PLATINUM VACUUM LAMP.

About this time another truth dawned upon the inventor—namely, that economy in the production of light from incandescence demanded that the incandescent substance should offer a very great resistance to the passage of the electric current. Concerning this the inventor writes:—"It is essential to reverse the present practice of having lamps of but one or two ohms (electrical units) resistance and construct lamps which, when giving their proper light, shall have at least two hundred ohms resistance."

The lamp, as it stood at this stage of the inventor's progress, is shown in figure 6.

FIGURE 6.



a is the burner or incandescent platinum in the shape of a bobbin supported within the vacuum tube, b, by a rod, b', of the same material as the bobbin. The vacuum tube, b, is sustained by the case, k, and around said tube, b, is a glass globe, l. Within the case, k, is a flexible metallic aneroid chamber, l, that opens into the glass case, so that the air, when expanded by heat, can pass into the aneroid chamber and give motion to the flexible diaphragm, x, and parts connected therewith. When the current circulating around the bobbin, a, becomes too intense and heats the latter too highly the air within the glass case, l, is expanded and bulges downward by the diaphragm, x, and the pin thereon pressing upon the spring, 5, and separating said spring from the block, 6, breaks the circuit to the burner. The temperature within the globe, l, lowers immediately and the parts return to their normal position, closing the circuit through the burner to 5 and 6. This opening and closing of the circuit is but momentary, and, therefore, the uniform brilliancy of the light is not affected and there is no danger of the burner becoming too highly heated.

PERFECTING THE MACHINERY.

The lamp, after these latter improvements, was in quite a satisfactory condition, and the inventor contemplated with much gratification the near conclusion of his labors. One by one he had overcome the many difficulties that lay in his path. He had brought up platinum as a substance for illumination from a state of comparative worthlessness to one well nigh perfection. He had succeeded, by a curious combination and improvement in air pumps, in obtaining a vacuum of nearly one millionth of an atmosphere, and he had perfected a generator or electricity producing machine (for all the time he had been working at lamps he was also experimenting in magneto-electric machines) that gave out some ninety per cent in electricity of the energy it received from the driving engine. In a word, all the serious obstacles toward the success of incandescent electric lighting, he believed, had melted away, and there remained but a comparatively few minor details to be arranged before his laboratory was to be thrown open for public inspection and the light given to the world for better or for worse.

A GREAT DISCOVERY.

There occurred, however, at this juncture a discovery that materially changed the system and gave a rapid stride toward the perfect electric lamp. Sitting one night in his laboratory reflecting on some of the unfinished details, Edison began abstractedly rolling between his fingers a piece of compressed lampblack mixed with tar for use in his telephone. For several minutes his thoughts continued far away, his fingers in the meantime mechanically rolling out the little piece of tarred lampblack until it had become a slender filament. Happening to glance at it the idea occurred to him that it might give good result as a burner if made incandescent. A few minutes later the experiment was tried, and, to the inventor's gratification, satisfactory, although not surprising results were obtained. Further experiments were made, with altered forms and composition of the substance, each experiment demonstrating that at last the inventor was upon the right track.

A COTTON THREAD.

A spool of cotton thread lay on the table in the laboratory. The inventor cut off a small piece, put it in a groove between two clamps of iron and placed the latter in the furnace. The satisfactory light obtained from the tarred lampblack had convinced him that filaments of carbon of a texture not previously used in electric lighting were the hidden agents to make a thorough success of incandescent lighting, and it was with this view that he sought to test the carbon remains of a cotton thread. At the expiration of an hour he removed the iron mould containing the thread from the furnace and took out the delicate carbon framework of the thread—all that was left of it after its fiery ordeal. This slender filament he placed in a globe and connected it with the wires leading to the machine generating the electric current. Then he extracted the air from the globe and turned on the electricity.

Presto! a beautiful light greeted his eyes. He turns on more current expecting the fragile filament instantly to fuse; but no, the only change is a more brilliant light. He turns on more current, and still more, but the delicate thread remains entire. Then, with characteristic impetuosity and wondering and marvelling at the strength of the little filament, he turns on the full power of his machine and eagerly watches the consequence. For a minute or more the tender thread seems to struggle with the intense heat passing through it—heat that would melt the diamond itself—then at last it succumbs and all is darkness. The powerful current had broken it in

...again, but not before it had emitted a light of several gas jets. Eagerly the inventor hastened to examine under the microscope this curious filament, apparently so delicate, but in reality much more infusible than platinum, so long considered one of the most infusible of metals. The microscope showed the surface of the filament to be highly polished and its parts interwoven with each other.

THE PAPER LIGHT.

It was also noticed that the filament had obtained a remarkable degree of hardness compared with its fragile character before it was subjected to the action of the current. Night and day, with scarcely rest enough to eat a hearty meal or catch a brief repose, the inventor kept up his experiments, and from carbonizing pieces of thread he went to splinters of wood, straw, paper and many other substances never before used for that purpose. The results of his experiments showed that the substance best adapted for carbonization, and the giving out of incandescent light, was paper, preferably thick like card board, but giving good results even when very thin. The beautiful character of the illumination and the steadiness, reliability and non-fusibility of the carbon filament were not the only elements incident to the new discovery that brought joy to the heart of Edison. There was a further element—not the less necessary because of its being hidden—the element of a proper and uniform resistance to the passage of the electric current.

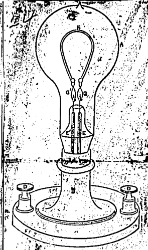
The inventor's efforts to obtain this element had been by far the most laborious of any in the history of his work from the time he undertook the task, and without it absolute success to electric incandescent illumination could not be predicated, even though all the other necessary properties were present in the fullest degree.

Passing over the scores of experiments made since the discovery that the carbon framework of a little piece of paper or thread was the best substance possible for incandescent lighting, we come to consider the way in which the same is prepared at the present time in the laboratory.

MAKING THE PAPER CARBON.

With a suitable punch there is cut from a piece of "Bristol" cardboard a strip of the same in the form of a miniature horseshoe, about two inches in length and one-eighth of an inch in width. A number of these strips are laid flatwise in a wrought iron mould about the size of the hand and separated from each other by tissue paper. The mould is then covered and placed in an oven, where it is gradually raised to a temperature of about six hundred degrees Fahrenheit. This allows the volatile portions of the paper to pass away. The mould is then placed in a furnace and heated almost to a white heat, and then removed and allowed to cool gradually. On opening the mould the charred remains of the little horseshoe cardboard are found. It must be taken out with the greatest care, else it will fall to pieces. After being removed from the mould it is placed in a little globe and attached to the wires leading to the generating machine. The globe is then connected with an air pump, and the latter is at once set to work extracting the air. After the air has been extracted the globe is sealed, and the lamp is ready for use. Figure 7 shows the lamp complete:—

THE PERFECTED LAMP—FIGURE 7.



A is a glass globe, from which the air has been abstracted, resting on a stand, B. F is the little carbon filament connected by fine platinum wires, G G', to the wires, E E', leading to the screw posts, D D', and thence to the generating machine. The current, entering at D, passes up the wire E to the platinum clamp, G; thence through the carbon filament F to G', down the wire E' to the screw post D'; thence to the generating machine. It will be noticed, by reference to the complete lamp in figure 7, that it has no complex regulating apparatus, such as characterized the inventor's earlier labors. All the work he did in regulators was practically wasted, for he has lately realized that they were not at all necessary—no more so than a fifth wheel is to a coach.

REGULATED AT THE MAIN, LIKE GAS—CHEAP.

He finds that the electricity can be regulated with entire reliability at the central station, just as the pressure of gas is now regulated. By his system of connecting the wires the extinguishment of certain of the burners affects the others no more than the extinguishment of the same number of gas burners affects those drawing the supply from the same mains. The simplicity of the completed lamp proves certainly to have arrived at the highest point, and Edison asserts that it is scarcely possible to simplify it more. The entire cost of constructing them is not more than twenty-five cents.

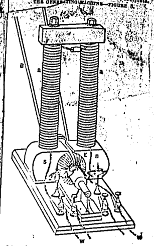
EASY METAMORPHOSIS.

The lamp shown in figure 7 is a table lamp. In chandeliers it would consist of only the vacuum globe and the carbon filament attached to the chandelier and connected to the wires leading to the generating machine in a central station, perhaps a half mile away, the wires being run through the gas pipes, so that in reality the only change necessary to turn a gas jet into an electric lamp is to run the wires through the gas pipe, take off the jet and screw the electric lamp in the latter's place. Although plans have been fully consummated for general illumination the outline of the probable system to be adopted is the locating of a central station in large cities in such a manner that each station will supply an area of about one-third of a mile. In each station there will be, it is contemplated, one or two engines of immense power, which will drive several generating machines, each generating machine supplying about fifty lamps.

THE GENERATING MACHINE.

Mr. Edison's first experiments in machines for generating the electric current did not meet with success. His primal apparatus was in the form of a large tuning fork, constructed in such a way that its ends vibrated with great rapidity before the poles of a large magnet. These vibrations could be produced with comparatively little power. Several weeks of practice proved, however, that the machine was not practical, and it was laid aside. Then followed a number of other forms, leading up gradually to the one at present used. Bearing in mind the principle common to all magneto-electric machines—viz., that the current is produced by the rotation of magnets near each other—it will not be difficult to understand, in a general way, how this machine operates. Figure 8 shows the generating or Faradic machine, as Edison terms it, in honor of Faraday, complete.

THE GENERATING MACHINE—FIGURE 8.



a a are two upright iron columns, three feet high and eight inches in diameter, wound with coarse wire and resting upon the [illegible] and s, which form its magnetic poles. This part of the apparatus is called the field of force magnet. Fixed on an axle, so as to freely revolve between the poles n and s, is a cylindrical armature of wood, e, wound parallel to its axes with fine iron wire. When this cylinder or armature is made to revolve rapidly between the magnetic poles n and s, by means of the belt B, driven by an engine (not shown in the cut), there is generated in the wire surrounding the armature a strong current of electricity, which are carried off by the wires, W W, to the electric lamps.

A DOMESTIC MOTOR.

By constructing the machine in the form shown in figure 9 there is obtained an electric motor capable of performing light work, such as running sewing machines and pumping water. It forms part of the inventor's system and may be used either with or without the electric light. To run an ordinary sewing machine it requires only as much electricity as is necessary to give out one electric light of the strength of a common gas jet. To put it in operation on a sewing machine the housewife has merely to attach it by a little belt at A with the wheel of the sewing machine, and turn on the electricity by touching a little knob conveniently attached. The cost is the same as if she was burning one electric light.

THE ELECTROMETER.

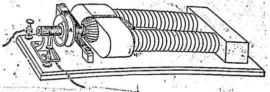
The apparatus for measuring the amount of electricity used by each householder is a simple contrivance consisting of an electrolytic cell and a small coil of wire, appropriately arranged in a box, the latter being of about half the size of an ordinary gas meter, and like a gas meter it can be placed in any part of the house. The measurement is obtained by the deposit of copper particles on a little plate in the electrolytic cell, such deposit being caused by the electric current passing through the cell. At the end of any period, say one month, the plate is taken by the inspector to the central office, where the copper deposit is weighed and the amount of electricity consumed determined by a simple calculation.

In addition to the various parts of the system above described, there are a number of other details, not so important to be sure as those of which sketches have been given, but nevertheless essential to make up the complete plan of economical electrical illumination. A description of these latter will not be attempted, as a proper understanding of them involves a technical knowledge of the laws of electricity. The entire system embraces an amount of work so extensive that one naturally wonders how a single man in such a brief space of time as fifteen months could possibly have planned and perfected it all. And surprise becomes greater when it is considered that during this period Edison found time to make other inventions. A sextuplex telegraph, or apparatus for sending six messages on one telegraph wire in opposite directions simultaneously, saw life during the progress of the electric light, patents for the same having only just been issued. Several new and important improvements in his chalk telephone, by which the efficiency of that invention is greatly increased, also attest his industry and versatility of genius.

POLYFORM.

But perhaps the latter quality is more strikingly exhibited in his polyform or preparation by which he is enabled to bid defiance to sick headaches, neuralgia and other nervous diseases, and to make himself largely independent of physicians in times of ailment. The polyform grew out of necessity. Being considerably afflicted with neuralgia and obtaining no relief from his physician, Edison set about becoming his own doctor. His chemical laboratory, one of the most complete in the United States, furnished him an ample field from which to draw. Experiment followed experiment, the inventor becoming more determined in proportion as his neuralgia grew more painful. At last he obtained a combination of chemicals, a slight application of which to

THE DOMESTIC MOTOR—FIGURE 9.



The Electric Light.

Dec 30/79

The electric light as Mr. Edison has it at Menlo Park, if not all that he claims, furnishes a singularly soft yet brilliant light, so pleasant to the eye that it may be studied closely. In his laboratory, which, by the way, is a large establishment running night and day, with perhaps fifty employees, the light is distributed equally all over the building. The little exhausted receiver lamp has the highest illuminating power, but the open flame is a very good light. In the small vacuum light there is hardly any heat, but the light is far purer and more steady. The shape now is that of a horse-shoe, but there is no reason why it might not be a circle, a crescent or a triangle, or any other form which personal taste might prefer. The light could be readily built into any form or design of art and made to be a picture.

The problem with Mr. Edison seems to have been not so much the production of sufficient electric force as that of a cheap lamp. Not long ago he was looking for iridium or platinum points to interrupt the current at each light. But these two metals are rare and costly, and probably there is not enough of them in the world to supply a single great city. The carbon point seems to have been agreed upon as the best, but even that was costly. It lasted well, as the London experiments showed, but it needed very nice handling and adjustment. Mr. Edison gets a cheap carbon point by only burning a slender thread of Bristol board at a high heat, and finds that the slender thread or horseshoe which results is tough enough to handle well and can be fitted easily across the electric current. The point which he seeks is an incandescent burner, so simple and so cheap that it can be easily managed by any intelligent person. One of these burners has been in use twenty days of twenty-four hours each, and is still one of the strongest lights on the main floor of the laboratory. Manufactured in quantities, such burners would cost about the one hundredth of a cent, and could be replaced at any time by any person of ordinary deftness of finger. So far as the burner is concerned, Mr. Edison has certainly achieved a success. He has found a cheap thing, which will answer every purpose, and got rid of all iridium, platinum and elaborate carbon points.

But all this does not fully settle the question of cheap light. Mr. Edison works a large manufactory and lights a number of residences and streets by the power of an eighty-horse power engine. He is confident that the system can be extended indefinitely and that with the touch of a thumb at a central office the whole city can be made brilliant in a light which is almost a true sunshine. But there are two difficulties which remain. One is the amount and cost of the power required to produce the electricity—modified by the deduction that in revolving the magnets it may at the same time work other machinery. The other doubt is as to whether the electric current can be so distributed through "all out of doors" as to be certain in its working. The cutting of a single wire might place a whole section of a city in darkness, just as the break of a gas main would do the same thing. In the electric light the thread is more slender, the intelligence required more exacting, but that is the fault of all inventions. Every advance of science requires a keener intelligence and a closer watch. In the Capitol at Washington a single pressure on one key down in the basement sets all the gas blazing, but the patient detail necessary to produce the result is unconsidered. An interruption at any one point is an interruption to all beyond it, and that may be an difficulty which Mr. Edison will

The difficulty of subdividing the electric current is supposed to have been overcome by making a vacuum in every lamp. He has neither oxygen, nitrogen, hydrogen or carbon as part of his fuel. The light passes from point to point of carbon, but there is no oxygen to consume his carbon. He gets light without heat. The flame is purely electric, but it burns nothing, for carbon will not burn unless it comes in contact with oxygen.

Art and Scientific Entertainments.

No city of the size of Newark has so many amusements and social entertainments. The greater number are given for the benefit of churches, Sunday Schools and local charities. The most of them are of the lightest possible character; pleasant, innocent and easily managed, but not often instructive. They have interfered largely with costlier and professional amusements, and very seriously with lectures, concerts and other forms of entertainment that are solid and instructive. These efforts to sustain institutions by means of dollars picked up from the general public, praiseworthy as they must be considered to be under the circumstances, have retarded the building of such a dramatic temple as may be found in every other city of any pretensions, and perhaps other artistic and even more useful additions to the metropolis, but it is a comfort to find that this season there has been some encouragement extended to worthy efforts which have hitherto been received with chilling indifference.

Five lectures have been delivered here on Ancient Art, with very fair success, and the more so as the lecturer was but little known in our community. They were not, in all respects, new; much of the information given is available in books, but they revived memories of past studies with some, and they were really fresh and instructive to a much larger class. Two lectures were given by another gentleman, on Paris, with a large number of stereopticon views, and, as with these, much historical information was pleasantly condensed, they were also profitable to those who heard them. Then, with many misgivings, Professor Proctor was invited to give two lectures on astronomy, and the nearly-filled house was a most gratifying surprise. There can be no doubt that his second lecture to-morrow night will be even better attended, for his subject is one of universal interest. At this time, also, we find art appealing to our citizens in the shape of a gallery of paintings from the easels of sixty of our best living artists. It cannot be supposed that that will lack appreciation in a city that counts so many elegant churches filled with educated congregations. Art in such shapes as we see it there appeals to every pure taste and sensibility; it develops the affections and the love of the beautiful. It is not every one who can afford to buy a fine oil painting, but when Newark arrives to that point of prosperity and to that esthetic culture which will enable it to permanently sustain an art gallery it will do as much towards the development of refined public taste as it has heretofore done in developing the homelier industries by which its people earn their daily bread. In these and in all other worthy lines of effort, the word spoken in season should never be refused, and with all the multitudinous efforts made to sustain churches and charities, there should be a continuation of that patronage towards worthy forms of popular instruction by which alone they can be drawn to our good city.

EDISON'S ELECTRICITY.

Washington Post

MENLO PARK ILLUMINATED WITH THE NEW LIGHT.

Dec 25 1879

Complete Success of the Carbon Paper Slip Illuminator—Scenes at the Home of the Great Inventor—The Death-Knell of Gas Companies.

Special Dispatch to THE POST.

MENLO PARK, N. J., Dec. 24.—This little village was illuminated with Prof. Thomas A. Edison's electric light this evening. Only four outdoor lamps were in operation, but electric burners to the number of twenty-eight were distributed in a dozen houses and the new light was pronounced a perfect success. It was demonstrated by illumination that the light of each of the so-called burners was fully equal to that produced by the ordinary gas-jet in the street-lamp or dwelling-house. Only two electric generators were in use to-day to supply the twenty-eight burners which were in operation, but with additional or more powerful generators the intensity of the light, Mr. Edison said, could be increased. A third generator will be finished in a day or two, and then a dozen or more additional burners will be set going. There was a marked difference between the light of the carbon paper burners at Menlo Park and the intense dazzling light given by the electric lamps which have for some time past been used in New York and other cities. The painful scintillation of the latter, caused by innumerable sparks chasing each other over the metal, instead of the carbonized retainer, is entirely avoided. After the visitors had witnessed the effect of the illumination from the lamps and from the outside of the houses, they were permitted to enter several of the private residences and judge of the utility of the new light for household purposes. One gentleman had an electric light in one of the sleeping rooms of his house. He said that the only fault he found with the light was that it was too bright. Said he, "I must either allow it to remain on full head or turn it off entirely. There is no intermediate point, but I presume Mr. Edison will make some small lamps for sleeping rooms." In the office attached to Mr. Edison's laboratory were three lights, which had been constantly burning a day and night. The carbon paper slips did not show the least deterioration and to all appearances were good for almost an indefinite length of time. One of Edison's associates was busily engaged in the laboratory to-day perfecting an invention that he hopes will supersede the old system of telegraphy. It is somewhat similar to the old automatic and produces a fac simile of the original message at the other end of the line. On a short circuit at the Park it has worked with complete success, and the inventor claims that it will operate over a wire 1,000 miles in length.

MENLO PARK, N. J., Dec. 24.—The little charred paper horseshoes are yet illuminating Edison's laboratory at 10 o'clock this evening. Besides this, there are five houses in the place lighted in the same way and three Christmas trees. Not one of the lamps thus far has been destroyed. It is a jubilant Christmas eve, and Edison has been in wonderful spirits. For four days and nights at the end of last week and the beginning of this week he did not once have his boots off. He was working and watching night and day. Now he says his work is done, and he is going to have a rest. The lamps which were first lighted have now been burning 136 hours with only a few short intermissions. On Mr. Edison's basis of calculation, that four hours and a half is the time that families use artificial light, these 136 hours are equivalent to thirty days of service.

...lamp, but not before it had emitted a light of several hours. Eagerly the inventor hastened to examine under the microscope this curious filament, apparently so delicate, but in reality much more infusible than platinum, so long considered one of the most infusible of metals. The microscope showed the surface of the filament to be highly polished and its parts interwoven with each other.

THE PAPER LIGHT.

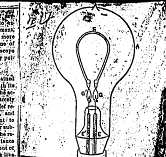
It was also noticed that the filament had obtained a remarkable degree of hardness compared with its fragile character before it was subjected to the action of the current. Night and day, with scarcely rest enough to eat a hearty meal, or catch a brief repose, the inventor kept up his experiments, and from carbonizing pieces of thread he went to splinters of wood, straw, paper and many other substances never before used for that purpose. The results of his experiments showed that the substance best adapted for carbonization, and the giving out of incandescent light, was paper, preferably thick like card board, but giving good results even when very thin. The beautiful character of the illumination and the steadiness, reliability and non-fusibility the carbon filament were not the only elements in dent to the new discovery that brought joy to heart of Edison. There was a further element the less necessary because of its being hidden element of a proper and uniform resistance to passage of the electric current.

The inventor's efforts to obtain this element been by far the most laborious of any in the hist of his work from the time he undertook the ta and without it absolute success to electric incand cent illumination could not be predicated, though all the other necessary properties were p ent in the fullest degree.

Passing over the scores of experiments made a the discovery that the carbon framework of a l piece of paper or thread was the best substance sible for incandescent lighting, we come to con the way in which the same is prepared at the ent time in the laboratory.

MAKING THE PAPER CARBONS.

With a suitable punch there is cut from a pie "Bristol" cardboard a strip of the same in the of a miniature horseshoe, about two inches in l and one-eighth of an inch in width. A numb these strips are laid flatwise in a wrought mould about the size of the hand and separated each other by tissue paper. The mould is then co and placed in an oven, where it is gradually to a temperature of about six hundred degrees renheit. This allows the volatile portions paper to pass away. The mould is then place furnace and heated almost to a white heat, an removed and allowed to cool gradually. On ing the mould the charred remains of the little shoe cardboard are found. It must be tak with the greatest care, else it will fall to After being removed from the mould it is pla a little globe and attached to the wires lead the generating machine. The globe is then nected with an air pump, and the latter is set to work extracting the air. After the been extracted the globe is sealed, and the l ready for use. Figure 7 shows the lamp com



THE PERFECTED LAMP—FIGURE 7.

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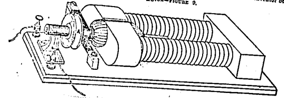
THE DOMESTIC MOTOR—FIGURE 9.



ing more determined in proportion as his neuralgia grew more painful. At last he obtained a combination of chemicals, a slight application of which to the face immediately relieved his pain. Gratified at his success, but hardly yet convinced, he tried the preparation on others similarly afflicted and with equally satisfactory results.

"IN COLLOGE VILL."

About this time there happened to stroll into the laboratory one day a dilapidated tramp on his periodic begging expedition from place to place. Now, this tramp was a particularly unfortunate one, his poverty being hardly more distressing than his physical ailments. One of his legs was swelled with rheumatism, neuralgia coursed along his face and a dozen or more sores and bruises made him a veritable Job. Happening to meet him Edison saw in him a most excellent subject for further polyform experiments. A hearty meal and a little change readily procured the tramp's consent, and soon the inventor was subjecting his new acquaintance to all sorts of chemical experiments. For more than a week the tramp found food and lodging in Menlo Park, giving in return a few hours of his time every night to be experimented upon. By the time his engagement was over his rheumatism and neuralgia had disappeared, and his sores were well nigh healed. The news of the tramp's good fortune soon spread, and now it is no uncommon thing for neighbors to come to the inventor's laboratory from miles around to request a little polyform—a request which the inventor always good naturedly complies with.

GOLD "TAILINGS."

The very, very latest enterprise of the indefatigable scientist is a scheme for obtaining gold out of "tailings," or the sand thrown away by miners as having been worked out. Rumor has it that Edison has succeeded in obtaining a chemical preparation which will take from $200 to $300 per ton out of "tailings" from which the present processes can obtain nothing. The matter, however, is as yet a profound laboratory secret.

ELECTRIC LIGHTING BEFORE EDISON.

Among its other properties electricity has that of developing heat. A substance through which an electric current is made to flow becomes heated to a degree proportioned first to the strength of the current, and accor[illegible] to the size and character of the

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... to buy a fine oil painting, but
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THE STAR: TUESDAY, JAN

WHAT MR. EDISON HAS ACCOMPLISHED,

And What he Hopes to Accomplish, in His Electric Light.

We have taken considerable pains to look into the present and probable results of Mr. Edison's labors in this direction, and will give them here as concisely and clearly as possible. Let us first see what is claimed by Mr. Edison as to the present perfection of the electric light and what he says regarding its future.

Mr. Edison claims that the electric light has been so much improved in his hands that it is almost, if not quite, in a state to compete with gas, and promises in a short time to improve it so much more that all things taken into account it will be far superior to gas. He also thinks that he can advantageously employ electricity to drive machinery.

The palpable fallacy of this last proposition is perfectly apparent when we consider that the source of this electricity is mechanical force, and to use this electricity to again produce mechanical force would be subjecting our original power to a transformation the only effect of which would be an immense loss of power.

Before discussing the comparative merits of gas and electricity as a means of lighting a city throughout, we should explain what the electric light is, how produced, and how maintained. When the end wires of a powerful battery are touched together and then slightly separated, an intense bright light is produced in the intervening space, which on account of its curved form has been called the voltaic arc. If the current from the battery is not immediately stopped, the points of the wires soon become heated and melt, and consequently if the ends are not moved nearer to each other, the interval between them increases, and finally becomes so great that the electricity can no longer leap from one wire to the other, and the light suddenly ceases. But if the wires are again brought together and separated as before, the light is reproduced.

If, however, instead of touching the wires, two sticks of hard conducting carbon are used on the ends, the light becomes of dazzling brilliancy, and is too strong for the eye to look upon directly. It may, nevertheless, be viewed through a piece of stained glass, or thrown upon a screen and then examined. This is the first form of the electric light, and as a powerful light it is to-day in advance of any other.

In temperature, as well as brilliancy, the voltaic arc far surpasses all other artificial sources of heat. By means of it Despretz has succeeded in reducing even the diamond to vapor. In this case the light evolved is due in considerable measure to the oxidation of the carbon by the atmosphere, but it is also due to the heat generated by the electric current encountering resistance as it passes through the space between the carbon points. As the light continues, particles of carbon are carried across the arc in both directions, but mostly in the direction of the positive current. The curious fact that the positive carbon wastes away much more rapidly than the negative, is also very noticeable. This may be said to be the first class of electric lights, of which there are four.

A second class of lights are those in which the carbon points are placed in a sealed transparent globe, free from oxygen, or in vacuo. In this case, of course, there is no oxidation, but one pole is being constantly increased at the expense of the other, as in the first class of lights.

[illegible] made to pass through [illegible] high resistance, not in [illegible] as a non-conducting [illegible] there is no interval [illegible] ous. In this case sufficient [illegible] render the particles of carbon [illegible] of the light is also due to the [illegible] the carbon on the surface. [illegible] iridium, platinum, etc., have been used, and have given much better results.

A fourth class of [illegible] which our attention has been called by Mr. Edison—but not invented by him—is the same as the third, except that the light is produced in a sealed transparent envelope free from oxygen, or in vacuo. This last method is superior to the other three, because it furnishes a lamp which is cheaper to make, will give a light not too powerful, and will last indefinitely, since there can be no combustion.

The electric lamp invented and now used by Mr. Edison to light Menlo Park, and that which is conceded to approach nearest to the solution of the problem of electric lighting, consists of a small horseshoe of about three inches in circumference and one-sixteenth of an inch in width, cut from a piece of thick white paper. After being compressed it is placed in a small muffle furnace and carbonized or charred. The horseshoe is then fixed in the center of a glass globe, of about three inches diameter with two small platinum wires connected to its extremities. The air in this globe is finally exhausted to the alleged extent of one-millionth of its original volume, and the globe is sealed with the platinum wires brought out at the place of sealing.

This is the whole of Mr. Edison's invention in regard to electric lighting as now carried on, viz.: the rendering of a piece of charred paper, in vacuo, incandescent, by the passage of an electric current.

Quite as important a part of the electric light as the lamp is the manner in which sufficient electricity to produce many such lights may be procured. It has been found vastly cheaper and much easier to generate electricity in large quantities by means of mechanical force, than by chemical means, as in a galvanic battery.

The operation by which the transformation of mechanical force is effected depends upon the fact that when a bar of soft iron, surrounded with a coil of insulated wire, is rapidly magnetized and demagnetized a current of electricity is generated in the wire at each change of magnetic state. The strength of these currents is proportional to the amount of magnetism given to the bar, and to the rapidity of change in its magnetic strength. In the machine these bars of soft iron are caused to revolve rapidly past the poles of a magnet, thereby becoming magnetized and demagnetized, and producing currents in the coils, which succeed each other with such rapidity that they practically form one continuous current. Since the strength of the current is dependent upon the velocity at which the machine is made to operate, a very fast revolution is necessary to secure a comparatively strong current.

Within the last ten or fifteen years these machines have been improved to a very great extent; but as we cannot discover what is the electrical equivalent of mechanical force, or how much electricity a certain amount of mechanical force is capable of generating, we have no means of judging how far we are from possessing a perfect machine, or, in other words, of how much more improvement this method of producing electricity is susceptible.

21

It may be asked, Why may not some mode of generating electricity be discovered? Such a question is ridiculous. We might as well ask, Why may not an entirely new kind of light be discovered? At present we know of but two ways of producing electricity of this nature; viz.: by magnetism, as just described, and by chemical action. But we do not understand how mechanical force is transformed into electricity by magnetism, or how electricity is generated in a battery—whether by heat, chemical action or what.

These—the lamp and the generating machine—constitute the electric light. We do not know to what extent either may be improved. It is therefore asked by some persons, Why may it not be made to supersede gas by further discoveries? We will now give the principal reasons why electricity cannot compete with gas at present for domestic purposes.

Primarily, their relative costs should be considered. The question may be asked: How is it possible to produce as much light with a given amount of heat by transforming the heat into electricity and then back to heat, as by utilizing the heat directly? This is possible simply because we obtain only about 8 per cent. of the amount of light which the energy expended in making gas is able to produce. That is to say, that if all the energy locked up in a pound of coal could be liberated and converted wholly into light, it would give twelve and a half times the amount of light now obtained from the gas made from a pound of coal.

To illustrate: Perhaps, on the average, one pound of illuminating gas will give seventy-five candle-lights per hour. The energy obtained from one pound of illuminating gas by complete combustion is equal to 16,000,000 foot pounds of work. This, if burned in an hour, would average about 250,000 units of work in a minute or about 3,500 foot pounds per minute for every candle-light. That is to say, the amount of illuminating gas which will give one candle-light in an hour will yield 3,500 foot pounds in a minute. A very large electric light—perhaps 10,000 candles—does not consume more than thirty foot pounds of energy per minute for every candle-light, and even a small one not more than 200. So it might not seem extravagant to assume that one pound of gas per hour would be burned in a good furnace under a good boiler, and produce steam enough to drive a steam engine, and the engine a magneto-electric machine, which should supply five electric lamps that would give more light than five gas lamps, each consuming one-fifth of a pound of illuminating gas per hour. But it must be remembered that this is the result of using an electric light of two carbon points, which could not be used to light private houses, because it is too powerful, is difficult to manage, and cannot be subdivided.

To this kind of light there are also the objections, that it is expensive, liable to get out of order and the carbons require renewal. Electric lamps, consisting of a thin strip of platinum, have been devised by Mr. Edison to meet these objections, and he succeeded in obtaining a very good light from them. But the lamp, which is now thought to be far in advance of all others, is the paper horseshoe in vacuo. This lamp is the best adapted to domestic use, for three reasons: First, because it gives a light of the required brilliancy, and is steady; second, it is not liable to get out of order, and third, it will last indefinitely, requiring no attention. But the main feature of this lamp seems to have been overlooked, viz.: that it is much more expensive.

A very important fact in the discussion of comparative cost is that small lights are relatively much more expensive than large ones. For example: If the current from a single light be divided so as to produce two lights, the latter will not each shine with half the intensity of the single light. This is because the light produced increases much faster than the strength of the current. The reason of which is, that before the carbon, platinum or paper becomes luminous, a certain amount of electricity is required to heat it; and this electricity is consequently of no value so far as giving light is concerned. There is also another reason: the resistance increases as the temperature of the substance, the greater the resistance the stronger being the light.

Another very serious objection to the introduction of the electric light is the liability of the wires to get out of order or to be broken. No idea of the danger of wires to get out of order or be broken can be formed by any one who has not had considerable experience in the laying and use of wires. That they are more likely to break than gas-pipes will not be doubted, and when they have broken there can be no more light beyond the fracture. But not so with gas: for when a gas-pipe breaks, the flow is not stopped or lost to any extent as a general rule, and the lights beyond are not seriously affected. Again, if the wire should break in the house and should leave a sufficient interval for a small electric arc to be formed, what is to prevent it from setting fire to the insulation, and perhaps the house, unless laid in iron pipes or in some such way?

Another serious objection is the liability of the generating machine to break or get out of order. Still another is the fact that no electricity can be stored up and kept in reserve for any time.

That the electric light is and will be used, where a powerful light is desired—even in cities—is beyond doubt. It is and will be used for lighthouse service, fortifications, armies in action, manufactories, show rooms, open-air use, railroad depots, steamboats, mines, theaters, streets, etc. But in these uses of the electric light Mr. Edison does not claim to have made any advance. For these purposes the electric light is superior to all others and much cheaper, but for private houses, etc., where a powerful light cannot be used, and where a light easy to manage, safe, cheap, steady and sure, is requisite, we cannot agree with Mr. Edison, but think that it will yet be a long time before we shall see its introduction.

A great deal has been said about the difficulty of dividing the current, as if this were the important difficulty. In the old form of carbon-point lamps it is difficult to divide the current, because the resistance of the lamp is constantly varying, but in the lamps where a continuous strip is used to emit the light, no such difficulty is encountered. It is just as practicable to divide the electric light (as they say) as it is to operate any of the systems of telegraphy by which more than one message may be sent over one wire at once.

To sum up. A substitute for gas in the form of electricity must be a lamp, which is in intensity between five and twenty-five candles, is as steady, as durable, as easy to manage, cheap to make, and which can be supplied with the electricity at an expense considerably less than gas. Mr. Edison has succeeded in constructing a lamp which conforms to these conditions much more than any other lamp, but at the same time he has made a lamp which requires so much electricity in proportion to the amount of light given out, that its cost alone excludes the possibility of its taking the place of gas. Had he succeeded in reducing the cost to that of gas, the reasons for still preferring gas are very apparent. It would require a cost far below that of gas to insure its introduction.

Let us suppose a city of 500,000 inhabitants to be furnished with electric light from platinum lamps—say ten candles to each inhabitant. The aggregate amount of light would be 5,000,000 candles, and if only 100 candle-lights were obtained from one-horse power (which is much more than the paper lamp of Mr. Edison gives), it would then require 50,000 horse power to furnish this amount, leaving alone the energy consumed in its production and distribution, which would, without doubt, exceed this amount, with the best generating machine yet devised.

A word as to how Menlo Park is now illuminated by the electric light. There are two generating machines run by a seventy-horse power engine—now running at about twelve-horse power—to supply between fifty and sixty lamps, distributed in the houses and streets. It is claimed that each is equal to ten candles, gas being equal to about seventeen. The light is not white, or of a bluish tinge, as the electric lights now seen about New York, but yellowish and pleasant, very much like gas. It is almost perfectly steady, and is not dazzling. As there shown, it seems at first sight to be a success, but it must not be forgotten that the conditions under which the electric lighting is there carried on could not be better.

PERSONAL PARAGRAPHS.

King Humbert has been able to take a sleigh-ride at home for the first time in nine years, there having been no snow in Italy before since 1871.

The German Emperor has ordered that the fund of more than $60,000, collected on the occasion of his golden wedding, be exclusively devoted to the relief of the famine-stricken Silesians.

Harijo Gondosiwojo, reigning Prince of Surakarta, in Java, has arrived in Paris, in order to make the tour of Europe.

Rubenstein has gone to live in Italy on account of the failing health of his son.

Electricity at Sea.

Dec 22 1879

Mr. Edison at last is able to reward the patience of the public with the assurance that he has completed all the devices required for the adaptation of electricity to domestic purposes. If Mr. Edison can do commercially and on a large scale what he has succeeded in doing in his laboratory and on a small scale, the gas corporations, may as well begin to inquire whether there is an existence after death. For the purposes of navigation, however, it must be admitted, electricity needs yet a vast amount of adaptation. The steed, it is true, is caught, but it has yet to be tamed. At several places on the English coast, in France, in Russia and at the entrance to the Suez Canal, electricity has developed marked, if not fatal defects, as an illumination for lighthouses. The intense brilliancy of the light is calculated to deceive the seaman as to distances, and even to blind him as to the presence of immediate objects, such as ships and half-sunken rocks. From this cause the electric light has been displaced at Dungeness, the point on the English coast where it was first used. The same defect disqualifies the electric light for use on vessels at sea. On vessels that are large and steady enough for it to be used both on the bow and sides, it may prove serviceable. Were it to be used on the bow alone it would absolutely blind the navigator to the approach of vessels abeam, and enhance the chances of the very disaster which it was designed to avoid. It is to be hoped that navigation may yet share in the benefits of modern discoveries concerning electricity. Evening Telegram

Dec 22 1879

EDISON'S LATEST DISCOVERY.

What Constitutes its Chief Value.

The latest report from Menlo Park is the announced discovery made by Mr. Edison of a new electric lamp, for which many startling things are claimed. The new light is produced from a little piece of paper heated to incandescence by an electric current which is made to pass through it. The piece of paper, "common bristol board"—two inches in length and one eighth of an inch in width, bent into the form of a horse-shoe, is heated in a furnace until nothing remains of it but a framework of carbon filaments. It is placed in a glass globe from which the air is extracted, and an electric current is passed through it.

Mr. Edison says that the results of his experiments show that the substance best adapted for carbonization and the giving out of incandescent light is paper.

The advantages claimed for the new light may be summed up as follows: The apparatus is ready to give out light that produces no deleterious gases—a pure, bright light without flame, without danger, requiring no matches to ignite it, free from all flickering, giving but little heat, contaminating no air, and a light that can be produced more cheaply than that from the cheapest oil.

Professor Ogden N. Rood, Professor of Physics in Columbia College, spoke to-day to a reporter of the EVENING POST to the following effect:

I believe that Mr. Edison is a great genius, but I also believe that he makes the mistake of being over-confident. I have not yet seen any experiment proving to me the properties of this new light, what it will do and what it will not do; but accepting the description which Mr. Edison furnishes, and admitting that the lamp works as claimed, it is not a discovery but an invention. No new principle has been discovered, but an ingenious invention of some importance has been made. Render carbon incandescent and you have nothing new. Incandescent carbon furnishes the light of nearly all the electric lights in use in the country.

Exhaust the air from the receiver in which the carbon is so as to extract the oxygen and you have accomplished something that has been accomplished in many previous cases. There have been methods in use to prevent the carbon of an electric light from being consumed by oxygen. In most electric lights the carbon points are separated, as the current passes the positive pole is eaten away particle by particle. Some particles give way more easily than others, and hence the flickering. Edison substitutes a continuous piece of carbon for his platinum wire. Now if this piece of carbon presents a uniform resistance to the current then scientists are rid of the regulators, which are expensive and very troublesome. This I consider the most important part of the invention.

HISTORY OF TWO DAYS.

1879 Daily Graphic Dec 22

Now for the annual winter howl about snow blocked streets. The job on Captain Williams's hands assumes huge proportions. He might read with interest Whittier's "Snow Bound."—Electrician Edison again "perfects" his electric light; no platform wanted; carbon, red cotton thread fills the bill; and electrician Sawyer says he did the same thing some months ago.—The Poncas drew a large

22

124

Detroit Free Press Jan 4 1880

It has been proven conclusively that Edison's method of electric illumination is a ghastly failure. Sawyer, the New York electrician, has shown beyond a doubt[?] that he had a lamp of his own long before Edison set his burning, and that Edison is using some of his ideas. A London scientist has demonstrated that no vacuum can be secured for any practical purpose, and a brother scientist in Edinburgh shows that the carbon horseshoe has none of the elements of permanency. The Count Dumoncel, a French electrician, laughs at the whole scheme as chimerical. And, to crown all, the gas men of two hemispheres are unanimously agreed that the electric light is not, never has been and never will be practicable. Why Edison should persist, in the face of all this overwhelming testimony, in continuing his work, or why his lamps should persist in burning under the same discouraging circumstances, is a mystery. Perhaps it is due, in his case, to dogged obstinacy and in the case of the lamps to what Gail Hamilton once called the "total depravity of inanimate things."

WHAT WE HOPE FROM ELECTRIC LIGHTS.

The electric light is becoming more popular and more common in various quarters of the city, but not so common as it should be because of its want of divisibility. Much as it may be serviceable in the more populous thoroughfares, its greater utility will eventually be demonstrated in the more private and less frequented streets and among the poorer classes. The public is looking forward to the promised improvements which Edison foreshadows with a great deal of anxiety and hope, for upon those we must rely for the moral advantages which will be derived from its adoption. Its introduction is looked for to rid the city of a large part of the criminals by whom it is now infested, and to purify abandoned vicinities which have been literally transferred to the worst classes of immoral characters.

round the negative pole correspond to the negative features seen in Fig. 1.

LICHTENBERG'S FIGURES.

On a surface of pure resin sifted with powder of sulphur and red lead the sparks give beautiful Lichtenberg figures of a different kind, which, when fixed on gummed paper, constitute valuable aids to the study of the electric discharge. These are illustrated by Figs. 3 and 4.

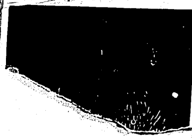


FIG. 5.

One remarks also that the movement leaving the positive pole envelops externally, like a sheaf of rockets, the negative movement (Figs. 3, 4, 5).

Often one perceives at the same time an interior flow of positive electricity round the line of the spark, besides the positive exterior enveloping current, and between the two the negative electric current, which seems as if sucked up (*aspiré*) by the positive current (Fig. 6). The negative

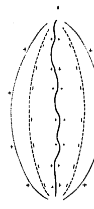


FIG. 6.

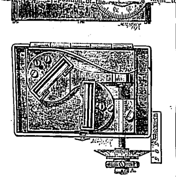
electricity of the ponderable matter which she takes along moves in an annular space formed by the electrified matter leaving the positive pole. This observation explains the effects of suction or ascension of water that we have obtained with currents of high tension. Do we not also in this phenomenon find the explanation of the uprise of water in the cloudy interior of a waterspout?

THE POCKET TELEMETER.

ALTHOUGH it is possible to measure the distances of accessible or inaccessible points without the aid of instruments, absolute accuracy is unobtainable by the processes used for this purpose; and hence arises the necessity of some instrument which shall give such measurements correctly and rapidly. The Telemeter invented, and recently improved, by Lieutenant Gaumet, fulfills in the highest degree, through its simplicity, the facility with which it can be used, and its small compass, all the conditions that an instrument of this nature should satisfy. This pocket telemeter is composed of two essential parts:

1. A system of two mirrors, D E (Figs 1 and 2), arranged on a small metallic plate in such a way as to form an angle of 45° between them. One of them, D (Fig. 2), is stationary, and the other, E, is mounted on a movable radial bar. The angles of the mirror may thus be made to vary from 41° to 49°.

2. A very accurate micrometer screw with a half millimeter thread. The head of this screw is a circle divided at its circumference into a hundred parts. The screw itself works in a nut which is fastened to the metallic plate. A small rule is fixed to the edge of the latter, almost in contact with the edge of the circle, and serves as a datum reference. A spring, bearing on the extremity of the radial bar, maintains a permanent contact between the latter and the end of the screw. All these parts are arranged in a rectangular box, having in the back part a horizontal slit to serve as an eyehole, and in front a rectangular opening for the entrance of the luminous rays emanating from the objects seen by double reflection. A tape line 10 meters in length, rolled around a bobbin, is affixed to the instrument and is used for measuring bases. The pocket telemeter is a direct application of the principle of double reflection. "When a luminous ray is reflected by two plane mirrors in succession in a plane perpendicular to their intersection, the angle formed



FIGS. 1 AND 2.—GAUMET'S POCKET TELEMETER. Perspective View, and Horizontal Projection, Actual Size.

3), places himself at A in such a way as to see at his right the point, C. The image of the point, C, appears placed directly beneath a natural or artificial signal, M, seen directly and situated on the direction perpendicular (or almost so) to A C. The angle, C A M, is a right angle every time that the two mirrors form an angle of 45°. When there happens to be no natural signal on the perpendicular direction, and it is impossible to locate an artificial one (man or rod) thereon, a neighboring point is chosen for this purpose; and, upon this point is brought the image, C', of the point, C, by turning the mirror at a small angle by means of the milled head of the screw.

(The error resulting from obliquity of the base is less than 1-200th of the distance when the inclination of the former does not exceed 8°.)

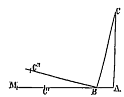


FIG. 3.

The image of the point, C, appearing in the direction of the point chosen, the observer measures off a base, A B, of 20 meters in the direction, A M. He then proceeds to the extreme end of the base and regards the signal anew. He then finds that the image of the point, C, no longer coincides with the signal, M, but is deflected to the right at a point, C'—C' B M being equal to A C B. In order to make them coincide again the movable mirror has to be turned at an angle equal to half of C' B M, or of A C B, which is equal to it. In the pocket telemeter, the angle of rotation of the mirror is measured by its tangent, and this measure is effected by means of the micrometer screw. The use of a like process gives a very close approximation; in fact, by means of the micrometer screw, a tangential displacement of 1-600th

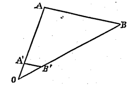


FIG. 4.

of a millimeter may be measured. When a coincidence between the signal and the point, O, has been effected at the end of the base line, the number of the division facing the side rule is read upon the head of the screw. The total number of divisions gives the measure of the tangent of the mirror's angle of rotation. This angle is half the angle, A O B, and the latter being always very small, the tangent of the angle, A O B, may be allowed, without perceptible error, to be double the tangent which measures the angle of rotation of the mirror.

Finally, for the purpose of doing away with all calcula-

29

tact-maker *h* will rest upon the stud *c*. The circuit is then complete between the two poles of the current represented by the two binding screws C and *a*. Supposing it to enter at the screw *c* it will pass through the magnet to the stud *c*, to the contact-maker *h*, and through the holder G to the outer carbon, thence through the inner carbon forming the luminous arc, and down the pillar E to the terminal *a*. The moment the current is established the magnet attracts the armature N, and places the outer carbon parallel to the inner one, towards which it had been inclined by the weight L, so as to facilitate the first flow of the current. When the carbons are consumed (as shown by pair number 1) as far as the finger *k*, the rod K is released, and the spring *m* turns it outward, removing the finger *f'* from its spring *f*, which rises and removes the pin *g* from contact with the stop-piece *d*; the spring M then causes the lamp to revolve until stopped by the next pin *g*, and so on for the whole series. As soon as the rod K turns a contact- … thereof is caused to bear … so makes the circuit … from the carbons … going description … diverted …

lights, which are distributed over the entrance halls and the outside of the Museum, being connected in one circuit of about 1,200 yards length to an alternate current machine.

The regulators in the Reading-room are the invention of Messrs. Siemens and Halske, of Berlin, and are of a very simple construction, so that they can be easily managed even by inexperienced hands. As they are constructed to take carbons nineteen inches long, and as these are consumed at the rate of about three inches per hour, the light can be maintained for about six hours without the regulators being touched.

For the alternate currents other regulators are employed, which are actuated by two solenoids on a differential principle; one solenoid forming part of the main circuit and tending to separate the carbons, the other forming a shunt round the carbons and tending to bring them together. The position of the carbons …

It has been proven conclusively that Edison's method of electric illumination is a ghastly failure. Sawyer, the New York electrician, has shown beyond a doubt that he had a lamp of his own long before Edison set his burning, and that Edison is using some of his ideas. A London scientist has demonstrated that no vacuum can be secured for any practical purpose, and a brother scientist in Edinburgh shows that the carbon horseshoe has none of the elements of permanency. The Count Dumoncel, a French electrician, laughs at the whole scheme as chimerical. And, to crown all, the gas men of two hemispheres are unanimously agreed that the electric light is not, never has been and never will be practicable. Why Edison should persist, in the face of all this overwhelming testimony, in continuing his work, or why his lamps should persist in burning under the same discouraging circumstances, is a mys-

ARBORESCENT ELECTRIC DISCHARGES.

In former numbers of the *Telegraphic Journal* we have illustrated the interesting experiments of M. Gaston Planté on the form of the sparks obtained from his rheostatic ma-

Sc. Am. Dec 20 1879

FIG. 1.

chine of 80 condensers under various conditions. More of these have recently been published by him in the second part of his work on "Recherches sur l'Electricité," and we are now enabled by his courtesy to place before our readers the most novel of them.

ARBORESCENCES.

When the poles of the machine are laid on a plate of insulating matter sprinkled with powder of sulphur the sparks are much elongated, and they also present tree-like figures when the excess of sulphur is raised by slight shocks given

FIG. 2

to the plate. Fig. 1 shows one of these figures, full size, obtained from a spark 0·15 meter long.

These effects explain the patterns of vegetation sometimes seen on persons struck by lightning; they are merely the branching of the lightning track.

Fig. 2 represents the furrow produced in the sulphur by a spark before giving the shocks which cause the arborescences. It will be observed that the width of the furrow is greater on the side of the positive pole. On the rays round the positive pole the sulphur is heaped up, while the traces round the negative pole correspond to the negative features seen in Fig. 1.

LICHTENBERG'S FIGURES.

On a surface of pure resin shed with powder of sulphur and red lead the sparks give beautiful Lichtenberg figures of a different kind, which, when fixed on gummed paper, constitute valuable aids to the study of the electric discharge. These are illustrated by Figs. 3 and 4.

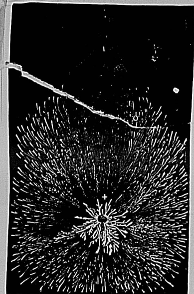


FIG. 3.

The difference between the effect produced by the brush discharge and sparks is very marked.

When the distance between the points of the excitor is too great for the spark to pass, and a brush discharge only appears, the electric movement of the ponderable matter leaving the negative pole, manifested by the red lead which adheres to the resin, does not extend to the positive pole. This last pole only presents traces of red dust in the middle of the crown of sulphur, with diverging rays, which surrounds it (Fig. 3).

But if the spark has passed, this crown is open and the interior is filled with red lead powder, showing that the electric movement leaving the negative pole extends even to the positive pole (Fig 4).

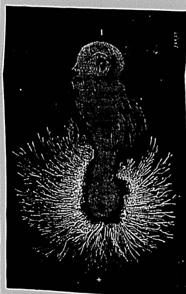


FIG. 4.

In the case of the spark the distribution of negative electricity presents a curious crab-shaped appearance (owl-shaped would, we think, be a better term); in the case of the brush it resembles more or less the form of a polyp having its tentacles directed toward the positive pole without attaining to it.

On the other hand, when the spark passes one recognizes sometimes, by the traces of sulphur round the negative pole,

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tact-maker *h* will rest upon the stud *c*. The circuit is then complete between the two poles of the current represented by the two binding screws C and *a*. Supposing it to enter at the screw *c* it will pass through the magnet to the stud *c*, to the contact-maker *h*, and through the holder G to the outer carbon, thence through the inner carbon forming the luminous arc, and down the pillar E to the terminal *a*. The moment the current is established the magnet attracts the armature N, and places the outer carbon parallel to the inner one, towards which it had been inclined by the weight L, so as to facilitate the first flow of the current. When the carbons are consumed (as shown by pair number 1) as far as the finger *k*, the rod K is released, and the spring *m* turns it outward, removing the finger *f*[1] from its spring *f*, which rises and removes the pin *g* from contact with the stop-piece *d*; the spring M then causes the lamp to revolve until stopped by the next pin *g*, and so on for the whole series. As soon as the rod K turns a contact-maker *n* at the bottom thereof is caused to bear against the bracket H, and so makes the circuit complete, whilst diverting it from the carbons. It will be seen from the foregoing description that although the current is diverted from the carbons by the contact-maker *n* it still passes through the magnet, and continues to attract the armature, opposing the revolution of the lamp. To obviate this the current may be caused to pass from the screw C to a pin *q* which secures one end of a flat spring *r*, the other end of which is raised a short distance from the face of the plate A. A pin *s* attached to the free end of this spring passes through the plate A, and directly underneath it is a contact-maker which leads to the magnet. As the lamp revolves the part *n* presses upon the spring *r*, and presses the pin down upon the contact-maker, thus rendering the circuit complete; as soon as the carbons are consumed the part *n* leaves the spring *r*, which then rises and leaves the contact-maker, thus interrupting the current until the armature has left the magnet, and another taken its place. Figs. 3 and 4 show another form of this lamp for four pairs of carbons.

Secondly, their invention consists in the use of an apparatus constructed in a similar manner to the lamps above described for regulating the transmission of currents to different circuits. For this purpose a self-acting or spring commutator may be employed, and its operation controlled by a series of triggers released at the required time by the consumption of a pair of carbons, one pair of carbons releasing one or more triggers either simultaneously or at different intervals as may be required. Such an apparatus may be so arranged as to require personal attention at considerable intervals only, and may be made to perform operations which at present are only performed with less regularity by hand.

LIGHTING OF THE BRITISH MUSEUM BY ELECTRICITY.

The lighting of the British Museum by the electric light has been commenced for the winter season, with great success. Two different systems are employed, the Reading-room itself being lighted by four lights of 5,000 candle-power each, produced by continuous currents, and the seven 400 candle lights, which are distributed over the entrance halls and the outside of the Museum, being connected in one circuit of about 1,200 yards length to an alternate current machine.

The regulators in the Reading-room are the invention of Messrs. Siemens and Halske, of Berlin, and are of a very simple construction, so that they can be easily managed even by inexperienced hands. As they are constructed to take carbons nineteen inches long, and as these are consumed at the rate of about three inches per hour, the light can be maintained for about six hours without the regulators being touched.

For the alternate currents other regulators are employed, which are actuated by two solenoids on a differential principle; one solenoid forming part of the main circuit and tending to separate the carbons, the other forming a shunt round the carbons and tending to bring them together. The position of the carbons depends, therefore, not on the strength of the current, but on the relative amount of electricity passing through each solenoid. By choosing suitable resistances for each coil an arc of a given resistance will always be maintained independent from the strength of current, and obviating the necessity of regulation after the lamps have left the hands of the makers.

These regulators are also so arranged that the going out of one, say through want of carbon, does not affect the burning of the other lights in the same circuit; and new carbons can be put in such a lamp in about half-a-minute, when it is ready to burn for another five hours.

The machines which supply electricity for the lights are placed in a shed behind the Museum, and are six in number, five being of the ordinary Siemens type (TELEGRAPHIC JOURNAL, November 15th, 1877), size B, and the other a Siemens-Alteneck alternating current machine (TELEGRAPHIC JOURNAL, September 1st, 1879). One of the machines is employed as the inductor for exciting the inducing magnets of the five others. The machines are driven by two 8 horse-power (nominal) steam engines, supplied by Messrs. Wallis and Steevens, of Basingstoke. These engines, which run very uniformly, are worked up to an indicated horse-power of 22, the steam pressure being 60 lbs. and the revolution per minute 120. The cylinders are 9½ in. diameter and 13 in. stroke. Messrs. Wallis and Steevens have just patented a new arrangement, which will enable the governors to maintain any particular rate of speed that may be desired, the adjustment being made gradually and without stopping the engine, thus fulfilling the condition so much desired by electricians, viz., the power to increase or diminish the normal speed of the engine at pleasure according as the lights require it, and then to maintain with perfect regularity the particular speed which is found to give the best light. The cylinders are steam-jacketed on Messrs. W. & S.'s improved plan of making the jacket and liner separate and fitting the liner into the jacket. The boilers are tested by hydraulic pressure to 150 lbs. per square inch, viz., double the highest working pressure of 75 lbs. to the inch. The fire-grate area and the amount of heating surface are unusually large. The engines are fitted with the makers now well-known Patent Annular-space Feed Water Heater, which delivers the feed water into the boiler at a temperature of

30

THE MORI-GRIFFIN LAMP.

Telegraphic Nov 1 1879

THE advantages claimed for this lamp, which is the invention of Messrs. Mori and Griffin of Leeds, are its automatic action and arrangement of parts, and the doing away with personal attention except at long intervals, say 9, 12, or 18 hours, according to the number of candles or carbons the lamp is constructed to hold.

A great saving in wire is effected by the automatic commutator or switch being made a part of the lamp. It is possible by its means to switch off and re-light at will any one or more of the lamps in circuit, without any perceptible change in the burning of the other lamps in the same circuit.

No injury can occur to the lamp after the whole of the carbons or candles are consumed, as the lamp moves forward on to a contact, thereby completing the circuit.

In figs. 1 and 2 we have illustrated a lamp for consuming eight pairs of carbons. This lamp is constructed so as to revolve upon a central spindle, and possesses advantages over the foregoing, inasmuch as the lighted carbons always occupy the same position, whilst the construction of the lamp is simpler and more mechanical. Fig. 1 is a sectional elevation, and fig. 2 is a plan view. A is a disc of hard wood, glass, or other suitable substance, and B is a circular box fixed underneath, in the middle of which is a binding screw *a* and a fixed spindle *b*. Another binding screw C is fixed to the under side of the disc, connected with which is one end of a coil of insulated wire forming the electro-magnet D, the other end of which wire is fixed to the stud *c*, which projects slightly above the upper face of the disc. On the surface of the disc is also a metal stop *d*, the use of which will be hereafter explained. E is a hollow metal tube, which fits upon the spindle *b* resting upon the bottom of the box, and free to revolve upon the said spindle. At the upper end of the tube is a circular table F, which carries a series of carbons, numbered 1 to 8, which are the inner carbons of each pair, the outer carbons being carried in holders G hinged to brackets H, screwed to the under side of a circular plate J, secured upon the hollow tube E. Between the brackets and the plate is a thickness of vulcanite *e*, and over the screws which secure the brackets to the plate are bone insulating eyelets. To each bracket H is secured a contact-maker *h*, that belonging to number 2 pair of carbons being shown resting upon the stud *c*. On the upper side of the plate J are a series of flat curved springs *f*, secured

Detroit Free Press Jan 11 1880

The New York Nation thinks the experiment at Menlo Park does not encourage an expectation of the early solution of "the problem of cost in the production of the electric light, which is the only substantial problem relating to the subject left unsolved before." It declares, or surmises, perhaps, that Edison takes great care to keep his lamps at a low point of incandescence. If any or many of them were to be extinguished, the increased flow of the current would sooner or later destroy those remaining. Hence, during his exhibitions, his assistant narrowly watches the galvanometer, and when a light is removed, carefully shuts off a portion of the current, taking care to prevent it from flowing in excess of the quantity required. The Nation intimates that "this young gentleman," though not prominent, is the most important part of the exhibition. That objection, however, is so eminently Mr. Edison's affair, that outsiders must take it for what is worth. Perhaps he contemplates inventing an artificial young man, like a "governor" to a steam engine."

THE TEMPERATURE OF CARBONS GIVING THE ELECTRIC LIGHT.

Sc. Am. Sup. Nov 22 1879

THE temperature of carbons giving the electric light has been examined by M. Rossetti, by means of a thermopile, the face of which is placed at a suitable distance to receive rays from a radiating surface of determinate size; the thermal effect being measured by a sensitive reflecting galvanometer. He comes to the conclusions that—1. The positive pole has higher temperature than the negative. 2. The temperatures vary according to the intensity of the current. 3. They are higher, the smaller the radiating surface, provided it comprises the extreme point. 4. In the negative pole the minimum temperature was 1910° Cent., with a large radiating surface of small brilliancy; the maximum 2532° Cent., the radiating surface being half the preceding. 5. For the positive pole the minimum temperature was 2312°, the carbon being large; the maximum 3200°, with a thin carbon and small radiating surface.

"THE ELECTRIC LIGHT ON SHIPBOARD.—A Liverpool contemporary says:—"If the electricians who are devoting themselves to the perfection of appliances for utilising electricity as an illuminating agent have not accomplished all that they promised, they have developed this system of lighting much further than many people could be induced to credit. The lighting of the Picton Reading Room by means of electricity illustrates what may be accomplished in a large apartment, though here the original intention of illuminating the place by the reflection of the light, rather than by the light itself, has not yet been carried out. However, we suppose the committee are anxious to move cautiously in the matter, with a view to acquire experience which may be useful in other corporate buildings. Experiments are being conducted on both sea and land. The first step in the direction of electric lighting on shipboard was taken by the Pacific Steam Navigation Company, as announced a short time back. The light was used experimentally in the saloon of the new steamship *Mendoza*, belonging to that company, as she came round to Liverpool from Glasgow, a simple Gramme machine and service lamp, used for the illumination of Messrs. Napier Bros.' boiler-shop, being utilised for the occasion. The satisfactory result of this trial is now manifested by the fact that the Pacific Company have entrusted the British Electric Light Company with the work of fitting two electric lights, produced by means of Blandy's patent, from one small Gramme machine, in the saloon of the *Mendoza*. This ship is intended for service on the West Coast of South America, and is a beautiful vessel, specially designed and adapted for the particular trade for which she was built. The saloon is large and tastefully decorated, as already described. The particular method of applying the light, which has been selected by Mr. Radcliffe Ward, the electrical engineer to the British Electric Light Company, is by reflection from special reflectors in the ceiling of the saloon. The result is a beautifully diffused soft light that effectively exhibits the tasteful painting of the saloon panels. On Saturday last, several of the directors of the Pacific Steam Navigation Company, with some friends, had lunch on board. The shutters of the saloon were closed, and the electric light was used to illuminate the apartment throughout lunch, with the exception of a few minutes when it was turned out to illustrate the marvellous difference between it and the usual candle light, which involves about double the expense of the electric light. The candles made a very weak display. Discussion of the merits of the light is almost superfluous. The success of the light on board the *Mendoza* will doubtless lead to the adoption of similar lighting on board all the principal ocean steamships before long. The illumination of the state-rooms by the incandescent system, in one form or another, is likely to be accomplished ere long. The boon to passengers of being able to turn on a bright settled light at desire will be very great. In this case the light will be placed in globes hermetically sealed. It will be seen that the electricians are doing their best to justify the hopes they raised a little time back."

Iron Nov. 21. 79

B.—Sprengel's Pump. C.—McLeod's Gauge. D.—Geissler Tube. E.—Bulb containing Phosphorous Anhydride. F.—Bulb containing Gold Leaf. G.—Electric Lamp Bulbs. Tube. b.—Air Trap. c. and e.—Mercury Sealed Stop Cocks. d.—Discharge Tube. f.—Scale. f'.—Gauge Tube. g.—Connecting Tube. h.—Mercury Sealed Joints.

...EDISON'S ELECTRIC

52

REYNIER'S NEW INCANDESCENT ELECTRIC LAMP.

As is well known, the principle of Mr. Reynier's electric lamp consists in making a slender carbon rod incandescent by means of an electric current that traverses a limited part of the rod, between a head contact and carbon holder in which the carbon glides forward.

Mr. Reynier has continually simplified his lamp until he has arrived at the novel arrangement shown in the annexed cuts.

The carbon, C, is pushed in the direction of the arrow by

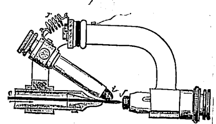


FIG. 1.—THE REYNIER ELECTRIC LAMP.

some suitable mechanism, and abuts against the end contact, B; the contact is mounted in the end of a lever held against the carbon, C, by a spring, *r*, and confines the incandescence of the carbon rod, C, to the space between *i* and *j*.

The end contact, B, is mounted in a carbon holder on a curved arm in the lower part of the lamp.

In order to introduce the carbon rod into the lamp the carbon holder is removed, the carbon, C, is placed into its tube, the carbon holder is replaced, and the lamp is ready for operation.

The incandescence shows itself, as we have said, between *i* and *j*, and varies in length from 0·16 to 0·31 of an inch. The light obtained is equal to that of 5 to 20 Carcel lamps, according to the intensity of the electric current and the length of the incandescent part of the carbon. With a pile

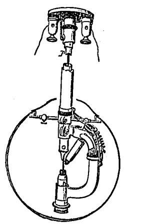


FIG. 2.—THE REYNIER ELECTRIC LAMP.

of 8 Bunsen plates (Ruhmkorff model) a light equal to about 12 Carcel lamps can be obtained.

If magneto-electric machines are used, 3 to 5 lights, each equal to 8 to 14 Carcel lamps, can be obtained per horse power, thus giving a production of 30 to 40 Carcel lamps per horse power.

Mr. Reynier has devised several variations of his lamp, and actuates the carbon rod by means of a hydrostatic mechanism or by counterweights, a moving barrel, which operates in all positions, and the suspended apparatus, which is the most simple of all, and is shown in Fig. 2. In this case the movement of the carbon is obtained by the descent of the cylinder, *p*, which acts directly upon the end of the carbon.—*La Nature.*

DR. MOTT'S ELECTRIC OBJECTIONS ANSWERED.

Herald Jan 6

NEW YORK, Jan. 2, 1880.

TO THE EDITOR OF THE HERALD:—

In yesterday's HERALD Henry A. Mott, Jr., Ph. D., presents ten objections to the use of electricity for domestic illumination. As these objections include those which are generally current I beg space for a brief reply, though some of them have already found satisfactory answers in the reports and explanations of Edison's inventions, which have from time to time appeared in your columns:—

First—He objects that electricity cannot be stored and that therefore any breakage of the generating apparatus must interrupt the light, to which I reply that from its simplicity of construction the electric apparatus would be but slightly liable to derangement. Interruptions would probably be less troublesome than those which occur from breakage or leakage of gas pipes. It will, perhaps, be found expedient that each generator should have a duplicate or a galvanic battery so arranged as to be automatically set in action by the stoppage of the current.

Second—He assumes that with a given apparatus it will require nearly the same power to produce a small as a large amount of electricity. On the contrary, the magnetic resistance, in overcoming which most of the force is expended, can be graduated simply and easily in accordance with the required amount of illumination. Every one who has used a magneto-electric machine is familiar with the means of effecting this result.

Third—The cost of the electric light is asserted to be much greater than that of gas. This may be true of the imperfect appliances hitherto in use, but under Edison's system (though that system will doubtless be further improved) it is destined to be far more economical than any other known means of illumination, because the intense incandescence produced (as shown by Tyndall) gives origin to a larger amount of light, in proportion to the heat emitted, than any luminous body except the sun, the ratio being probably three times higher than that of a gas flame.

Fourth—The assertion that the current cannot be utilized beyond 500 feet is true only when the quantity is small or the conductors imperfect or inadequate. In practice, however, it will not be necessary to convey it very far from its source.

Fifth—Within certain limits the division of the materials which is subjected to incandescence produces no great change in the total amount of light evolved. The statement that the Wallace machine gives but six lights to the horsepower is misleading. If a current of this strength is used after Edison's method in six lamps each should give more light than one hundred candles. It can certainly be divided very far beyond this.

Sixth and Seventh—If the strength of the current varies the light will fluctuate, as gaslight does under varying pressure, but every one who has tried both knows that the electric is by far the steadier light, being little affected by currents of air or by changes in atmospheric temperature.

Eighth—The objection that it will be expensive to distribute electricity from a main station seems extraordinary, in view of the fact that nothing is required but ordinary conducting wires, whose cost would be but a small fraction of that of such a system of tubing as is necessary to convey gas. To measure the supply to consumers simple registering electro-magnetic meters may be devised, which, like gas meters, may be made to record with perfect accuracy.

Ninth—This objection refers to the divisibility of the light, which has been already noticed (five).

Tenth—The objection that people will become moonstruck by the electric light (if seriously offered) suggests that possibly its author has experienced the effect of a malign influence of the kind, to the detriment of the mental equilibrium that should always be preserved by a Ph. D.

The electric light surpasses all others in purity and brilliancy, and it may be rendered absolutely safe, a most important consideration when we regard the vast number of disastrous fires which we owe to our present means of illumination. Requiring no air to sustain it, it neither robs the atmosphere of our dwellings of its vital constituents nor loads it with a noxious effluvium to poison our lungs.

EZRA R. PULLING, M. D.

EDISON'S VACUUM APPARATUS.

With the exception of the peculiar carbon used by Mr. Edison in the construction of his lamps, there is nothing of more vital importance in the development of his system of electric illumination than the apparatus employed to exhaust the air from the little globes containing the carbon horseshoes, for upon the perfection of the vacuum depends the success of the lamp.

Since Otto Von Guericke invented the air-pump in 1650 it has been the subject of various modifications and improvements; but the most perfect forms of piston air-pump yet devised are incompetent to produce the degree of exhaustion demanded by modern experimenters.

In vacuum apparatus, as in most things connected with scientific investigation and experiment, the simplest means and methods prove the best. It seems that in the natural course of invention, simplicity is the latest feature attained. Air-pumps and vacuum apparatus form no exception to this general truth. The most recent as well as the most perfect air-pumps consist essentially of a glass tube and a column of mercury. Two forms of mercurial pump are used by Mr. Edison in removing the air from his lamp bulb: one for exhausting the greater volume of air, the other for perfecting the vacuum. The first is the invention of Geiss-

tubes that connects the two pumps, the Geissler tube, and the lamp bulbs. The connecting tube, *g*, extends over the scale, *f*, parallel to and near the gauge tube, *f'*.

To produce a vacuum in the bulbs, G, the pinch-cock on the rubber pipe, *a*, is opened so as to permit a rapid succession of drops, or a full stream of mercury to flow down the internal tube of the Sprengel pump, B. This stream of mercury, falling through the space between the internal tube and the lower end of the bulb, enters the long tube of the pump, and carries with it a certain quantity of air, which is discharged together with the mercury into the cup at the bottom. As this process is too slow for creating a vacuum from the beginning, while the Sprengel pump is still working, the Geissler pump, A, is brought into use for removing the greater portion of the air. To operate this pump, the stopcock, *c*, is first closed, the reservoir of mercury—connected with the pump by a rubber tube—is raised by the attendant, as represented in the cut, until mercury flows up the long pump tube, and filling the bulb, drives out the air before it through the discharge tube, and finally overflows through the tube, *d*, into the cup at the lower end of the tube. The mercury reservoir is then lowered until the two vertical columns of mercury break in the bend of the discharge tube, and the mercury in the pump is below the stopcock, *c*, the latter is then opened, and the mercury reservoir is lowered until the mercury in the pump will sink no farther. The stopcock, *c*, is then closed and the operation is repeated two or three times. The Sprengel pump, which has been in operation meanwhile, is now permitted to finish the work. As the vacuum becomes more and more perfect the mercury rises in the pump, and when the drops strike the mercury column, a sharp metallic clink is heard, indicating that the atmospheric resistance to the falling metal is little or nothing. As fast as the mercury accumulates in sufficient quantities in the reservoir below, it is poured into the reservoir above.

Electric sparks from an induction coil are continually

Fig. 2.

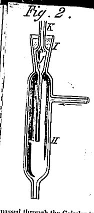
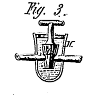


Fig. 3.



passed through the Geissler tube, D, as long as the vacuum is low enough to admit of it. Mr. Edison says that when a 9 inch spark fails to pass the ⅛ inch space between the electrodes in the tube the vacuum is still course.

The McLeod gauge is relied on mainly for testing the perfection of the vacuum. This gauge is operated by simply raising the mercury reservoir connected with it until the gauge bulb is sealed off from the other parts of the apparatus, the mercury, as it rises, closing the connecting tube, *g*. The mercury reservoir is then raised still further, until the mercury will go no higher in the gauge tube, *f'* Should the mercury rise to the end of the gauge tube it would indicate a perfect vacuum, but this is never attained. The quantity of air contained in the tube, *f'*, indicates exactly the proportion of the air in the apparatus to the capacity of the apparatus or air at its normal density. Another method of calculating the value of the vacuum is based upon the difference in the level of mercury in the two tubes in front of the scale, *f*.

Mr. Edison informs us that the vacuum in his lamps is so nearly perfect that only a millionth of the original volume of air remains.

It is obvious that the Sprengel and Geissler pumps must be longer than a barometer, to obtain the full effect of the falling column of mercury. All of the rigid parts of this apparatus are made of glass, and wherever there is a joint or a stop cock, it is sealed with mercury. Figure 2 shows the upper portion of the Sprengel pump in detail, and also gives a good idea of the manner of sealing the joints. The bulb, H, has a conical mouth, I, into which is fitted and ground the enlarged portion, J, of the mercury tube, K. The space in the mouth, I, above the enlarged part of the tube, K, is filled with mercury.

Figure 3 represents a mercury-sealed stop cock, L being the stop cock, entirely surrounded by mercury contained in the cup, M.

The lamp bulbs, G, are connected with the apparatus by a joint similar to that represented in figure 2. From time to time, while the air is being exhausted from the lamps, they are tested by connection with wires from the electrical generator. When the vacuum is practically complete, the

for information which any school geography or the nearest public library could furnish. He then goes on to describe conditions of Brazilian climate, productions, social customs, and the like, which make it impossible for many articles of American manufacture ever to find a market there, pointing out at the same time several lines of manufactures which, by proper management, might be sold largely in that part of the world.

A particularly suggestive and valuable part of the report will be found in the comparison made between the methods of German commercial agents and merchants and those of our own country. The mercantile training of the former embraces not only all the details of office work, but a thorough knowledge of geography and of the products of every land, of mercantile law, and of at least two languages besides their own. The first business of the German agent is to master the language of the people he is to trade with, if he has not already acquired it. Similar qualifications are the exception among the ambassadors of American trade. The majority of them have to employ an interpreter to make their business known, and the interpreter can rarely speak so as to compel attention and belief. Under such unfavorable conditions it is not surprising that American agents in Brazil are apt to be less successful than those of German

ler; the second, of Sprengel. The engraving shows the arrangement of these pumps in connection with the McLeod gauge, and other accessories.

Several sets of this apparatus are employed by Mr. Edison, and he has so far improved their construction and working as to enable the attendant to produce very high vacua in twenty-five minutes.

The Geissler pump, A, the Sprengel pump, B, and the McLeod gauge, C, are all connected with the socket that receives the lamp bulbs, through the bulb, E, which is partly filled with phosphorous anhydride—a powerful absorbent of moisture—and through the bulb, F, which contains gold leaf to absorb traces of mercurial vapor. Each set of apparatus is secured to a vertical board, behind which on a bracket near the top sets a reservoir of mercury, which supplies the Sprengel pump, B, through the flexible tube, a, and through a vertical glass tube, having at the top a trap, b, for receiving any air that may be carried by the mercury.

The Sprengel pump, E, consists of a glass tube about 1/8 inch in internal diameter and 36 inches in length, dipping at its lower end into mercury contained in the small vessel resting on the bracket, and having an overflow connected by a flexible tube with a mercury receiver. At the upper end of the 1/8-inch tube is formed a bulb, into which the mercury

EDISON'S WESTERN RIVAL.

Cincinnati Jan 10

A Young Inventor Said to Have a Practical Electric Light.

CINCINNATI, O., Jan. 9.—A young inventor named Edwards, of this city, has invented a method of producing the electric light which those who have examined it believe to be superior, in almost every respect, to the Edison method. Among those interested in the inventor and his schemes, are Messrs. A. D. Bullock, W. H. Eckert, of the Bell Telephone Company, Flamen Ball, Jr., and A. J. Hodder, and these gentlemen will supply the means necessary to perfect his invention.

So far nothing has been perfected except on paper, but those who have seen the plans of the inventor assert that if successful the result will be to throw the Edison light clean in the shade. The inventor, Edwards, is a young man who has devoted his life to the study of electric science.

Brunswick Jan 8/80

ELECTRIC LIGHT.—It seems now to be an established fact that the electric light has at last been brought into practical use by the "wizard of Menlo Park." Since the announcement that the the light and laboratory were ready for the inspection of visitors, a great many have availed themselves of the privilege, until the crowds became so large that all work had to be practically suspended. Among those who helped to swell the crowd Thursday evening were about one hundred and fifty-four from this city, and from what we can learn from them, the rush of incoming visitors continued until midnight, and the railroad company had extra trains running to accommodate the travel. The rush was so great and the visitors so disorderly (not those from this city) that the assistants were kept busy until a late hour guarding the scores of valuable and delicate instruments in the laboratory. A number of articles were broken and others stolen, among the rest a number of electric lamps, and, in consequence of all this, admission to the laboratory to see the lights will be, hereafter, only by special invitation or permit from the company's offices in New York, although the private dwellings and the street lamps will be kept burning nightly, so that those who wish to see the light will not be disappointed.

34

Wash Jan 15 1880

WASHINGTON, Jan. 13.—Mr. Sawyer has entered a protest at the Patent Office against Mr. Edison being granted a patent for his horseshoe lamp, claiming a first patent for the Sawyer-Mann electric lamp. This protest can have no effect, however, because before granting a patent a thorough examination is made to discover if there is any infringement upon other inventions. If there has been an infringement no patent is issued. No more thorough examination of Edison's lamp will be made now than if Mr. Sawyer had not filed a protest.

Scientific American Jan 8 1880

The Electric Light at Sea.

The pioneer in the use of the electric light in passenger steamers, the Inman steamship City of Berlin, arrived at this port, October 14. Six electric lamps were employed, four in the main saloon and two in the steerage, each of 400 candle power. The passengers expressed themselves as highly delighted with the new method of illumination.

THE ELECTRIC LIGHT IN HULL.—At a town's meeting held at Hull on Monday night was resolved to empower the corporation to apply to the next Parliament for provisional pow to introduce electric lighting into the town in consequence of the high price charged by two the three gas companies.

Nov Dec 79

THE POSTAL TELEGRAPH DEPARTMENT.—As some indication of the extent to which the increased activity which has been manifested in many branches of business during the last two

PERFORATING GLASS BY ELECTRICITY.—A simple method of perforating glass with the electric spark is described by M. Fages in a recent number of *La Nature*. The apparatus required consists (1) of a rectangular plate of ebonite, its size, for a coil giving 12 ctm. sparks, about 18 ctm. by 12; (2) of a brass wire passing under the plate and having its pointed end bent up and penetrating through the plate (not further). This wire is connected with one of the poles of the coil. A few drops of olive oil are placed on the ebonite plate about the point, and the piece of glass to be perforated is superposed, care being taken not to imprison any bubbles of air. The olive oil perfectly accomplishes the object of insulating the wire. One has then only to bring down a wire from the outer pole of the coil, on the piece of glass, above the point of the lower wire, and pass the spark. By displacing the glass laterally, for successive sparks, it is easy to make a close series of holes in a few seconds.

Manchester

Every part of life, if rightly taken, should be a stepping-stone for higher endeavour, of one kind or another be impossible. We can always remember what we cannot recall; and where we have fallen below we can resolve to rise yet higher, so that this temporary lapse may be forgotten. If we cannot—if we have created too great a ruin ever to build up again, and must henceforth be content with disgrace and disaster—then have we always the future perfect purification by perfect penitence to look to, and the time when all this shall be at an end and the poor tired slave, bound to the dead body of his own mistakes, may lie down to rest undisturbed by the waking bell calling him to the day's weary toil.

EDISON'S LATEST ELECTRIC LIGHT.

Sc. Am. Jan 10 1880

It is somewhat strange that carbon, the only substance of any value for the contact surfaces of telephone transmitters, should also prove to be the only substance suited to the light giving portion of electric lamps. The production of an electric light by the incandescence of platinum is, for the present at least, laid aside by Mr. Edison for the more promising and more satisfactory carbon. Not the carbon so familiarly known in connection with electric lighting, but a new article having different qualities, and remarkable both for the simplicity of the process by which it is made, and its efficiency as a light-giving body when raised to incandescence by the passage of an electrical current.

The discovery of this new form of carbon was partly accidental, but more the result of Mr. Edison's faculty of seizing upon the slightest suggestion and following it as long as it invites investigation.

The first carbon prepared by Mr. Edison for this purpose was formed of a thread enveloped in a paste made of lampblack and tar, and carbonized at a high temperature. This carbon thread, although not remarkably successful, gave sufficient encouragement to warrant further investigation in the same direction. After the trial of a number of other substances it was determined that the best of all was paper, simple plain paper, without lampblack or other applications. In making these carbons the quality of cardboard or paper known as Bristol-board is used.

The completed carbon is shown full size in Fig 1; the blank from which it is made is shown full size in Fig. 2. It will be observed, by comparing Fig. 1 with Fig. 2, that the paper shrinks enormously during the process of carbonization.

The manufacture of these little carbon "horseshoes," as they are called at Mr. Edison's laboratory, is very simple. The paper blanks, after being cut by dies in the form shown in Fig. 2, are subjected to heat sufficiently strong to drive off by destructive distillation all volatile matters. The paper horseshoes thus prepared are placed with alternate layers of tissue paper in shallow iron boxes, and weighted down with thin plates of ordinary carbon. These boxes are closed by tight-fitting covers, and placed in a muffle, when they are raised to a high temperature, which is maintained for a considerable time. The only index of the completion of the process is the crackling of the oxide iron boxes. ... boxes and placed between ...ises, a a, which are supported thin platinum wires blown in the glass base and forming electrodes. A portion of the glass base and the carbon its supports are inclosed by a glass bulb, from which the is so completely exhausted by means of a Sprengel that only a millionth part of the original volume ins.

Edison has improved the Sprengel pump so that high may be produced in 25 minutes instead of the 45 consumed in the operation by some of our physicists. ...uum is so nearly perfect that none of the tests to the lamps have been subjected so far, indicate the of the slightest trace of air.

...ding his Sprengel pumps and other vacuum appar... Edison fortunately secured the services of an expert glass worker, who was formerly engaged in the laboratory of the famous Geissler, of Bohn.

The electrical resistance of the slender carbon horseshoe is 100 ohms, and, while the lamp shown in Fig. 3 is intended to afford a light equivalent to a single four foot gas jet, it may be forced to give a light equal to that of 8 or 10 such jets. We saw a single lamp of this kind giving a light that enabled us to read the SCIENTIFIC AMERICAN 100 feet away. This was certainly an extraordinary performance for a piece of carbon having a surface no larger than that shown in Fig. 1.

One of the most remarkable experiments connected with the exhibition of these lamps was that of connecting one of them with the main electrodes by means of a yard of No. 36 copper wire, no larger than a horse hair. The light was maintained without heating this very small conductor. Of course a wire of this size is too small to use in regular practice, but it strikingly exhibits the advantage of having a light-giving body of high resistance.

The carbon is very tough and flexible, and not liable to be broken or injured by jars. We saw one of the carbon horseshoes nearly straightened before it broke. The carbon not only withstands rough mechanical usage; it is also proof against injury by the sudden turning on and off of the electric current. One of these carbons has been subjected to the severe test of applying and removing the electric current a number of times equivalent to 36 years of actual daily use, and yet the carbon is not in the least impaired.

The horseshoe form of the carbon has a great advantage over the straight pencil or the voltaic arc, the light being more diffused, and therefore softer and mellower, casting no sharp black shadows, nor giving such an intense light as to be painful to the eyes. The light resembles that of a gas jet excepting in the matter of steadiness, the electric light being perfectly uniform and steady.

The lamps are connected in multiple arc, *i. e.*, the two wires leading from the electrical generator run parallel to each other, and the lamps are placed between and connected with each wire. As Mr. Edison has his circuit arranged it does not make the slightest difference, so far as the lamps are concerned, whether one or fifty of them are in use; it does make a difference, however, in the power consumed at the generator. The regulation of the current is reduced to the simple matter of varying the intensity of the magnetic field in which the armature of the generator revolves.

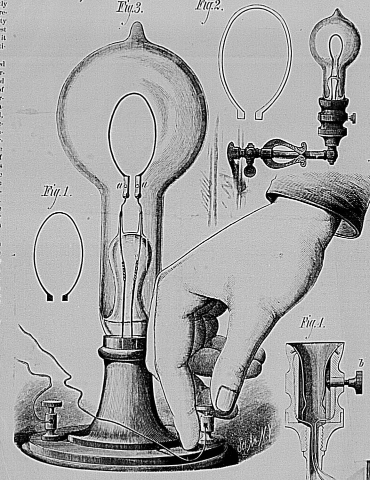
The entire lighting apparatus of a house, store, office, or factory, consists in the lamps and a few wires. There are no regulators, no complicated switches, no resistance coils to replace the lamps when the latter are not in use. The lamp, in its present form, is as simple as a candle, and, candle-like, it may be taken from its socket and replaced. This may be done while the current is on.

The construction of the socket which supports the lamp will be understood by reference to Fig. 4.

The lamp has attached to its electrodes slips of copper, which are bent upward against the sides of the glass, and touch two springs at opposite sides of the socket. One of these springs is connected with one of the electrical conductors; the other spring merely touches the copper strip, and does not form a part of the electrical conductor until it is touched by the thumb screw, *b*, this screw being connected with the second electrical conducting wire. To start the light it is only necessary to turn the screw, *b*, until it touches the spring. To stop the light the screw is turned in the reverse direction. From this it will be seen that the electric lamp is managed easier than a gas burner, as it requires neither lighting nor regulating.

On the evening of our visit to Mr. Edison's laboratory, he had more than thirty of these simple little lamps in operation, the current being supplied from one of his machines. Each lamp gives a clear, soft light equal to that of a four foot gas burner. These lamps had already been in continued operation for more than 48 hours, and they had seen altogether as much use as they would in 30 days of ordinary domestic or business service. The light certainly leaves nothing to be desired so far as its efficiency is concerned, and we are assured by Mr. Edison that, on the score of cheapness or economy, his system of illumination is far in advance of any other, not excepting gas at the cheapest rates. It seems that the subject of general electric lighting is now reduced to a mere question of time. If Mr. Edison's lamps withstand the test of time, he has unquestionably solved the vexed question and has produced what the world has long waited for; that is, an economical and practical system of electric lighting adapted to the wants of the masses.

The details given above were obtained by us direct from Mr. Edison and his assistants during a recent visit to the Menlo Park laboratory.



EDISON'S LATEST ELECTRIC LAMP.

ELECTRIC LIGHTING.

A FURTHER extension of the Jablochkoff system of electric lighting has this week been made from the central station at Charing Cross on the Thames Embankment. It will be remembered that rather more than twelve months ago that part of the Embankment between Westminster and Waterloo Bridges was lighted by 20 Jablochkoff lamps supplied by two Gramme machines, the motive power being one of Messrs. Ransomes, Sims, and Head's portable engines of 20 nominal horse power. After some months, an extension was made to Blackfriars Bridge, the number of lamps being increased to 40, and still more recently Waterloo Bridge was illuminated by ten lamps, which with five others fitted up in the board-room of the Board of Works, made the total number of lamps driven from the centre of Charing Cross no less than 55, and the length of conducting wires of over 18 miles. The latest addition was made on Monday last, on the afternoon of which day ten lamps, which had been fitted up in the Victoria Station of the Metropolitan Railway, were lighted. The space illuminated is 300 ft. long, 50 ft. wide, and 40 ft. high. The ten lights are distributed as follows: Over the down platform there are five lamps placed at equal distances apart; over the up platform there are four alternating with them, and there is one placed centrally against the bridge crossing the station; all of these lamps are placed at a height of 13 ft. above the ground. The arrangement of the lamps is the same as that employed on the Embankment, and the candles are enclosed in opal globes 16in. in diameter. The ten lights are worked on the two spare circuits of the machines employed for illuminating Waterloo Bridge. In brilliancy and steadiness the light within the station leaves little to be desired, although the pulsations and changes of colour, which hitherto have been inseparable from the system, are apparent here as elsewhere. Of course any comparison between the

2652. "Improvements in electric lamps." CHARLES WILLIAM SIEMENS. (A communication from abroad, by Friedrich von Refner Alteneck of Berlin.) Dated July 1. 6d. Relates to a method of regulating electric lamps by the counteracting forces of two coils of different resistance, through one or other of which the lamp current was shunted. For this purpose the electric conductor in some part of its course to or from, or in the lamp, divides into two branches, the one leading through the coil of a solenoid or electro-magnet of high resistance, directly back to the external circuit, and the other leading through the coil of a solenoid or electro-magnet of lower resistance indirectly back to the external circuit through the carbons and the lamp. The cores of the two solenoids or the armatures of the two electro-magnets are connected by a lever to one of the carbon holders in such a manner that, when the one solenoid or electro-magnet, namely, that having the coil of high resistance, is excited, the movement of its core or armature causes the carbons to approach towards each other, and when the other solenoid or electro-magnet, namely, that having the coil of low resistance, is excited, the carbons are caused to recede from one another, and thus, when both are excited, the carbons are caused to take a position dependent on the relation of the two counteracting forces operating upon them, which position, by suitable adjustments, can be determined so as to produce the desired illuminating voltaic arc. (A full description of this lamp is published on page 412 of the present number of this JOURNAL.)

Platinum, after being rendered homogeneous under the vacuum treatment, is, Mr. Edison says, dissolved with great difficulty in aqua regia. Mr. Edison has submitted a specimen of vacuum-treated platinum to the action of boiling aqua regia for five days without its being dissolved.

Ironmonger Nov 22 1879

Edison's Last.—A telegram states that a public display of his new lamp has been going on for a week continuously without any failure.

...the Water Supply.—Rumour says that

EDISON appears to have solved the electric light question, at least, if we judge from the value of the stock of his electric light company, which has advanced from $300, at which it stood some months ago, to $5000 per share. Gas stocks have declined both in London and here, and other indications seem to confirm the substantial success of the new process.

Engineering & Mining Journal Dec 27

The antiquated method of manufacturing illuminating gas will soon be among the things of the past; for whether EDISON has actually succeeded in making electric light much cheaper than gas, as he asserts, or not, it is certain that he has solved many of the difficulties which had heretofore been deemed by the gas magnates as insuperable, and any remaining difficulties will soon disappear.

We welcome the advent of electric light as we welcome the cheap production of water-gas for heating and metallurgical purposes. These two great inventions will create a revolution in industry, and bring honor and credit to our American inventors.

Thomas Alvah Edison.

THE man most talked about at the present time appears to be Mr. Thomas Alvah Edison. An account of his latest invention appears in this issue, together with facts gained from personal observation at the Menlo Park Laboratory. Opinion is widely divided regarding Mr. Edison. In some quarters he is stigmatized as a fraud, a wilful deceiver of the public, a pseudo scientist, etc., etc. On the other hand, he is regarded by many as a scientist of high accomplishments, an inventor of such brilliant achievements as to render appropriate to him the figurative application of the term Wizard, etc., etc. Exaggeration seems the rule on both sides, in estimating this man's character. We shall depart from this rule, and accord to Mr. Edison the possession of a truly original inventive talent and much heterogeneous knowledge of scientific facts. We do not estimate him as a scientist in the full sense of that term; neither is he so far beyond all other inventors in originality of conception as to merit the name of Wizard. We regard the discoveries of, say, the late Professor Henry, considering the state of electrical science at their date, as far exceeding in merit anything Mr. Edison has ever accomplished. Mr. Edison is a rather more than ordinarily brilliant inventor, with a fragmentary knowledge of scientific facts; and we think that this is a just estimate—neither according too much nor too little. Fortunately for the exercise of his inventive talents, Mr. Edison has enjoyed the confidence and support of capitalists, who have supplied everything requisite for experiments and enabled him to concentrate upon, and apply to, invention and study, all the talent he possesses, un-

EDISON'S ELECTRIC LIGHT IN RAHWAY.—It having been stated in some of the papers that Mr. Edison purposed extending his wires to this city to test the electric light in our streets, Councilman Osborn, as chairman of the lamp committee, has written to him tendering the use of the vacant lamp-posts on such streets as he may desire for that purpose—subject to the approval of the Common Council.

National Democrat Rahway

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Plumber & Sanitary Engineer Jan 1 1880

EDISON'S LAST (?) ELECTRIC LIGHT.

In the fall of 1878, when the electric light excitement was at its height, the press was filled with sensational accounts of what Mr. Edison was about to do, and values were seriously disturbed. In accordance with our custom to treat all such questions carefully, honestly and intelligently, we submitted the matter to one of the highest scientific authorities on such subjects in this country, Prof. Henry Morton, President of Stevens Institute of Technology. His articles appearing in successive issues of this journal at the time, did much to enlighten the public and to check the previous sensational methods of treating this subject. When, therefore, a week ago, the *Herald* again startled the world with further claims in behalf of Mr. Edison we were naturally a little skeptical, and again applied to Prof. Morton for his views on these latest claims, which are set forth in the letter we now publish, and which we considered so important that we furnished it to the press in advance of its appearance in our columns. The postscript has been added since its publication in the daily papers, and was suggested by the comments it elicited.

To the Editor of THE SANITARY ENGINEER:

Having a sincere respect for Mr. Edison as an enthusiastic and ingenious investigator, I am sorry to see his name used by writers who evidently are quite ignorant of the subjects about which they treat in a way that will inseparably connect it with discreditable (because false) claims, evidently made in the interest of financial speculators.

No one can more thoroughly appreciate than I do the originality of conception, the indefatigable patience and immense labor which have been involved in the series of experiments of which a sketch has been given in the New York *Herald* of Sunday the 21st; but when I see the conclusion of these, which every one acquainted with the subject will recognize as a conspicuous failure, trumpeted as a wonderful success, I have only left before me the two alternative conclusions that the writer of such matter must either be very ignorant, and the victim of deceit, or a conscious accomplice in what is nothing less than a fraud upon the public.

Such writing as this, in fact, has the melancholy result of placing Mr. Edison and his electric light in the same catagory with Mr. Keely and his "water motor," Mr. Payne and his "electric engine," Mr. Garey and his "magnetic motor," and others of the same class.

Against this I protest in behalf of true science and for the sake of Mr. Edison himself, who has done and is doing too much really good work to have his record defaced and his name discredited

Oct 15 1879

863. "Electric lamps." E. P. ALEXANDER (communicated by J. C. Jamin, Paris). Dated ... 6d. ... describes Jamin's electric candle, consisting of two upright rods of carbon side by side with air between, as in Wilde's well-known candle, the arc forming at the top according to Ampere's law. The conducting wire is made to loop over the arc and divert the latter or draw it out to a point. Various arrangements of the arc and circuit are described. In two conducting wires are made to run parallel with the carbons till they turn off at a certain point at right angles to the latter. The arc therefore passes between the carbons at a point near this, and the carbons are burned into two parts. The upper parts of the two carbons being supported loosely in tubes will then gradually descend as they are consumed, while the lower parts remain practically unconsumed. By another plan a solenoid is placed opposite the arc of an ordinary electric lamp, to draw it out to a point against a piece of lime or other refractory body.

A NEW comic opera to be produced in Baltimore, America, bears the name of "The Electric Light." Some talented low comedian, a Yankee Lionel Brough or J. L. Toole could make excellent capital out of a burlesque of Edison and his wonderful lamp. Here is an opportunity for histrionic fame.

Oct 15 1879 Telegraphic Journal

Oct 15 1879 Telegraphic Journal

740. "Electric lamps." F. MORI, C. E. HALLEWELL, W. MILNER, W. GRIFFIN. Dated Feb. 24. 6d. Switching the current in electric lamps from one pair of carbons to the next by an automatic commutator set in motion by spring or other motor, and kept stationary when necessary by other springs or stops, the action of which is determined by the waste of carbons by means of clock-work mechanism.

783. "Obtaining electric light." G. P. HARDING. Dated Feb. 26. 6d. A pencil of carbon in a sheath of lime or other refractory earth is heated by passage of an electric current, and the lime gives off a brilliant light. Instead of the carbon a metal conductor may be used in conjunction with a regulator to keep it from fusing.

EDITORIAL NOTES.

Ironmonger

THE ELECTRIC LIGHT AGAIN!

FOR some little time past we have not heard a great deal of the electric light, with the exception of particulars from time to time of its successful use on the Thames Embankment and certain places elsewhere in the metropolis. It does not appear, however, that the gas companies are to be left in sole and undisputed possession of the field, seeing that a telegram from Philadelphia reminds us that the redoubtable Mr. Edison is still bent on demonstrating the superiority of his pet means of illumination. Not satisfied with having proved that platinum can be obtained in large quantities, instead of being the scarce metal we had always supposed, the eminent American experimentalist and inventor is reported to have now discovered an effective and cheap means of utilising the electric light as a substitute for gas for domestic uses. The telegram informs us that "after 15 months' experimenting Mr. Edison accidentally discovered that burnt paper is the best substance to use. He cuts from cardboard a narrow strip, shaped like an elongated miniature horseshoe. This is placed in a wrought-iron mould, which is heated slowly to a white heat, driving off all volatile portions of the paper, which is then gradually cooled. The charred remains of the horseshoe are taken carefully out and are placed upright in a little glass globe, the wires of the generating machine being attached at the end of the horseshoe. The air being exhausted from the globe, it is sealed, completing a lamp costing about 1s. This, it is claimed, will produce a bright, mellow light, without flicker or pulsation." These are, doubtless, somewhat vague and general particulars, but they certainly seem to show that Mr. Edison has at length hit upon about the cheapest and least weighty kind of carbon which could possibly be obtained. Whether he really and unfailingly performs the programme detailed above yet remains to be seen. Philosophy nowadays needs to be thoroughly practical, or it is liable to be counted as being of little worth. We had better, therefore, await further particulars before we dispose of our gas shares, clear out our stocks of chandeliers and burners,

39

5 MR. EDISON'S NEW LAMP.

New York World Jan 1880

AN INVENTION OF GREAT PROMISE.

MENLO PARK ILLUMINATED—CARBON MADE INCANDESCENT IN A VACUUM—AN OLD IDEA NOW UTILIZED BY MEANS OF MODERN SCIENTIFIC APPARATUS—A GREAT STEP TAKEN IN ADVANCE.

Menlo Park, the little village at which Mr. T. A. Edison has established his shops, is now partially lighted at night with electric lamps of a new pattern, constructed within the last two or three weeks. The shops of Mr. Edison, three dwellings, and the street lamps along two or three roads are supplied with this new light, the total number of lights being so far forty-five; and new lamps are being made so as to increase the number in a few weeks to about 800. One of the lamps now in use has been lighted, day and night, for about seventeen days. The others have been used about two weeks.

For the first time, Mr. Edison allows the general public to inspect a lamp of his invention in actual use, and these new lights are freely exhibited every day, large numbers of people going out to Menlo Park every afternoon and evening to see them. They are lighted daily and put on public exhibition in order to develop defects and subject them to the practical test of every day use in order to discover if they really are what they seem to be to the inventor—a solution of the problem of household illumination by means of electricity.

The lamps are constructed on an old principle, which inventors have been trying to utilize for about forty years, and which Mr. William E. Sawyer of this city especially has been laboring diligently for the last two or three years to realize. A piece of carbon introduced into an electric circuit, and made incandescent in a vacuum, is the whole principle. The secret of Mr. Edison's apparent success is that he has been able to obtain an almost perfect vacuum, the best ever known, and to seal up his lamp in a way which positively and absolutely forbids the entrance of the air. The defects of the lamp are not yet fully understood, but it is being subjected to a rigorous test, and its weak points will soon be known, if it has any.

The steps which led up to the present invention are interesting, and will explain the principle on which the lamp is founded better than any formal description.

THE LABORS OF KING, KONN, SAWYER AND EDISON—THE PLATINUM LAMP THROWN ASIDE—A LUCKY SUGGESTION, OBTAINED BY ACCIDENT, FOLLOWED UP WITH ENERGY AND INTELLIGENCE.

The main idea of the new Edison lamp was thought of about forty years ago. An American electrician by the name of King attempted to utilize it in 1845. He invented a lamp wherein a glass globe was employed from which the air had been exhausted with an air pump. Inside of it was placed a piece of carbon or platinum, introduced into an electric circuit, and made incandescent by means of a strong current. Mr. King gave the gas companies in America a great shock. His invention was regarded as "an unfortunate discovery." He took it to England and created a sensation there also for a short time. He might have revolutionized the lighting of dwellings with it could he have maintained a good vacuum, when a carbon burner was used, or could he have regulated his current, when platinum was employed. He could do neither, and his light passed out of existence in the course of a very few years.

De Changy, a Frenchman, took up the idea in 1857 and congratulated the world promptly in a public manner on the success of his efforts, but he made a failure of it after all, and accomplished nothing. He had the same trouble as King.

Latterly, two men named Lodyguine and Konn, have taken up the idea in Russia. They have produced a lamp in which carbon is used in a vacuum, and have succeeded, within two or three years, in introducing it into several European warehouses and shops. The carbons burn out in a day or two and the lamps have to be replaced, but the light is so pure, strong and steady, and it is so absolutely free from fumes or products of combustion, that it is preferred to gas in certain establishments. It is costly, however, and has never come into general use.

Two or three years ago Mr. W. E. Sawyer, of this city, took up the idea, and last year he began to exhibit, at his little shop on Walker-st., a lamp very much superior to anything ever before produced. Mr. Sawyer employed a straight glass tube, about a foot long and two inches in diameter, closed at the upper end, and sealed at the other into a brass base. At first a slender pencil of carbon an inch long, bent into the form of a horseshoe, and held between two stout pieces of carbon, was used, this part of the lamp being supported on heavy coils of copper, which conducted the current. Afterward a straight pencil of carbon, half an inch long, held between two large pieces of carbon, was employed. The tube was filled with nitrogen gas and sealed. By means of a switch of Mr. Sawyer's own invention, the current of electricity was regulated in quantity, and the light could be turned up and down exactly like gas. The light was equal to four or five gas jets, and was as pure, mellow and brilliant as the sunshine, which it resembled. The light produced by this lamp was fit for any dwelling, and it excited such great interest that Mr. Hugh McCulloch and other gentlemen of high standing formed a company to supply Mr. Sawyer with the means required to go on with his experiments. The drawbacks of the lamp were, first, that it was large and clumsy and not a desirable addition to the furniture of a tasteful apartment, and, secondly, that the carbons could not always be depended upon. The lamps would grow warm, and in cooling the sealing material would frequently crack, admitting the air, and promptly burning the carbon the next time it was lighted. It was found very difficult to get rid of every trace of oxygen. So long as any remained, mixed with the nitrogen, it was impossible to prevent the combustion of the carbon. Frequently it was found that there was enough air left in the carbon to destroy it in a short time. It may be said that Mr. Sawyer has continued his experiments diligently, and is still going on with them at the present time. He has a new lamp now, which he guarantees to burn 500 hours, but he has not been able to produce a perfect vacuum in his glass globe yet, or to exclude the oxygen completely from his nitrogen.

MR. EDISON TRIES PLATINUM.

Mr. Edison took up the problem of the electric light a little over a year ago. Like Sawyer, he made use from the beginning of the well-known law of Ohm for the subdivision of the electric current. In passing a current from a heavy main wire to a number of equal branches, the current is exactly subdivided according to the number of branches. Mr. Edison saw that he could divide the power of his current sufficiently to maintain any number of small lights, 10,000 or any other number, on one circuit, provided that a good lamp could be made to give out the light.

He tried the experiment first of using a wire of hardened platinum. The startling announcement, made in his behalf, in September, a year ago, that he had solved the whole problem with his platinum lamp, is well remembered. In spite of that announcement, Mr. Edison has never been able to utilize the idea of a platinum burner, either in a vacuum or any other way. He tried the experiment of enclosing the platinum in a glass globe in a vacuum, and found it economical. The radiation of heat from the incandescent wire was less in a vacuum than in the open air, and the energy of the current was therefore saved for the purposes of light. But that did not obviate the fatal defects of his lamp, against which he has struggled in vain with all the energy of a strong nature for over a year.

N. Y. Evening Post Jan 2 1880

MR. SAWYER SCEPTICAL.

HIS VIEWS IN REGARD TO THE PRACTICABILITY OF THE NEW EDISON LAMP.

Mr. W. E. Sawyer, of No. 78 Walker-st., in this city, who has made long and careful researches into the problem of the electric lamp, was found at his office yesterday busily engaged in the perfection of a new invention designed for illumination. He is very much interested in the new claims of Mr. Edison, and was quite willing to express his opinion in regard thereto. He said:

"The public has received from Menlo Park the following positive assertions: (1.) That Mr. Edison's new lamp consists of a horseshoe of carbon about two and one-half inches long, clamped in platinum holders, and hermetically sealed in a glass globe from which the air has been exhausted. (2.) That the horseshoe, consisting of carbonized bristol-board, is so tough and flexible that it can be twisted nearly half way round without breaking. (3.) That the horseshoe of carbon, no oxygen being present in the globe, will last an ordinary lifetime; that it has already been run over 100 hours without suffering deterioration. (4.) That the light from each lamp is about equal to an ordinary gas jet, or say ten or twelve candles. (5.) That no dynamo-machine known can generate sufficient electricity to destroy one of Mr. Edison's horseshoes. (6.) That the chief point of advantage in the new lamp is its high resistance—140 Ohms. There are other statements, but the foregoing cover the ground pretty thoroughly. Having, during the past three years, made the most complete series of experiments respecting electric lighting by incandescence that have probably ever been made, I am enabled to speak positively about many points that to those unfamiliar, or only partially familiar with the subject may seem uncertain, or else correct when entirely wrong."

"First, then," asked the reporter, "what is your idea about the use of platinum for conducting wires?"

"The use of platinum as a holder for the incandescent carbon conductor," replied Mr. Sawyer, "is fatal to the durability of a lamp. Carbon only, of larger section than the incandescent carbon, can be employed, for the reason that at a white heat the carbon combines with the platinum to form the platinic carbide, and disintegration takes place with great rapidity. The same is true of any metal. I have welded carbon pencils in all shapes, and the best way to establish the connection of the incandescent carbon with its holders is to weld the two together. This I have done by first clamping the horseshoe in carbon holders, then inverting the lamp and immersing horse-shoe and holders in any hydro-carbon, preferably pure olive oil; finally turning on a torrent of electricity, so that the horse-shoe is made intensely incandescent. With great violence the oil is decomposed, the hydrogen escaping, and the carbon being deposited, most rapidly, at the points of contact of the horse-shoe and its holders. The weld is so perfect that the horse-shoe will break anywhere else rather than at the joints.

"Mr. Edison's paper carbon is very much longer than yours, Mr. Sawyer?"

"Yes, and when a length of incandescent conductor of one-half inch is reached, the current can no longer be economically used, because to increase the size is to increase the radiating surface, and the short carbon can be made to give all the light desired, viz., from 25 to 250 candles."

"What do you think of the kind of carbon which Mr. Edison employs?"

"The denser, harder and more homogeneous the carbon, the tougher it is and the more durable the lamp, for the reason that the whole action of the current (that very action which produces light, an intense vibration of the atoms or molecules of the carbon, amounting to several hundred trillions of vibrations per second) is to disrupt and disintegrate the carbon. The carbon formed by the process discovered, in my experiments, is the only one thus far that offers hope of permanency—a fine pencil of carbon being immersed in olive oil or any hydro-carbon gas or liquid, and electrically heated as in the process of welding before described, whereby it is built up with carbon so hard and homogeneous that it may be polished like jet. As we descend from this we get less durable material, the order of durability being: a. Carbon deposited by electric action; b. The hardest retort carbon; c. The best artificial carbon; d. Hard coke; e. Dense charcoal (charcoal impregnated with syrup and the syrup carbonized); f. Willow, paper and other fine charcoal; g. Ordinary charcoal; h. Graphite. Mr. Edison's carbon belongs to the class e or f, and as carbon in all its forms is extremely brittle, his statement that his paper carbon is so tough and flexible that it can be twisted half-way round, &c., without breaking, is open to criticism. The best carbons of the charcoal order we have produced by impregnating with syrup the finest French willow charcoal, used by artists, and carbonizing the same, repeating this process a sufficient number of times. This is substantially the process of Peyret and of Gaudoin. In pencils of 1/8 inch diameter and 1/2 inch length, with perfect carbon connections, and in an atmosphere of pure nitrogen, not even the 1/100,000,000 of oxygen being present, these carbons will last as follows, under the action of the electric current: a. At a red heat, giving a light of perhaps 1/2 of a candle, 100 to 200 hours; b. At between a red and a white heat, giving a light of 1 or 2 candles, 20 hours. c. At a white heat, light 4 candles, 5 hours. d. At true carbon incandescence, when the pencil has the hazed appearance of the sun, and gives a light of 25 or 30 to 250 candles, 20 to 5 minutes, or even less than 1 minute, disintegration then occurring very rapidly but no consumption taking place. The smaller the section of the pencil, the shorter its life. The larger the section, the more current required. The longer the pencil the more current required."

"Do you think that the horse-shoe lamps are liable to be injured by an accidental and sudden increase in the strength of the current?"

"When a carbon is in a high state of incandescence," replied Mr. Sawyer, "double the current invariably ruptures or disintegrates the carbon. If Mr. Edison will only bring the current necessary for ten of his lamps suddenly into one of them he will be surprised at the beautiful manner in which it will disappear. Experience has demonstrated that, within reasonable bounds, the less the resistance of an electrical circuit, which includes the resistance of the wires of the machine and that of the lamps outside of it, the less the power required for effective work. The arrangement of Mr. Edison's lamps in multiple circuit so as to lessen the external resistance where a large number of lamps are to be run is hazardous. In running 2,500 lamps by a single generator, the mean will be found in a square of fifty in series and fifty in multiple. This would make the external resistance of Mr. Edison's circuit 140 O, requiring an intensity of current that would give violent shocks to those who might by accident touch the conductors, and a most costly insulation of the main wires. To place less lamps in series and more in multiple is as hazardous as to go the other way, inasmuch as it would increase the chances of a short circuit extinguishing lamps in other series. No lamp can be practical unless of low resistance."

Iron

THE BRUSH ELECTRIC LIGHT.—On Tuesday evening a successful trial of the Brush system of electric lighting took place in the presence of a number of scientific gentlemen at the offices of the Anglo-American Electric Light Company, No. 74, Hatton Garden. This system is the invention of Mr. C. F. Brush, of the United States, where it is in extensive use, and is now being introduced into this country by the above-named company. The system embodies important improvements and advantages in the three essentials necessary for electric lighting, viz.:—The generator or dynamo electric machine, the lamps or carbon regulators, and the carbon. The Brush Dynamo Machines are made in several sizes, capable of operating from 1 to 16, or even more lights in a single circuit, which may be of 10 or 12 miles length if required. In construction the machines differ essentially from all others both in the armature, the arrangement of the field magnets, and the commutator, and the novel mode of connection, producing, it is stated, from a given amount of power, a larger available current than has hitherto been obtained from any other combination. At the same time the mechanical construction is such, that the wear and tear is reduced to a minimum. The current is continuous, and the results of the experiments were highly satisfactory. We reserve details of this latest development of electric lighting for our next issue.

41

WHY NOT AN ELECTRIC LIGHT?

Evening Gazette Dec 23 1879

There are those who dispute the claims of Edison to the discoveries of electric illumination, who say that others have preceded him in the essentials, and that the whole thing is impracticable. But this kind of talk need not surprise Mr. Edison, nor need the envy of all the horde of scientific theorists keep him from going ahead with his wonderful evolvements. It is said that at the very time when Fulton was getting ready to run his steamboat on the Hudson river, this same class of conservative speculators, who called themselves scientists, proclaimed the impossibility of utilizing steam for the uses of locomotion or for any practical purpose. These old fogy croakers will always, we suppose, be blocking up the avenues of real scientific advancement and of frightening timid adventurers back into the old sloughs in which it is popular to wallow.

But we hope Edison will not be deterred from persevering in his noble work for mankind. Suppose his present plans fail when it comes to the pinch: it does not follow that the investigation need be pursued no further. Why cannot electricity, the most powerful of all of nature's known forces, be utilized? We believe it can, and will be—not only for lighting our houses and streets, but for all purposes where steam is now used. In fact the possibilities in the use of electricity seem so grand that the imagination cannot lead one but a short distance into the brilliant domain.

Go ahead, Mr. Edison. Light Menlo Park if you can. But whether you can or not, do not "give up the ship." The practical men of the world believe you are on the rigght road; thus encouraged, you can afford to let the theorists twist and deride.

New York Herald Dec 21

THE ELECTRIC LIGHT continues to draw pilgrims to the Edison shrine at Menlo Park, where the little horseshoes gleam on the night. The necessary steps for a general illumination there are in progress, but as the system is extended it can be seen nightly. A letter elsewhere details the immediate plans of the inventor, and pertinently recalls some features of the struggle coal gas went through for public recognition at the beginning of this century.

Rochester ... Dec 21

There seem to be doubts in various quarters as to Edison's ability to do all he says he can do with his electric light, though most of the doubts have a croaking sound. It is hardly reasonable to suppose that by means of his invention every telegraph pole will be made to at once blossom out and shine like a double-sun-power calcium light; but that the perfected lamp under discussion will do all that any lighting apparatus can, and even more, there is little or no reason to doubt.

SUPPLEMENT.

N.Y. Herald

house politicians ... for an Assemblyman.

Dec 22 1879

A Lucky Horseshoe.

Yesterday, December 21, was the winter solstice, when Phœbus Apollo, driving the solar chariot toward the Antarctic Pole, stays his weary steeds for a moment and poises himself for his joyous progress northward. It was also the day set apart in the church calendars for honoring the "doubting apostle" who required tangible evidence before he would believe the latest and greatest of the Christian miracles. The day thus devoted to the prototype of all sceptics coincides very appropriately with the moment when solar light and heat are at their apogee, when the darkness can be felt and almost cut with a knife.

> St. Thomas gray, St. Thomas gray,
> The longest night and the shortest day

should, if our chronology were a really scientific one, based upon the eternal fixity of astronomical facts, be the date of the new year; and indeed it is probable that our year was intended as an approximation to the true solar epoch, minute accuracy being prevented by the fact that the winter solstice occurs in the middle of a month instead of at the end. The philosophers of the French Revolution, in reforming their calendar, attained this object, except that they chose to make the year commence at the autumnal equinox (September 21) instead of the winter solstice, and in so doing they merely reverted to the ancient astronomical year of the Hebrews and the Chaldeans. There are many who believe that the rising of "the Sun of righteousness with healing in his wings" was expressly typified by the assignment of the birth of Christ to this moment of deepest darkness before dawn, when "Light, more light!" is the despairing cry heard from the abyss of cosmical gloom.

Be this as it may, the renewal of light and life dates from the winter solstice in the social world no less than in the astronomical year. Christmas and New Year's are close at hand, and henceforth we are in full saturnalia. Millions of kindly souls are now intent upon the selection of gifts with which they will gladden the hearts of children, friends and lovers. Many and mirthful are the legendary tales, the symbolic practices and the half credited superstitions connected with this period. Books of fairy lore are in especial request by young and old. Ornaments in the form of a horseshoe have ever been exceedingly popular, and this year, as never before, the fashion has set in this direction. It is well known that the horseshoe possesses the magic virtue of warding all evil from its favored possessor and of conciliating to his service the sprites and elves of field, forest and flood. What more appropriate New Year's gift, then, could the master wizard of our time make to his countrymen than a "lucky horseshoe," which should at the same time be a magic lamp more practically useful in this workday world than the perilous marvels wrought by Aladdin? What more wonderful fairy tale was ever invented by Arabian imagination than the simple chronicle which the HERALD presented to a sceptical generation on St. Thomas' Day of the triumphs achieved by "that marvellous boy, that sleepless soul," Thomas Alva Edison? The record of his fifteen months wrestling with the most hidden problems of the physical universe will forever render memorable the annals of the current year, which is so crowned by an invention "in its simplicity sublime." One of the strongest and most enduring things in the world proves to be the mere cinder of a scrap of paper. Henceforth a manual of fairy lore will be as indispensable to the scientific man as his rows of cyclopædias and technical dictionaries. The Wizard of Menlo Park, after

> nourishing a youth sublime
> With the fairy tales of science and the long results of time,

takes his countrymen into his secret, and on New Year's Eve will present them with the "lucky horseshoe," the magician's wand which is destined to solve more problems in heaven and earth than are dreamt of in the current philosophies. Great is Cinderella and Tom Edison is her prophet.

Herald Jan 6

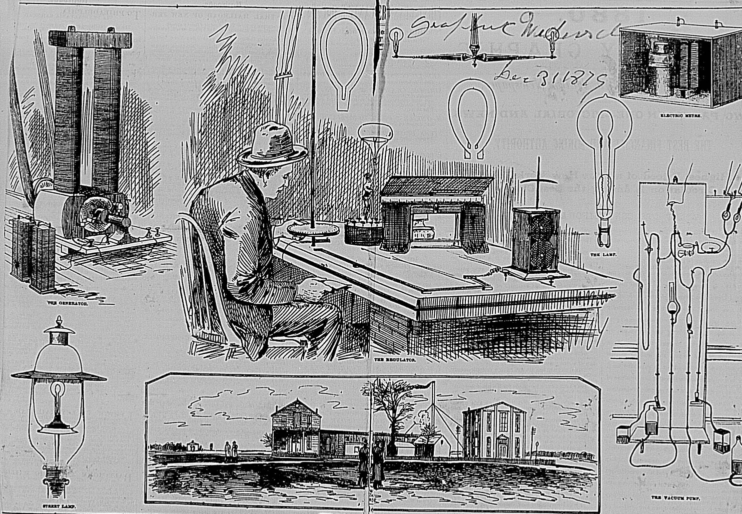
A Challenge to Edison.

Mr. W. E. Sawyer, of New York, is not yet done with Mr. Edison. He asserts that, statements of Edison and other witnesses to the contrary notwithstanding, the Menlo Park inventor cannot run one of his lamps at twelve-candle power for more than three hours. After thus bluntly giving the lie to a brother scientist Mr. Sawyer kindly invites Mr. Edison to a private residence in New York, presumably his own, where he proposes that the Jersey electrician shall show what he can do. A neater method of implying that Edison is an idiot could not possibly be devised. If Mr. Sawyer had never invented anything else this challenge would be sufficient proof of the deftness of his ingenuity. If Mr. Sawyer wishes to test an Edison burner or a number of them why does he not take some trusty watchers, go to Menlo Park and make observations? Perhaps Edison would keep up the illumination many hours extra for the sake of converting this doubting Thomas.

Mr. Edison will probably be the subject of many such letters before his system is in practical use throughout any large city. The best thing he can do with them is to burn them. A man who has on his hands such a gigantic enterprise as the electric light is claimed to be is under no obligations to waste a moment in giving points to a rival. Letters and criticisms will be written from all sorts of motives—some of them honest, others to help the gas stock market for a day or to bring desired capital to the coffers of some rival company, or even to bear Edison stock, so that the writers may buy some at a decline; still others will write mistakenly, because, although they never thought of the possibility of such a thing, they do not know all or exactly the same things that Edison does. Let the inventor stick to his laboratory, making his tests to the public only; then, if any one chooses to remain unconvinced, in spite of his eyes, he will not be missed from the crowd.

Graphic [illegible]

Dec 31 1879



SKETCHES IN EDI[SO]N'S LABORATORY.

ILLUSTRATING THE MECHANISM EMPL[OYE]D IN PRODUCING HIS ELECTRIC LIGHT.

177

EDISON's latest electropyre, or electric burner, consists of a small cylinder of pure zircon, heated to whiteness by a surrounding coil of platino-iridium wire.

42

EDISON's call for platinum for his electric lamp has been responded to with interest by Western "prospectors," and a crystalline vein of it has been found in a seam of talc in Santa Clara County, California. The schistose rock in which the talc is imbedded was found to be so hard, however, that the work of quarrying proved unprofitable. Prof. Stewart, nevertheless, thinks that with proper tools it might be made to pay. Drift platinum was once found along with gold in old diggings of Trinity and Humboldt Counties, and the same authority recommends search in that region.

Telegraphic Journal Apr 1 1879

1622. "Improvements in the means employed [in] producing electric light." RICHARD COMINGS THO[MP]SON. Dated April 24 2d. Relates to the electro[des] used in the production of the electric light, and c[on]sists in the employment either in a dry powdered, o[r] a moistened and plastic state, of the carbon or car[bon]aceous material or composition usually made into [illegible] pencils or sticks of carbon for the purpose; ... advantage being that the supply of the carbon may be made practically continuous. (*Not proceeded w[ith].*)

Gas stocks may weaken, but Electrician SAWYER stands like a stone wall. In a letter addressed to the editor of THE SUN, he renews his profession of unshaken incredulity in the alleged discoveries of Mr. EDISON. He concedes that Mr. EDISON is a "mechanical genius," but denies that he has any rightful claim to the title of electrician. Several of Mr. EDISON's alleged discoveries and improvements in electric lighting are fully covered, he says, by his own patents: the horseshoe lamp in particular is derided by Mr. SAWYER, who avers that he himself invented it, tested it over a year ago, discarded it as worthless, and because it was such an utter failure decided that it wouldn't pay to take out a patent on it. In short, Electrician SAWYER asserts that Mr. EDISON "has absolutely nothing that is new or valuable in electric lighting." Electrician SAWYER has an electric light of his own, however, which he promises to exhibit, "in practical household use," in this city next week.

The Sun Aug 25 1879

The locomotive electric light recently introduced in England for railway use, is said to operate satisfactorily. To a light six-horse power four-wheel locomotive a dynamo-electric machine is attached; any electric light can be used. When the engine is moving along the line, the electric machine rotates at its proper speed, and, when it is necessary to stop, in order that the light may be directed on some particular spot, the driving wheels are thrown out of gear by means of the disengaging handle attached to the pinion on the crank shaft, and the machine ceases to be locomotive, while the engine continues to move the dynamo machine at its proper velocity. The engine is furnished with sensitive governors, so that the speed of the dynamo [illegible] be accurately regulated [illegible] very important in order to [illegible] brilliant continuous light.

Sun [illegible]

how wonderful it! I understand it all now. You bottle up the light in these little globes and then sell it for so much a bottle! Isn't it nice?" Another intellectual visitor entertained a crowd of admiring friends by explaining at length how the little chalk telephones which abound in the laboratory furnished the electricity that gave out the electric light.

COOL REQUESTS.

The requests for lamps and horseshoe carbons are numbered by the thousands, and many of the visitors feel indignant when the assistants politely decline to take their proffered pay for the same, explaining that they are not for sale. The little globes of fire still continue burning in all their beauty, notwithstanding the predictions of the skeptics. The three hours' test which a rival electrician loudly dared Mr. Edison to make, proclaiming that only that length of time was necessary to prove the utter failure of the invention, has now grown into a test of 240 hours, and still the lamps are burning. The lamp which I referred to three days ago as having been placed under water and made to give light in that position still remains submerged, and no change has occurred in the light, thus suggesting an important aid for submarine divers in their work. Several thousand people have now seen the light, and Mr. Edison feels satisfied that he has practically answered the sceptics.

THE QUESTION OF COST.

The exact cost of the new light the inventor has not made public, but it is characteristically summed up in an answer which he was overheard to give an inquirer:

"After the electric light goes into general use," said he, "none but the extravagant will burn tallow candles."

Herald [illegible] 1879

Edison's Triumph.

As might have been expected, the magnificent success of Thomas Alva Edison in developing his electric light, as made known in Sunday's HERALD, has had the instantaneous effect of calling forth the carping criticisms of rival inventors. A paragraph in one of the city dailies yesterday referred to Edison's invention as a mere modification of the Sawyer-Man patent, and another of our contemporaries, the *Sun*, contains an ill-natured fling by Mr. W. E. Sawyer, in which he challenges the well-earned reputation of our great inventor in respect to his quadruplex telegraph and his carbon telephone. It is rather late in the day to discuss these points, and we are satisfied to leave them to the mature judgment of the present generation of scientists. But Mr. Sawyer proceeds to formulate a series of eight challenges to Mr. Edison, offering one hundred dollars premium for a successful answer to any one of them. They cover pretty nearly all the points presented as the distinctive features of Mr. Edison's invention, and if he were so disposed he might doubtless win eight hundred dollars by merely demonstrating them to a committee of Mr. Sawyer's friends.

We do not, however, think it necessary in this year of grace 1879 for any one seriously to discuss a question of comparative originality as between Thomas Alva Edison and W. E. Sawyer. We say this without disparaging the problematical laurels of the latter in his own sphere as an inventor, but we would counsel him not to try conclusions with the "Wizard of Menlo Park." All great inventors have had their rivals and their detractors. What will the men of the twentieth century say if perchance they learn from some dog-eared volume that the greatest invention of the greatest inventor of all time was challenged by one W. E. Sawyer? Let Mr. Sawyer demonstrate his own inventions as satisfactorily as Mr. Edison and the world will then listen to him.

As compared with such carping criticism the generous commendations of Mr. Richard A. Proctor, printed in yesterday's HERALD, are refreshing to the generous mind, and the letter which we to-day print from Mr. E. J. Mallett, Jr., is a further testimony from the pen of a thoroughly competent scientist, who has himself experimented in a most interesting manner with the same wonderful element, carbon, which has yielded to Mr. Edison his last and greatest triumph. If any one is authorized to contest with Edison the palm of originality as a carbonographer it would seem to be our correspondent, Mr. Mallett; but his letter, instead of filing a bill of complaint, contains a generous appreciation of the merits of his fellow physicist. His experiments with platinic chloride form a distinct addition to the sum of knowledge in this obscure branch of metallurgy and entitle him to rank as a discoverer. The differing attitude of Messrs. Mallett and Sawyer in this respect is deserving of notice, and the public will find no difficulty in awarding the premium for genuine scientific insight and fellowship.

PRICE TWO CENTS.

EDISON'S LIGHT.

A VISIT BY A WELL-KNOWN PHILADELPHIAN TO THE LABORATORY.

Mr. Henry Bentley in Company With William Leatham Bright and Engineer Joseph John Tylor Discourses Some New Uses for the Wonder.

Philadelphia News Jan 7

Columns and columns have appeared in the newspapers regarding Edison's electric light, and the subject might well seem written out, at least until Edison gives to the world figures concerning what the cost will be. However, there was a visitor at Menlo Park Monday who wished to investigate the light and with whom the question of the cost as compared with gas is a matter of small moment. This gentleman was Mr. Joseph John Tylor, a noted English engineer. He was accompanied by Mr. William Leatham Bright, the son of John Bright, M. P., and Mr. Henry Bentley, president of the Philadelphia Local Telegraph Company. Mr. Tylor and Mr. Bright have been traveling in this country since August last. Mr. Bright, who is a manufacturer, having a mill at Rochdale, England, employing over 2,000 operatives, wished to see if Edison's light could be used in his works, he having tried all the other electric lights and found them impracticable. Mr. Tylor, who is largely interested in coal mines in Wales, and who is an authority in mining matters, desired to investigate Edison's light to find whether it would not be practical to use it in coal mines and prevent the terrible loss of life which occurs when the fire-damp is ignited by the miners' lamps. Both gentlemen examined the light, spending Monday afternoon and evening in the work, and expressed themselves as perfectly satisfied that each had found what he had been seeking for.

"The question of lighting mines by electricity," said Mr. Bentley this morning, "is not a new one, but no means have hitherto been devised that would accomplish the purpose. The Edison light, however, bids fair to overcome the difficulties, and if it is brought into use there will be no more of the terrible catastrophies in mines. The ordinary electric light formed by the combustion of carbon rods would be as dangerous in a mine as an ordinary flame. But not so with Edison's. His light comes not from combustion, but from the heating of paper horseshoes (charred Bristol board) by the passage of electricity through them until they glow at a white heat. To prevent the combustion of the paper horseshoes and to make the lamps permanent, they are enclosed in a glass globe or bulb, from which the air is exhausted and a vacuum formed. Should the glass be broken while the light is burning the passage of air into the globe would, on the instant, cause the destruction of the paper horseshoe and there would be no light, not even a spark. From this it will be seen that the lamp is practicable for use in mines, and that it will prove one of the greatest boons ever presented to mankind. There will be no loss of life from the explosion of the dreaded fire-damp—at least from the miners' lamps; the work can be carried on in light instead of semi-darkness, and there will be a great saving of life from the latter fact alone. Hundreds of men are killed annually in the coal mines of England of whose deaths the public hear nothing, and that is by being run over by the cars in the dark tunnels. With Edison's light will come a new order of things. Wires will be run into the mines and lamps placed wherever required, so that the dark caves will be as light as day. Then other lamps can be carried about by the miners, connection being made to the main wires by means of flexible conductors. There will be no danger at all from their use. As explained the breaking of the glass globe of the lamp instantly destroying the light, and when the lamps are intact of course no gas can enter as they all are hermetically sealed. Mr. Tylor was perfectly enraptured by Edison's light and intends upon his return to England to lay the subject before the Royal Institute, of which he is a prominent member. He says that the excitement in England over the electric light question is intense. Mr. Bright was equally pleased with the light. He has tried every other system, but without success. The ordinary electric light was found impracticable, simply because it is too powerful. The workmen in his mills after once looking at the light could not see the threads in the looms for some minutes afterward. Various devices for modifying the light by means of reflectors were tried, but found not to be satisfatory.

Mr. Bentley, while talking to a NEWS reporter, told of different experiments the visitors made with Edison's lamps. One was to plunge the lamp, after the glass had become heated, into a jar of water, letting it remain there. It was there when Mr. Bently left, glowing as brightly as ever, and this, he says, suggests another use for the lamp. With an insulated conductor it can be taken down under water and will not be affected. It will be of as much use to the diver into watery depths as to the miner delving into coal seams. "What a field of discovery," continued Mr. Bentley, "will it open to the naturalist and to the seeker after the mysteries of the sea. In Jules Verne's "Twenty Thousand Leagues Under the Sea," the characters in that wonderful fiction are represented as walking on the bed of the sea with electric lights in their hands and breathing air from a holder which they carry on their backs. The first part of this idea is now realized, and who can tell but that the other will follow in time. Edison's lamp is entirely practicable for strolling through submerged pleasure grounds, the length of the walk depending on the length of the wire running from the lamp to the generator situated on board a vessel, air, of course, being pumped to the diver in the usual way."

HEINRICHS' ELECTRIC LAMP.

43

Telegraphic Journal Oct 1 1879

ON Tuesday evening, the 10th ult., an exhibition of one of Mr. Heinrichs' lamps (see TELEGRAPHIC JOURNAL, 15th September) took place at 80, Gray's Inn Road, upon which occasion a number of gentlemen were invited, all of whom take an interest in electric lighting.

The exhibition commenced at eight o'clock, when about thirty gentlemen were present, among whom were Lord Lindsay, M.P., Mr. Spottiswoode, F.R.S., Mr. S. Wells, Mr. E. Cox, Mr. F. Flower, and Mr. J. Ashby.

The lamp was suspended in the open air, and during the evening was raised to an elevation of sixty feet. The current was supplied to the lamp from a single current dynamo-machine of 1,200 to 1,800 candle power. The light in the first instance was not quite as satisfactory as the inventor intended it should be, but after a short time it became very steady, and produced a most brilliant effect, the high elevation at which the lamp was placed showing this to great advantage. Mr. Heinrichs then showed, by quick interruptions of the current, that the lamp was always instantaneously re-lighted, and during the whole evening, up to ten o'clock, the regulating apparatus acted perfectly, which may be taken as a fair proof of the practicability of the step-by-step feeding arrangement (see TELEGRAPHIC JOURNAL, 15th September).

The lamp was c[overed] by a glass globe, and was provided with a [large] white japanned reflector, 36 inches in dia[meter]. A noticeable point in the illumination was the absence of the usual shadows from the mechanism which holds the carbon, whilst the shadows of any objects upon the ground were remarkable for their absence of sharpness of outline.

All the visitors seemed to be very much satisfied with the favourable results obtained with this new lamp, which prognosticated for the system an extensive employment.

There has been a great want of a simple form of electric lamp for lighting up railway stations, churches, or large public halls, which will burn steadily for a long period, and as the Heinrichs' lamp will last for ten to twenty-four hours, without change of carbons, it may prove a dangerous competitor to other systems in use.

Mr. Heinrichs also showed his new electric-motor, which gave most favourable results as a transmitter of power, and which we hope to describe in detail at some future time; at present we will give only a few notes of the results obtained with this motor during the evening.

The current of a Gramme machine driven at 850 revolutions per minute by 1½ to 2 horse-power, was connected by sixty yards of cable to Heinrichs' electric-motor. The revolving armature of this motor weighs over forty pounds, and was driven by the current at a rate of 1,600 revolutions per minute. The motor was then connected by a belt to a grindstone 30 inches in diameter and 4 inches wide; the grindstone was then driven by the motor at a speed of from 230 to 250 revolutions per minute, whilst the motor kept up a speed of 1,100 revolutions per minute. When rough work was put in operation upon the grindstone the speed of the latter was but little reduced. It is stated that the loss of power in this motor, worked by a dynamo-machine at a distance of 60 to 100 yards, was not 20 per cent.

Mr. Heinrichs promises to have in a short time a new single current dynamo-machine for light purposes, and will then be able to give more exact figures as to the illuminating power of his light and how much power is lost by the transmission of power by his new electric-motor, which must be very favourable according to the results obtained.

We are informed by Mr. Heinrichs that the expense of the circular carbons, which were manufactured by Messrs. Johnson and Phillips at their Charlton Works, is not greater than that for straight ones.

The whole system was patented in England and abroad November, 1878.

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Dec 21 /79 Sun Weekly

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how wonderful! I understand it all now. You bottle up the light in these little globes and then sell it for so much a bottle! Isn't it nice?" Another intellectual visitor entertained a crowd of admiring friends by explaining at length how the little chalk telephones which abound in the laboratory furnished the electricity that gave out the electric light.

COOL REQUESTS.

The requests for lamps and horseshoe carbons are numbered by the thousands, and many of the visitors feel indignant when the assistants politely decline to take their proffered pay for the same, explaining that they are not for sale. The little globes of fire still continue burning in all their beauty, notwithstanding the predictions of the skeptics. The three hours' test which a rival electrician loudly dared Mr. Edison to make, proclaiming that only that length of time was necessary to prove the utter failure of the invention, has now grown into a test of 240 hours, and still the lamps are burning. The lamp which I referred to three days ago as having been placed under water and made to give light in that position still remains submerged, and no change has occurred in the light, thus suggesting an important aid for submarine divers in their work. Several thousand people have now seen the light, and Mr. Edison feels satisfied that he has practically answered the sceptics.

THE QUESTION OF COST.

The exact cost of the new light the inventor has not made public, but it is characteristically summed up in an answer which he was overheard to give an inquirer:

"After the electrict light goes into general use," said he, "none but the extravagant will burn tallow candles."

N.Y. Herald Dec 23 1879

Edison's Triumph.

As might have been expected, the magnificent success of Thomas Alva Edison in developing his electric light, as made known in Sunday's Herald, has had the instantaneous effect of calling forth the carping criticisms of rival inventors. A paragraph in one of the city dailies yesterday referred to Edison's invention as a mere modification of the Sawyer-Man patent, and another of our contemporaries, the *Sun*, contains an ill-natured fling by Mr. W. E. Sawyer, in which he challenges the well-earned reputation of our great inventor in respect to his quadruplex telegraph and his carbon telephone. It is rather late in the day to discuss these points, and we are satisfied to leave them to the mature judgment of the present generation of scientists. But Mr. Sawyer proceeds to formulate a series of eight challenges to Mr. Edison, offering one hundred dollars premium for a successful answer to any one of them. They cover pretty nearly all the points presented as the distinctive features of Mr. Edison's invention, and if he were so disposed he might doubtless win eight hundred dollars by merely demonstrating them to a committee of Mr. Sawyer's friends.

We do not, however, think it necessary in this year of grace 1879 for any one seriously to discuss a question of comparative originality as between Thomas Alva Edison and W. E. Sawyer. We say this without disparaging the problematical laurels of the latter in his own sphere as an inventor, but we would counsel him not to try conclusions with the "Wizard of Menlo Park." All great inventors have had their rivals and their detractors. What will the men of the twentieth century say if perchance they learn from some dog-eared volume that the greatest invention of the greatest inventor of all time was challenged by one W. E. Sawyer? Let Mr. Sawyer demonstrate his own inventions as satisfactorily as Mr. Edison and the world will then listen to him.

As compared with such carping criticism the generous commendations of Mr. Richard A. Proctor, printed in yesterday's Herald, are refreshing to the generous mind, and the letter which we to-day print from Mr. E. J. Mallett, Jr., is a further testimony from the pen of a thoroughly competent scientist, who has himself experimented in a most interesting manner with the same wonderful element, carbon, which has yielded to Mr. Edison his last and greatest triumph. If any one is authorized to contest with Edison the palm of originality as a carbonographer it would seem to be our correspondent, Mr. Mallett; but his letter, instead of filing a bill of complaint, contains a generous appreciation of the merits of his fellow physicist. His experiments with platinic chloride form a distinct addition to the sum of knowledge in this obscure branch of metallurgy and entitle him to rank as a discoverer. The differing attitude of Messrs. Mallett and Sawyer in this respect is deserving of notice, and the public will find no difficulty in awarding the premium for genuine scientific insight and fellowship.

PRICE TWO CENTS.

EDISON'S LIGHT.

A VISIT ... DELPHI ...

Mr. Henry B... Leatham...

The dark caves will be as light as day. Then other lamps can be carried about by the miners, connection being made to the main wires by means of flexible conductors. There will be no danger at all from their use.

HEINRICHS' ELECTRIC LAMP. 43

Telegraphic Journal Oct 1 1875

On Tuesday evening, the 16th ult., an exhibition of one of Mr. Heinrichs' lamps (see Telegraphic ...nber) took place at 80, Gray's ... occasion a number of gentle... of whom take an interest in

...menced at eight o'clock, when ...n were present, among whom ...P., Mr. Spottiswoode, F.R.S., Cox, Mr. F. Flower, and Mr.

[ITEM FOUND IN BOOK]

~~Lefomeyer~~

~~Book 35~~

p 39

From New York Tribune Jan. 2, 1880

"Mr Sawyer Skeptical"

p 40

Editorial from New York Herald, Jan 5, 1880

"A Challenge to Edison"

p 42

Editorial from New York Herald, Dec 23, 1879

"Edison's Triumph"

From Cat. 1051, pages 112-113, Scrapbook E 173-35B

ones.

The whole system was patented in England and abroad November, 1878.

Phila Ledger Jan 5 1880

EDISON'S ELECTRIC LIGHT.

SECOND VISIT TO MENLO PARK.

MENLO PARK, Jan. 3, 1880.

Mr. EDITOR:—I visited Edison's laboratory again this evening to note the results of another week's trial of the lamp, but everything is running on so smoothly that I find little that is new to report. The same lamps that I saw here last week are still aglow with light without any sign of deterioration. As to the identity of most of the lamps I of course take the assurance of Mr. Edison's assistants, whose word I have no reason to doubt; as to one of the lamps of low resistance I know of my own knowledge that it is the same that I saw a week ago, for I mentally noted slight peculiarities whereby I could recognize it at a glance. It was the central light in Mr. Upton's parlor which I mentioned in my former letter as having been hung upside down by wires from the ceiling, the wires themselves being entwined with flowers and grasses. I have good reason to believe that it has not been disturbed during the week, for shadows of overhanging blades of grass, &c., fall on the same parts of the wall of the room that they rested on last Saturday.

INQUEST ON A BROKEN LAMP.

One of the three lamps hung to the wires over the Sprengel pumps broke during the week after the carbon had been incandescent something more than one hundred hours. An inquest was held over its remains, but the cause of the accident could only be guessed at, as there were no witnesses to the breakage. The carbon horseshoe was not consumed, but was broken by the breaking of the glass globe. The remains of the glass and a piece of the carbon still attached to the platinum clip which connected it with one of the wires were lying on the laboratory table for examination by visitors. The neglected microscope that I mentioned in my last letter was there also, lighted by one of the carbon lamps, and by its use the parts of the broken lamp could be minutely examined. The carbon had, to all appearance, undergone no change except that it was a little more lustrous and metallic looking than the carbonized horseshoes that had never been made incandescent. The edges of the card board cut by a knife appear quite jagged under the microscope, and this furred appearance remained in the piece of carbon that had been incandescent for several days. Mr. Edison was well pleased with the appearance of the fractured lamp and its carbon horseshoe under the microscope. They did not indicate any weak points requiring correction. The other two unbroken lamps had been incandescent 213 hours on Saturday night.

AN EARLIER FORM OF LAMP.

The carbon lamp, used for illuminating the object under the microscope, was one of the earliest made, and although the same in appearance and effect as the others, had the wires connected to the carbons by a different form of platinum clip, and the glass through which the connections were made was of a different kind from that now used. Nearly all of the lamps of this earlier form failed in practical use, and Edison was momentarily expecting the breakage of this lamp. He wanted to be "in at the death," however, and seldom left the table where it continued to burn on Saturday evening until all the lamps were extinguished by the stoppage of the engine for the night.

EVERYTHING OPEN AND ABOVE BOARD.

The absence of all attempts on the part of Mr. Edison or his assistants to make his light appear any better than it is is very well illustrated by the public exhibition—made without explanation except to inquirers—of this broken lamp and by the public use, also without explanation of a lamp expected to break down at any moment. When we add to this the fact that no reflectors or artificial aids of any kind are used to concentrate the illuminating power of the naked lights and make them show to better advantage, and also that no restrictions whatever are placed upon visitors, one can readily see that the inventor has the utmost confidence in the practical value of his system of illumination.

DIFFUSION OF THE LIGHT.

When I was here a week ago the laboratory where the principal display of lights was made was in a condition very unfavorable for experiments in illumination. The boards forming the ceiling had once been white but were then nearer black owing to heavy deposits of smoke from the gas jets. The boarded sides were also discolored and prepared to absorb a great deal of light. Since then the ceiling only has been given a single coat of white paint, which has greatly improved the effect of the lamps although the paint, streaked and blended with the soot, is very far from being white. The laboratory is still darker than most workshops but the electric lights illuminate it in every corner much better, I believe, than the same number of gas jets would. As to the diffusive power of the light I should say that it was greater than that of gas but for the fact that I have seen a contrary opinion expressed. I have no doubt whatever that it is at least as good, and I judge this by observations made in a dining-room lit by two electric lamps. The room was about the same size as one in Philadelphia lit by three gas jets, and if there was any difference in the diffusion of light I should say that it was in favor of the electric lamp. Observations made of the street lamps at Menlo Park, compared with street lamps in Philadelphia, are not likely to yield satisfactory results, the conditions being very different. Here there are no buildings to reflect the light. In the city almost every street lamp is flanked on either side by buildings with glass windows or white shutters to serve as reflectors. I have lived on the outskirts of Philadelphia where the street lamps were under the same conditions as these at Menlo Park—few and far between—and with no buildings near them to confine and reflect the rays of light. I have no doubt in my own mind that the Menlo Park street lamps are quite as good, if not better, than those of Philadelphia.

VISITORS TO MENLO PARK.

This place has been so overrun with visitors during the week that comparatively little work has been done. The New Year's callers were numerous, and some of them began the new year very badly. Not being offered any wine some unconscionable relic hunters took lamps that were not offered to them. More than a dozen lamps were stolen from their sockets by visitors, and the inventor was thus deprived of so many aids to the general illumination for which he is preparing. There are probably one hundred lamps now in position, but those in most of the private houses were not lit on Saturday evening, so that I saw only about the same number (sixty) that were in use a week ago. Several of these were in street lamps erected during the week. To enable his men to continue their work and to protect his property from vandals, Mr. Edison resolved to close the laboratory to all except invited visitors, leaving the general public to look at the street lamps and (through the windows) at the lamps in private houses. His good nature, however, got the better of his good resolutions, and on one pretext or another every one who called Saturday evening managed to get through the guarded private office and into the laboratory. The visitors were chiefly country people and villagers from the neighborhood, there being comparatively few people from New York or Philadelphia. Among those present I noticed Mr. John Wanamaker, of your city, who made a very thorough examination of the light and appeared to be well pleased with its effects, which he can contrast with the much more powerful carbon-point lights used to illuminate his Grand Depot.

ABOUT THE COST.

I failed to learn anything new about the cost of the light, but Mr. Edison and all his assistants are very confident that it is much cheaper than gas. The cost cannot, in the nature of things, be satisfactorily determined until a practical trial of actual working in a city has been made. Nor can even a laboratory test of any value be made until there are more generators and more lights at Menlo Park. At present there are only two generators in use, one furnishing the current, a third, a "field generator," being employed to increase the force of the magnetic fields in the others. These three generators are run by an eighty horse power engine. They can undoubtedly be run with less power, but how much less is a question only to be satisfactorily settled by putting on more generators, until the limit of the engine's power has been reached. The same thing may be said of the lamps themselves. Mr. Edison expects to produce eight or ten lights, each equal to an average gas burner, per horse power, and whether he is over sanguine or not, can only be settled when he is using all the power of his engine and reaches a limit as to the number of lamps he can maintain. It can be safely said, however, that the light promises to be cheaper than gas.

ARRANGEMENT OF THE GENERATORS.

A plan has been drawn by Mr. Samuel Mott, Mr. Edison's draughtsman, showing the arrangement of the generating shop in a city station. According to the plan the generators are arranged on two sides and in front of a powerful engine, which runs all of them. Five of the generators produce the current which is carried through the wires wound about the magnets of the others, thus making a stronger magnetic field in the forty or more generators which supply the main circuit. From this main circuit, supplied by all the machines acting together, branch circuits carry the current to different quarters of the section of the city to be lighted.

AN OBJECTION PRACTICALLY ANSWERED.

I found Mr. Edison in good humor, in spite of the annoyances to which he has been subjected during the week in the stealing of lamps, breakage of apparatus and acts of malicious mischief, apparently designed to break down his lamps. He was being cross-examined by a Professor with a series of what appeared to be set questions, well conned before they were propounded, all of which he answered with the utmost frankness. One of the last questions asked related to a source of failure in his lamps, which had been carefully pointed out by a rival, and Mr. Edison was asked what he thought about it. This question had already been "answered" in practice by the lamps then burning in sight of the Professor. With a merry twinkle in his eye, Mr. Edison pointed to one of the lamps and said: "That's what I think about it. There is the lamp which has been burning for two weeks, in spite of the objection!"

MR. EDISON AS A SCIENTIST.

I have been amused ever since I first visited Menlo Park by articles in various papers which draw a sharp line of demarcation between Mr. Edison and scientists generally. If Mr. Edison is not a scientist, whose opinions on matters electrical are entitled to as much respect as the opinions of any other scientist in this country or in Europe, I do not know where we should go to find one. His methods look to me to be entirely scientific. He does not trust implicitly to books, but experiments for himself, making a note of conditions and effects, philosophizing as to causes, and preserving carefully kept records of all his experiments. He is well acquainted with the literature of electricity, familiar not only with the laws that have been laid down, but with the observed facts from which the laws have been deduced, but, fortunately for him, he has not been educated to an undue reverence for books and professors. He is a skeptic, and, being skeptical, is not satisfied with being told that a thing cannot be done until convinced of it, either by reasoning or, what satisfies him still better, by experiment. If scientists are to be divided into two classes, those who have received college education and those who have not, the distinction being limited by the former, then Edison is not a scientist; but, if the name is to be applied to all who are "learned in science" and pursue scientific methods, then, so far as electricity is concerned, Edison must be counted as one of them, and one at the head of his class.

METHODS OF INVENTION.

A good many stories have been told about Mr. Edison's methods of invention which are held to show that he stumbles over discoveries, and is simply to be credited with a happy faculty of seeing at once what tripped him up. Most of those stories are not strictly true. Mr. Edison ascertains what is needed and searches with his eyes open for the substance or the form that will answer his purpose not by trying everything that comes to his hand, but by trying everything which theoretically promises good results. By carefully noting down the results of experiments and by trying to ascertain the causes of failure, he discovers things which would escape the notice of careless investigators.

HIS OTHER INVENTIONS.

Mr. Edison's favorite invention seems to be the phonograph, which he thinks can yet be made of practical value and commercially successful. He says that when it first talked back to him in language as plainly articulated as any that has since come from it he was actually frightened, and for a moment dropped the crank he was turning. [illegible] run by clockwork and made to articulate clearly, which can be used, if volume of sound is sacrificed, would be of use in dictating messages, articles, &c., to an amanuensis. In the laboratory is an instrument, now eclipsed by the electric light, which is designed to send telegraphic messages in the sender's own handwriting. I had not time to examine this curiosity. The chemical telephones appear to be entirely satisfactory, and great numbers of them are being made.

FIRST IMPRESSIONS CONFIRMED.

In conclusion, let me say that a second visit to Menlo Park has only confirmed first impressions as to the electric light. The light is entirely satisfactory considered as a light. It has stood another week of the "time test" without any sign of deterioration, and, as to its cost, nothing has been developed to show that it is any more costly than Mr. Edison claims. He is credited now with declaring that, when his light is introduced, "none but the extravagant will use tallow candles," but I did not hear him say that, and it may be only one of many false quotations which have subjected him to criticism as being over-sanguine.

A. B. C.

Telegraphic Journal 1/1/79

HEATING METALS IN VACUO BY THE ELECTRIC CURRENT.

A VERY interesting paper, by Mr. T. A. Edison, was read before the American Association at Saratoga the other day:

"In the course of my experiments on electric lighting," says the author, "I have developed some striking phenomena arising from the heating of metals by flames and by the electric current, especially wires of platinum and platinum alloyed with iridium. These experiments are still in progress.

"The first fact observed was that platinum lost weight when heated in a flame of hydrogen, that the metal coloured the flame green, and that these two results continued until the whole of the platinum in contact with the flame had disappeared.

"A platinum wire, twenty-thousandths of an inch in diameter was wound in the form of a spiral one-eighth of an inch in diameter and half an inch in length. The two ends of the spiral were secured to clamping posts, and the whole apparatus was covered with a glass shade. Upon bringing the spiral to incandescence for twenty minutes that part of the globe in line with the sides of the spiral became slightly darkened; in five hours the deposit became so thick that the incandescent spiral could not be seen through the deposit. This film, which was most perfect, consisted of platinum, and I have no doubt but that large plates of glass might be coated economically by placing them on each side of a large sheet of platinum, kept incandescent by the electric current. This loss in weight, together with the deposit upon the glass, presented a very serious obstacle to the use of metallic wires for giving light by incandescence, but this was easily surmounted after the cause was ascertained. I coated the wire forming the spiral with the oxide of magnesium by dusting upon it finely powdered acetate of magnesium. While incandescent the salt was decomposed by the heat, and there remained a strongly adherent coating of the oxide. This spiral so coated was covered with a glass shade and brought to incandescence for several minutes; but instead of a deposit of platinum upon the glass there was a deposit of the oxide of magnesia. From this and other experiments I became convinced that this effect was due to the washing action of the air upon the spiral; that the loss of weight in and the colouration of the hydrogen flame was also due to the wearing away of the surface of the platina by the attrition produced by the impact of the stream of gases upon the highly incandescent surface, and not to volatilisation, as commonly understood.

"I will now describe other and far more important phenomena observed in my experiments.

"If a short length of platinum wire, one-thousandth of an inch in diameter, be held in the flame of a Bunsen burner, at some part it will fuse and a piece of the wire will be bent at an angle by the action of the globule of melted platinum; in some cases there are several globules formed simultaneously, and the wire assumes a zigzag shape.

"With a wire four-thousandths of an inch in diameter this effect does not take place, as the temperature cannot be raised to equal that of the smaller wire owing to the increased radiating surface and mass. After heating, if the wire be examined under a microscope, that part of the surface which has been incandescent will be found covered with innumerable cracks. If the wire be placed between clamping posts, and heated to incandescence for twenty minutes by the passage of an electric current, the cracks will be so enlarged as to be seen with the naked eye, the wire under the microscope presents a shrunken appearance, and is full of deep cracks. If the current is continued for several hours these effects will so increase that the wire will fall to pieces.

"This disintegration has been noticed in platina long subjected to the action of a flame, by Prof. John W. Draper. The failure of the process of lighting invented by the French chemist, Tessié-du-Motay, who raised sheets of platinum to incandescence by introducing them into a hydrogen flame, was due to the rapid disintegration of the metal. I have ascertained the cause of this phenomenon, and have succeeded in eliminating that which produces it, and in doing so have produced a metal in a state hitherto unknown, and which is absolutely stable at a temperature where nearly all substances melt or are consumed, a metal which, although originally soft and pliable, becomes as homogeneous as glass and as rigid as steel. When wound in the form of a spiral it is as springy and elastic when at the most dazzling incandescence as when cold, and cannot be annealed by any process now commonly known.

"For the cause of this shrinking and cracking of the wire is due entirely to the expansion of the air in the mechanical and physical pores of the platinum, and the contraction upon the escape of the air. Platinum as sold in commerce may be compared to sandstone in which the whole is made of a great number of particles with many air spaces. The sandstone upon melting becomes homogeneous and no air spaces exist. With platinum or any metal the air spaces may be eliminated and the metal made homogeneous by a very simple process. This process I will now describe. I had made a large number of platinum spirals, all of the same size and from the same quality of wire; each spiral presented to the air a radiating surface of three and one-sixteenth of an inch; five of these were brought by the electric current up to the melting point, the light was measured by a photometer, and the average light was equal to four standard candles for each spiral just at the melting point. One of the same kind of spirals was placed in the receiver of an air pump and the air exhausted to two millimetres; a weak current was then passed through the wire to warm it slightly for the purpose of assisting the passage of the air from the pores of the metal into the vacuum. The temperature of the wire was gradually augmented at intervals of ten minutes until it became red. The object of slowly increasing the temperature was to allow the air to pass out gradually and not explosively. Afterward the current was increased at

over

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46

intervals of fifteen minutes. Before each increase in the current the wire was allowed to cool, and the contraction and expansion at these high temperatures caused the wire to weld together at the points previously containing air. In one hour and forty minutes this spiral had reached such a temperature without melting that it was giving a light of twenty-five standard candles, whereas it would undoubtedly have melted before it gave a light of five candles had it not been put through the above process. Several more spirals were afterward tried, with the same result. One spiral which had been brought to these high temperatures more slowly gave a light equal to thirty standard candles. In the open air this spiral gave nearly the same light, although it required more current to keep it at the same temperature.

"Upon examination of these spirals, which had passed through the vacuum process, by the aid of a microscope, no cracks were visible; the wire had become as white as silver, and had a polish which could not be given it by any other means. The wire had a smaller diameter than before treatment, and it was exceedingly difficult to melt in the oxyhydrogen flame, as compared with untreated platinum; it was found that it was as hard as the steel wire used in pianos, and that it could not be annealed at any temperature.

"My experiments with many metals treated by this process have proved to my satisfaction, and I have no hesitation in stating, that what is known as annealing of metals to make them soft and pliable is nothing more than the cracking of the metal. In every case where a hard drawn wire had been annealed a powerful microscope revealed myriads of cracks in the metal.

"Since the experiments of which I have just spoken, I have, by the aid of Sprengel mercury pumps, produced higher exhaustions, and have, by consuming five hours in excluding the air from the wire and intermitting the current a great number of times, succeeded in obtaining a light of eight standard candles from a spiral of wire with a total radiating surface of 1-32 of an inch, or a surface about equal to a grain of buckwheat.

"With spirals of this small size which have not passed through the process the average amount of light given out before melting is less than one standard candle. Thus I am enabled by the increased capacity of platinum to withstand high temperatures, to employ small radiating surfaces, and thus reduce the energy required for candle-light. I can now obtain eight separate jets, each giving out an absolutely steady light, and each equal to sixteen standard candles, or a total of one hundred and twenty-eight candles, by the expenditure of thirty thousand foot pounds of energy, or less than one horse-power.

"As a matter of curiosity I have made spirals of other metals, and excluded the air from them in the manner stated. Common iron wire may be made to give a light greater than platinum not heated. The iron becomes as hard as steel and just as elastic. Nickel is far more refractory than iron. Steel wire used in pianos becomes decarbonised, but remains hard and assumes the colour of silver. Aluminium melts only at a white heat."

EDISON'S ELECTRIC LIGHT.

N.Y. Herald Dec 17 1879

The announcement that on Christmas Eve Mr. Edison would throw open his laboratory to the public and light up Menlo Park with his new electric light seems to have been prematurely made. A HERALD reporter yesterday called on the inventor and asked him concerning the proposed exhibition.

"I never announced that I would show the light on Christmas Eve," was his reply.

"But it has been extensively reported that you would," suggested the reporter.

"I cannot help that," said Mr. Edison. "It was without my authority. I made no promise for Christmas. I had intended to give the exhibition on New Year's and will be all ready to give it on that date if the company that controls the light will permit. Since it has gone out of my hands, you must know," he added, "their wishes in the matter are binding on me. However, I don't think there will be any doubt that the public exhibition will be made on New Year's, but certainly not on Christmas. Ample notice will be given, so that all who desire may come and see it."

"Then, your electric light is all complete?" asked the reporter.

"So far as the work on it is concerned, yes," replied Mr. Edison. "It is finished, but, on account of the latest patents, I am compelled to keep the laboratory closed to all visitors until the public exhibition takes place."

Manufacturer & Builder Jan 1880

PERFORATING GLASS WITH THE ELECTRIC SPARK.—If the glass intended for the perforation is very thick, it is customary to imbed one of the electrodes in a mass of melted resin, placed on the surface of the glass. This operation requires heat, and is tedious, not to speak of the trouble of clearing the glass afterward of the resin, so as to see the perforation.

M. Fages, architect, of Narbonne, France, publishes in the French papers an improved method, which consists in the use of a small, simple apparatus that may serve for any number of experiments. It consists, first, of a rectangular disk of hard rubber 5 by 7 inches, and second, a brass wire, of which the point passes through the rubber and comes flush with the other side, and is held in place by friction or a screw-thread. A plate of this size is necessary for a Ruhmkorff coil, or its equivalent, giving sparks 5 inches long; larger machines require larger plates of rubber.

In order to use this instrument, it is placed horizontally upon a support, with the brass wire below; the latter is then connected with the electric machine, while a few drops of olive oil are placed on top over the place where the brass point reaches through the rubber; the glass plate is then laid on top, taking care not to have any air bubbles between the oil, so that the latter entirely fulfills its purpose, which is to isolate the point. (Any other well isolating oil will do as well). Then the other electrode is placed on top of the glass, and the spark passed. If the glass is slightly displaced sideways, it is easy to perforate it in several places close together.

The only condition necessary to observe in this experiment, is that the plate of hard rubber be large enough and perfectly flat, so as to fit well against the glass plate, making it impossible for the spark to fly off on a sideward path.

SUBDIVISION OF ELECTRIC LIGHT.—It is reported from San Francisco, Cal., that the Molera & Cebrian system of subdividing and distributing electric light is a great success. The method consists in the use of a system of lenses and reflecting mirrors; the first make the rays of light parallel, when the mirrors reflect them and conduct them to any desired distance, without weakening them in intensity, except to a very small degree. On reaching the place to be illuminated, the rays of the parallel beam are made divergent by a distributing lens or reflector. It is claimed that in this way the light of a single electric lamp may be distributed and divided through all the rooms of a hotel without any material loss of intensity. The supply of course is also regulated and controlled by reflectors, so that the light in any of the rooms may be increased or diminished at will.

It is evident that this method dispenses with the use of conducting wires, while it is claimed that the total cost of such a method of illumination is less than that required for gas works. We should not be surprised if this method were found to be more practical and economical than the transportation of the electric current through wires, as the sending of a beam of light

on a transatlantic steamer, he wants to rest assured that science has done all it can to make his journey safe.

The above remarks were suggested by the opinion expressed recently at the Iron and Steel Institute in Liverpool, that the tests required at present for steel were too stringent and severe. But it was answered that the traveller would not feel as safe as he does were the tests of steel diminished in severity. Criticism was chiefly directed to the tests applied by the Lloyds and the Admiralty to steel used in ship-building only; but it is probable that if stringency is relaxed in one direction, it will be in all. The argument was that although steel makes a better framework for ships than iron, it will not be employed at present, because it must undergo tests proportionately much more severe than those to which iron is subjected—in other words, the

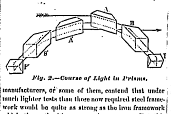


Fig. 2.—Course of Light in Prisms.

manufacturers, or some of them, contend that under much lighter tests than those now required steel framework would be quite as strong as the iron framework which the authorities constantly approve. But this may be an argument against the sufficiency of the iron tests rather than against the stringency of the steel tests.

Whether it is or not, however, Dr. Siemens, than whom no man ought to be more competent to speak on the subject, pointed out a difference between iron and steel which appears to justify the maintenance of the severest tests. Iron, he said, always holds together, except when fractured by a blow under peculiar circumstances; its tendency is to hold together when struck or strained, whether it is of good or poor quality. But this is not the case with all steel. The best steel, it is true, will bend like leather rather than break; but anything inferior to that quality is far more liable to disastrous fracture than iron. Hence, said Dr. Siemens, do not diminish the tests of steel, but rather increase their severity.

Practically, this positive expression of opinion from so high an authority settles the question for the time being. We do not mean that there was no dissension from the views of Dr. Siemens, but none of the steel tests under consideration are likely to be relaxed in opposition to his emphatic advice. As the maintenance of a high standard of excellence in Great Britain is conducive to the maintenance of a like standard in this country, we regard this result with content.

MORNING COURIER

RONDOUT, P. O. THURSDAY, JAN. 8, 1880

HORATIO FOWKS, Editor.

EDISON'S NEW LIGHT.

The little village of Menlo Park, New Jersey, is just now the centre of attraction for scientific men and all those interested in human progress. In it Mr. Thomas A. Edison, one of the youngest and greatest inventors of the age, is toiling sedulously, day and night with an able corps of assistants to perfect a new method of artificial illumination that now bids fair to cast a shadow upon all illuminating devices heretofore known. The eyes of the civilized world are upon him, and the daily achievements of his busy brain, as they are heralded throughout the length and breadth of the earth, along the ocean's bottom, and through the air above, by the same mysterious force and substance which forms the basis of all his experiments, are causing tremors of excitement and wonder in all the arteries of commerce. Until now men of science and great practical experience have declared that the obstacles which Mr. Edison has now overcome were insurmountable; but he holds up his little "carbon loop" and they subside. For forty years inventors and savans have been struggling with this identical problem, and with this same well known principle in view; but success continually eluded their grasp, and they said it was impossible. Mr. Edison now steps to the front with his little "vacuum" almost perfect. The learned gentlemen are skeptical, but they watch his continuously burning lights in breathless anxiety. Mr. Sawyer, a man who has devoted much of his life to the solution of this same problem, sees defects; but the beautiful lights burn on, and Mr. Edison is surprised at the manner and success of his own achievements.

The electric light is not, as many have supposed, a new invention by any means. In fact the main idea now employed in the Edison lamp was used thirty-five years ago, and even in that early stage of its development it created consternation among gas men. Carbons were used in a vacuum, as now, and the light was clear and bright. But owing to many imperfections, not well understood then, those carbons burned up rapidly, and the lamps were practically a failure. Since that time various parties in this and foreign lands have been studying and experimenting to remedy these existing defects, and now for a year past various forms of electric lamps have been in operation in New York, and in other large cities and manufactories throughout the world. Among these experimenters none have labored so diligently and with such untiring zeal as Mr. Edison, especially in late years. Dejected and well nigh broken down in mind and body at times when nothing but failure seemed to impregnate the very atmosphere of his well-appointed laboratory, he toiled on day and night. Ubiquitous reporters sought him out and stuck their enterprising pencils into his half-matured plans. And seventeen months ago the newspapers proclaimed the startling news that Edison had solved the whole problem of electric lighting with his platinum lamp. But Mr. Edison himself knew better and pursued his experiments with redoubled energy. He found he was on the wrong track and encouraging reassertions of the absolute impossibility of success poured in upon him anew from all sides.

While seated one day before a mass of lamp-black and tar, used in his laboratory for the manufacture of his telephones, he rolled some of the material between his fingers and found it could be drawn out into a thread. The idea flashed into his mind of making a carbon thread for his electric lamp burner. And from this simple suggestion has proceeded the carbon resistant lamps that illuminate Menlo Park to-day. One of the most skilled glass-blowers of Europe was summoned to his aid; and with his assistance, together with a complex air-pump, which Edison had modified to suit his purpose, he finally succeeded in producing the most perfect vacuum ever obtained, and sealing it with only a millionth part of the original volume of air left therein, which is so rarefied that when an electric current is passed through it to the carbon loop, the radiant light toward which a world is now looking with anxious eyes is produced. He found his lamp-black carbons still imperfect, however, succeded better with common sewing thread; and finally paper, which proved the very substance wanted, and which is the material forming the burner of every one of those fifty lamps burning in Menlo Park to-day. A slender thread of bristol-board paper, stamped out in the form of a ring about an inch in diameter, and carbonized, is held in a small platinum holder, and tightly sealed in the glass globe or vacuum mentioned above. This is connected with a powerful electric generator, and is the latest form of Mr. Edison's lamp. The entire lamp is four inches long, can readily be removed from fixture, and will cost about twenty-five cents to make. The entire cost of the light cannot yet be definitely stated, but it is claimed to be cheaper than gas, and very much better. The flame being tightly enclosed and neither match nor taper of any kind required to light it, much danger from fires will be averted by the use of this light. Whatever further time and testimony may show Mr. Edison has certainly produced an incandescent electric lamp which will work, and does work; and this no man has ever done before him. Having succeeded, therefore, the lamp and light are strictly his, and still the young inventor keeps at work. All honor to the great scientist.

47

48

have a 20-seconds period, and the invisibility only 15 seconds. The Start and the St. Agnes would then give a flash every 10 seconds, and the Wolf a flash every five seconds, which is the same as Buchan Ness, the Rhynns of Islay, and the little Ross, on the Scottish coast, undoubtedly the three best revolving lights in the world. What an unspeakable improvement this would be to the lighting of the Engish Channel! The triple-flash light of the Royal Sovereign Shoals Lightship is at present very admirable, and to a patient enough observer, with time enough to spare, it is thoroughly distinctive. But the 37 seconds of darkness is a serious defect of that light, and the slowness of the three flashes, occupying the remaining 23 seconds of the period, is an altogether unnecessary derogation from the distinctiveness of character which greater speed would give them. Three short flashes in three or four seconds, with an interval of six seconds of darkness, would have an instantly recognisable rhythm (letter S of the Morse flashing alphabet); and, when once described, the light would be known to be what it is and nothing else, even before the completion of two of its 10-seconds periods.

"Revolving lights are, however, but a small minority of all the lighthouses of the world. Of the 623 lights of the British and Irish coasts, just 110 are revolving lights, and the remaining 513 are fixed, and there is a crying want of distinction for fixed lights. The distinction by colour alone ought to be prohibited for all lighthouse lights, on account of its liability to confusion with ships' and steamers' side-lights. Southsea Castle, with its red and green port and starboard side-lights, seems as if actually planned to lure on to destruction an unsuspecting enemy carefully approaching the coast with Thomas Gray's happy rule well impressed on his mind:

"'Green to green, and red to red,
Perfect safety, go ahead.'

He does so, and is wrecked on Southsea beach.

"My proposal for supplying the want is to distinguish every fixed light by a rapid group of two or three dot-dash eclipses, the shorter, or dot, of about half a second duration, and the dash three times as long as the dot, with intervals of light of about half a second between the eclipses of the group, and of five or six seconds between the groups, so that in no case should the period be more than ten or twelve seconds. This proposal has been carried into effect with perfect success in Holywood Bank Light, Belfast Lough, now the leading light for ships entering the Lough, but which until 1874 was enclosed in a red glass lantern and was only visible five miles, and was constantly liable to be mistaken for a sailing vessel's port-side light entering or leaving the harbour of Belfast, or the crowded anchorage of Whitehouse Roads. In 1874 the red glass was removed, and the light was marked by dot, dot, dash (— — ——, or letter U), repeated every ten or twelve seconds, and has been so ever since. It is now recognised with absolute certainty practically as soon as seen in ordinary weather from the mouth of the Lough, ten miles off, and has proved most serviceable as leading light for ships bound for Belfast or entering the Lough.

"It is much to be desired that the dot-dash system should be seriously considered by the lighthouse authorities of our islands. Hitherto, when attention has been called to it, it has been dismissed with a pleasantry, 'Winking lights won't do,' or else something utterly different has been gravely considered and justly condemned. It is satisfactory now to know that the Deputy Master of the Trinity Board, Sir Richard Collinson, K.C.B., has, after its character was correctly put before him by the recent Select Committee of the House of Commons on Electric Lighting, given it his approval in the concluding answers of his evidence.

"Is it too much to hope that when the new Eddystone Lighthouse is finished the light shall not be, as hitherto, an undistinguished fixed light, but a fixed light distinguished by a group of dot-dash eclipses — such as dot, dash, dot (— —— — letter R)—which is particularly easily distinguished by its rhythmical character; and that the Needles Light, which shows red over a great area of sea south of it, and when undistinguished, as at present, is liable to be inconveniently and even dangerously mistaken for a ship's port-side light, shall have a distinctive dash, dot (—— — or letter N) given to it, which, whether in its red or on its white sectors, will instantly show it to be itself and no other light at sea or on shore? The five years' practical demonstration of the dot-dash system in Belfast Lough ought surely to weigh with the authorities. The introduction of a well-proved remedy for an admitted defect of our lighthouse system should not need that advocacy which moved the unjust judge, and the seafaring world should not suffer the delay in gaining a great benefit which the strict following of that judge's precedent would entail.

"I remain, your obedient servant,

"WILLIAM THOMSON.

"The University, Glasgow."

HOWELL'S BATTERIES.*

Telegraphic Journal

By C. F. HOCKIN.

Dec 15 1879

Having lately tested several of these elements, I think the results may be interesting to some of your readers, particularly as the cell in question is, I believe, a very good one, and has a higher electromotive force than any cell with which I am acquainted.

The plates are zinc and carbon.

A cylindrical glazed porcelain vessel, about $6\frac{1}{2}$ inches high and $5\frac{1}{2}$ inches in diameter, contains a smaller cylinder $6\frac{1}{4}$ inches high and $2\frac{1}{2}$ inches in diameter, of the same material, which is open at both ends and has four longitudinal slots in its walls.

The smaller cylinder stands with its axis vertical in the larger vessel.

In the space between the inner wall of the larger cylinder and the small cylinder (called the separator) is placed first a rod of carbon, on to which is fitted a terminal.

Around this block is a mass of broken carbon and peroxide of manganese, filling the clear space described to within about $1\frac{1}{2}$ inches of the top of the cylinder. On the top of the mass is placed a layer of white manganese or native sulphate of

* An illustrated description of this battery was given in our last number.—Ed. Tel. Jour.

49

D shaped permanent magnet, one pole being made longer than the other and placed uppermost. Below this long pole is fixed a single bobbin electro-magnet having a soft iron core passing through the long pole of the permanent magnet, and magnetised by it, and made in two parts, the lower part being fixed in the bobbin and the upper part capable of being adjusted at any required distance from the other by a screw, shown at the top of the bobbin, carried on a bracket on the long pole of the magnet.

Below the shorter pole of the permanent magnet and also directly below the top electro-magnet is placed another single bobbin electro-magnet, with an iron core capable of being adjusted in regard to its height above the coil by an adjusting screw below. It will thus be seen that the iron cores of the electro-magnets face each other with a space

N Y Tribune

NOVEMBER 6, 1881.—

AN IMPROVEMENT IN ELECTRIC LAMPS.

[BY TELEGRAPH TO THE TRIBUNE.]

CINCINNATI, Nov. 5.—A very clever mechanism is being perfected by two young electricians of this city, W. M. Thomas and L. W. Skinner, to avoid the constant flickering in all electric lamps now in use. The arrangement is entirely automatic, the current itself regulating the distance between the upper and lower carbons. The lower carbon is connected through the frame of the lamp with an insulated wire at the top to the positive pole of the battery. The upper carbon is taken through a coil of insulated wire connected at the top with the negative pole of the battery. On top of the carbon and fastened to it is a piece of soft iron of the same shape, also fitting into the coil. The iron and carbon are nearly balanced by two weights attached to two wheels which run up and down on each side of the coil. When these wheels touch the coil the insulation is taken off and the wheels touching the wire lead off the current from the lower part of the coil and by another wire to the upper carbon. The current only passing through the upper part of the coil attracts the soft iron upward. When the carbon burns slowly away the current is reduced and has less lifting force. The carbon slowly sinks. The wheel and weight also sink. When the carbon again burns away the strength of the current is reduced and the carbon gradually drops. The weights are small metal buckets to be filled with shot according to the strength of the battery. The advantage of the light is not only its steadiness, but the sensitive regulation of the length of the arc, which gives a good soft color to the light and does away with the necessity of ground glass globes. Three patents have already been applied for and allowed, the claim being that by this means the current works automatically. Clutches, glycerine cups, or clockwork are all done away with in this way.

the permanent magnet, as it is magnetised by the line current only when passing.

No reacting spring to raise the vibrating armature is needed, as the permanent magnet magnetising the pole or core of the upper electro-magnet raises the armature directly the line current is off, and this degree of magnetism is regulated as described by having the upper core in two parts adjustable to each other.

If the apparatus is worked on the "double" current system then it can be much more delicately adjusted, as the reversal can be caused to raise the armature to its normal position.

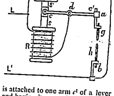
The instrument when adjusted will give a good readable sound when traversed by a current of about 10 milliwebers (1 Daniell cell through 100 ohms resistance).

A small galvanometer is placed in the front of the instrument to indicate whether a current is passing or not, should the instrument fail to work.

SIEMENS' DIFFERENTIAL ELECTRIC LAMP.

The general principle of this lamp is shown by fig. 1: g and h indicate the carbons held respectively in the sockets a and b, and provided with means of feeding as they are consumed. The one

FIG. I.



socket a is attached to one arm c^1 of a lever pivoted at d, and having its opposite arm c connected to a piece of non-magnetic material uniting a pair of iron cores s, s^1. The core s is free to play up and down within a solenoid R, the coil of which is of large wire offering small resistance, and forms part of the lamp circuit. The core s^1 is free to play up and down within a solenoid T having a coil of smaller wire offering greater resistance than the coil of R. The coil of T is in a circuit external to the lamp, that is to say, joining the conductors L, L^1, excluding the carbons. When the solenoid R, being excited, draws in its core s, the points of the carbons are separated; when on the other hand the solenoid T draws in its core s^1 the carbons are caused to approach each other. As the relative force of the two solenoids depends upon the strengths of the currents of electricity passing respectively through their coils, and as this depends upon the relative resistance of their respective circuits, the one circuit

A RIVAL OF THE ELECTRICAL LIGHT.

Aug 1879

An intensified gaslight, by some called the "albo-carbon light," is attracting considerable attention in England at present. Its special advantages are that it economizes the consumption and improves the quality of the gas, and involves no change in mains, meters or piping, or the general apparatus of gas service. It is also claimed by the patentees that albo-carbon causes no obstruction and leaves no residuum; and that the evaporation of the substance under heat is so thorough that vessels in which it is used may be replenished without any fear of accumulating deposits. A variety of interesting photometric tests were recently applied to this light at an exhibition in London; and one of the most pleasing effect produced was that of its hue, which was cheerful and sunny as well as intensely brilliant; and the shadows cast by objects within its range were of a subdued tone quite different from the intense darkness that contrasts so unpleasingly with the moonlight brightness of the electric light, which requires at present for its production elaborate machinery not needed in connection with albo-carbon.

This substance, used as an adjunct to gaslight, imparts to the latter a warm, sustained, and steady light, that does not in spite of its strength, fatigue or discommode the eye. As employed as an auxiliary to common gas, the improved light consists of some properties of pure white carbon in the solid form of small cylinders, having much the appearance of sticks of pure white candy. The apparatus required to adapt the feeder and enricher to an ordinary gas-burner is so simple that it demands a management no more skillful than that needed to fill and trim a common table lamp.

ELECTRIC LIGHT.

Latest Developments in the Science of Illumination.

What Edison Has Been Engaged in Perfecting at Menlo Park.

Illustrations of the Machinery Producing the Light.

The Inventor's Claims as to What It Will Accomplish.

What the Gas Men Have to Say on the Subject.

They Regard the System as Entirely Too Expensive,

And Claim to Prove This Upon Edison's Own Statements.

Why Electricity May Not Supersede Coal Gas.

Mr. Edison has long been busily engaged almost day and night, with a trained corps of able assistants, and with a large factory and laboratory at his service, more than a year, in the task of inventing a practical electric light to supersede gas in houses and rooms, as well as in streets and public halls. Within this time he has invented a number of new and ingenious electric machines and devices—notably a new and more economical electric generator than has ever before been known, which is part of his electric light machinery, several electric motors, a number of forms of lamps, etc., besides several inventions and improvements not pertaining to this subject. He has also made some surprising scientific discoveries, one of the most notable of which is the condensation of platinum and other metals by repeated heating in a vacuum. He has invented new processes for obtaining various chemicals; he has overcome the difficulties of subdividing an electric current, and of regulating its subdivisions and intensity by a simple arrangement at the generator. In all, he has, during this time, made at least fifty or sixty inventions which may prove of great future value. But the attention of the world has been most strongly fixed upon his attempts to create a perfect, or nearly perfect, electric light for ordinary use. He now thinks he has succeeded; and he is daily giving exhibitions to crowds of visitors of his lamp and its accompanying machinery.

Certainly, this lamp and machinery are exceedingly, we may fairly say are marvellously simple. The lamp itself can be manufactured and sold at a cost of twenty-five cents. It contains a loop of charred paper of the kind known as fine bristol board, about as large as a bit of coarse black thread, say two inches long, bent in the form of a horseshoe. These horseshoes are first cut by dies from sheets of bristol board. They are, when cut, the size of a thick and coarse woolen yarn. They are then laid so as not to overlap each other in an iron box with a tight cover. Then a sheet of tissue paper is put over them; and then another layer of horseshoes, and so on. On top of all is a weight of a pure carbon block. The box is then shut, and heated red or white hot in a furnace, till the paper is thoroughly charred, so that it comes out as black as a piece of coal. When cool enough to handle, the horseshoes are carefully taken out, and each perfect one is fixed in minute clamps to the ends of two small platinum wires, set in the base of a lamp. The paper is now frail, and has to be handled delicately; but, after electricity has flowed through it awhile, it becomes so tough that there is no danger of injuring it by any jar, or any handling which the glass of the lamp will stand without breaking. These loops of charred paper, when the electric current flows through them, glow with a mellow and bright light, which neither flickers nor sparkles, but is as steady as sunlight. Each horseshoe is covered by a pear-shaped glass globe, about two inches wide and four inches high. The air is exhausted from this globe by a machine invented by Mr. Edison, and more thoroughly exhausted than has ever before been considered possible. The horseshoes are thus left in a practically perfect vacuum. The platinum wires which go through the bottom of the glass are welded directly to the glass. The glass is of such quality that it expands the same as the wires. Besides, the wires pass first through one thickness of glass, to which they are welded, then, through a vacuum chamber as large as a chestnut, and then through another floor of glass to which they are again welded. In order for air to get in and around the wires it would have to pass through the first thickness of glass, then through the vacuum chamber, and then through another floor of glass. We now present a cut of the lamp, which is so simple as to be easily understood.

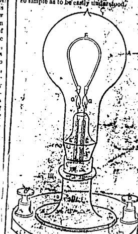


FIG. 1.—EDISON'S COMPLETE ELECTRIC LAMP.

In this figure F is the charred paper horseshoe; A is the glass globe; B is the standard, of wood or metal; D D are the screws for attaching the electric wires; E E are the vacuum chamber, with the wires passing through it; G G are platinum clamps with their fine platinum wires. The current of electricity being turned on, by connecting this lamp with the wires from a generator, the horseshoe carbon immediately glows with light. By simply turning either of the screws, the light ceases, or can be turned down to any desired dimness, or can be turned on again. The light goes just as well under water, upside down, laid on its side, hung up anywhere, or laid down in any position. The cut represents a table lamp. So long as the glass globe remains unbroken, it is all right; but the moment air gets into the globe, the light ceases. It can be carried anywhere in the hand, like a lamp, so long as the two wires are kept fastened to it. Jarring does not affect its steadiness. The glass does not get hot enough to burn your hands. It is, in fact, so perfectly steady, without flicker, or sparkle, or flame, as to be restful to the eyes. Its intensity is regulated at the generator, and never varies. It can be made so bright that the eye cannot look at it; but it really is of just the brightness the customer asks for; and it is kept at just that brightness without change so long as he desires. It will be furnished singly, or in chandelier clusters, with any base, or no base, or in any form, for any position desired. It can be arranged so that each light in a house may be started by itself, when wanted, and all be started at once if desired, so that a person in bed in the night, by simply touching a thumbscrew placed within reach of his hand, can instantly light every room in the house.

We now come to the generator, by means of which the power of the steam engine is converted into electricity, and the current of electricity is regulated. This machine Edison has named in honor of Faraday,

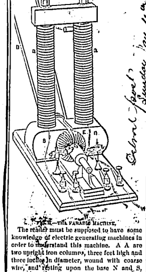


FIG. II.—THE FARADIC MACHINE.

The reader must be supposed to have some knowledge of electric generating machines in order to understand this machine. A A are two upright iron columns, three feet high and three inches in diameter, wound with coarse wire, and resting upon the base N and S, which form its magnetic poles. This part of the apparatus is called the field of force magnet. Fixed on an angle so as to freely revolve between the poles N and S is a cylindrical armature of wood (E), wound parallel to its axis with fine iron wire. When this cylinder or armature is made to revolve rapidly between the magnetic poles N and S, by means of the belt B, driven by an engine (not shown in the cut), there is generated in the wire surrounding the armature (E) strong currents of electricity, which are carried off by the wires W W to the electric lamps.

By constructing this machine in a slightly different form it becomes a motor for running a sewing machine or doing other mechanical work when a current is driven through it from the above machine. One of these motors can be run with the same current which will run a lamp, so that the current can be used to run a sewing machine by day and a lamp by night.

The current is regulated at the generator by turning a small wheel. There is also a remarkably ingenious register to show the amount used by each consumer, just as a gas meter registers the amount of gas burned; but we cannot illustrate these devices, which would be understood only by those having some knowledge of electric science and art.

It must not be taken for granted that Mr. Edison regards this lamp as really perfect. He is still experimenting. He thinks he has hit upon the right system, but he is trying all sorts of forms in place of the horseshoe, all sorts of shaped glasses and different kinds of paper, and he is continually meditating improvements. In fact he can't help, with his inventive genius, constantly thinking of new experiments. His inventive mind never was and never can be entirely satisfied with anything. But he pronounces this light a great success.

Detroit Free Press Sunday Jan 4 1880

What the Gas Men Say.

In connection with the above, it will be interesting to know what the men most interested in the manufacture of gas have to say on the subject of this new alleged rival, how badly they are scared, and what they expect to do about it. One of the most prominent and well-known representatives of the gas manufacturing interests in the city is

MR. WILLIAM H. FITCH

of the Mutual gas company. He talked freely on the subject, and his views are given in full.

"There is a great deal of science in these newspapers, nowadays," Mr. Fitch remarked. "Now, here's two pages with illustrations," picking up a copy of the New York Herald. "Now I am not going to tell you what I think. I will let you figure for yourself. You need not say Fitch said so, once. Here's something about it in the Herald, Edison's own statement: 'Although the plans have not been fully consummated for general illumination, an outline of the probable system to be adopted is the locating of central stations in large cities in such a manner that each station will supply an area of about one-third of a mile. In each station there will be one or two engines of immense power, which will drive several generating machines, each generating machine supplying about 50 lamps.'

"Now you just figure that out for yourself. There are 18 square miles of this city lighted with gas. You see it makes 54 stations necessary. He says it will require two engines at each station; and why? If there is only one the minute the engine stops the section supplied by it is in the dark. So two engines are necessary. But you may calculate on one. I won't calculate it; I want you to;" and the veteran of his calling pushed a pad of paper toward his interrogator. "Just see for yourself. I don't misstate it nor misquote Mr. Edison. Here he says 'engines of immense power.' That you would regard as meaning about the largest made; such as they have up at the water works, for instance. Now these cost $125,000 apiece. Take half the number of engines that he says are required, only one for each station. The engines alone, without real estate, without buildings, without boilers, generating machines, or anything else, will cost $6,750,000. That is a beginning. But all these other things have to be bought. If he needs duplicate engines he needs duplicate batteries of boilers. He must have buildings and generators, and all that, for 54 'plants.' Well, all these will cost at least $15,000,000. But give these little things to him. Concede these trifles for the sake of the argument. At the lowest estimate it will require four men at each station. That is a very small number. That makes 216 men for the generation of the light alone; more than three times as many men as both gas companies employ. I don't see any economy or saving sticking out there.

"In the last place. The fuel required to run all these engines would be twice as much as is now required by both companies for gas making material. The entire amount of money paid by this city for gas to both companies, from public and private parties, suppose it were all clear profit, would not pay 3 per cent. interest on the cost of making Mr. Edison's light, supposing it to be a success in all particulars, just as he claims.

"The only paper outside of this city which I have seen that is sensible on the subject is the St. Louis Globe-Democrat. They have an article in which they speak of Mr. Edison as a fraud; that he deserves to be called so. From the very first, when he has said he has discovered anything, he at once throws out remarks as to the effect it will have on gas stocks. If he was a true scientist, and working for science, he would say nothing about gas stocks.

"You can take these facts, and figure it out for yourself. You needn't figure it out for me at all. Because, although it is true, it would simply invalidate it to a good many people to let them know that Fitch said it, on account of my being connected with the gas company."

"How do you account for the recent fall in gas stocks?"

"That is another thing I will tell you about and you may figure it out. The people I know say the gas stocks are going to blank, and all that. But you see it is in this way. In New York there is a good deal of competition and they are not paying dividends regularly every year. So gas stocks would have declined without Edison. You have noticed that gas stocks in Montreal are lower a dollar or two a share. So they are all over the country, for this simple reason: Fuel will be $2 or $2 50 per ton higher next spring than we have paid for several years, and it is likely to remain so for 5 or 10 years to come. There will be just that much less money made by the companies. You can't reduce the price of gas. That is a difficult thing to do. We have to make $2 or $3 on a ton less, and that is a good deal. This amounts to a good deal more than is indicated by the depreciation of stocks. Gas stocks in England have gone down for very similar reasons. The price of fuel and of labor and everything have gone up. Gas is about the only thing which has not been increased in price; so the dividends paid are necessarily less and must be for years to come. This has been brought about within the last six months and would have happened any way, for this boom in coal has taken place within six months. It has not affected our present contract, because that was made in June. Since the contracts were made coal has gone up from $2 50 to $3 in price per ton. The cost of transportation has more than doubled. I made a fortunate contract, and the company that sells our coal had to pay twice as much for transportation as they had expected, and on the first of November would have gladly paid me $2 a ton not to take the coal."

"You apparently do not feel very much frightened about this new invention."

"Among intelligent people—that is, intelligent on this subject—all these things are taken into account. No doubt there are very many intelligent people on other subjects who would and do get excited about it, and think nothing about the cost of it. I presume some college presidents and others equally well informed might. I notice that some one asked Mr. Edison the other day, at Menlo Park, what it was going to cost him to accomplish this. He said they could furnish the equivalent of eight gas jets like that one up there, per horse power of their engines. Now if you want to compute how many horse power it would take to light your office, and then see how many tons of coal per day it would take, and then compare it with your gas bill, although I have no doubt it is large, you would find the electric light would cost the most, after all the apparatus was paid for. And the same is true of any other building in the city. Here is the whole thing in a nutshell: The fuel that runs the electric generator will make more light in gas than Edison can make with his electric light. It has al-

57

...ways been so, and always will I think, till he can gather electricity out of the atmosphere by an inexpensive method. At present he can't touch gas in any way, shape or manner, if it sells for less than $10 per thousand feet. This I say is true, figuring only from the data he himself furnishes.

"Of course there are people who will take this thing up at once. The wish is father to the thought. People would like to see it done. So would I. If the world can get a cheaper light than gas I will get it, and light the city of Detroit with it. I calculate to stay in the business. I had as soon light the city with electricity as with gas. Whenever I find anything that can be furnished cheaper than gas I am going to get it for the good people of Detroit. I don't propose that anybody else shall get it for them either.

"Of course there would have to be just as many book-keepers and men outside the works as now. The labor in this office, the clerical work, depends on the number of people, not the nature of the article furnished. The thing which is attracting so much attention is the cheapness of the burner, which, he says, he can furnish for 25 cents. That's a mere bagatelle in the cost of the light, and practically does not enter into the consideration at all."

As the reporter withdrew Mr. Fitch remarked, "You see, young man, we are not much afraid of the Edison electric light; not yet."

ALEXANDER LEWIS,

president of the Detroit gas light company, said: "The invention has not yet proved itself practicable to any extent. If it should be, I think the cost would stand against it at all times. We know of nothing yet that will take the place of coal gas, from the fact that it can be manufactured much cheaper than Mr. Edison can run his lamps. I presume it would take at least 50 engines to supply this city. The number of men required to run them would be much greater than at present are necessary. So I don't think the gas people need to dispose of their stock on account of the electric light. Of course the expense of the burner is trifling. The expense of making, the cost of running the whole thing, is what makes the difficulty."

"As between the two, petroleum and electricity, which do you consider the greater enemy to the gas men?"

"I don't think the gas men have either to fear. The convenience and safety of gas make it the most desirable light we have. Of course the electric light would be just as safe as gas; but I do not think it can be brought into such general use as gas. Scientific men have investigated this thing and they say it cannot compete with gas. We do not regard the occupation of the gas men as gone, by any means. Gas companies are not making more than a fair profit, and have not ... years. Gas is furnished as cheap as it can reasonably ... [illegible] ... prospect of its being superseded."

JEROME CROUL,

one of the directors of the Detroit gas company, said: "Mr. Edison and his friends seem very sanguine that they have attained success. If it is such a great benefit to the public, of course we shall have to accept the inevitable. I have had no practical demonstration of it and know nothing of the details of it. It will have to be thoroughly demonstrated before the public will accept of it. At present I regard it as an experiment.

"Gas, like water, does not cost much; it is the getting it to the customers that costs. Water does not cost anything, but the pipes and works do. We have a three million dollar plant here. It is the same way with gas. And Mr. Edison proposes to send his light in the same way through pipes. The wires, I understand, are to be enclosed in gutta percha, and ... in pipes. I can demonstrate the workings of this thing, as it is represented to me by ... McKenzie, Mr. Edison's agent here. They claim to be able to supply the light from any given station for a radius of 3,000 feet. In order to supply the whole city, numerous stations must be established, and when you get 20 or 30 of them, with all the necessary outlay for engines, machinery, fuel and labor, it seems as though the expense must be greater than it is at present.

JACOB S. FARRAND,

another of the directors of the company, said the whole matter hinged on two questions: the practicability and the cost. "Of course," he said, "we do not feel at all sure Mr. Edison has accomplished what he proposes. If the light is better than gas people will buy it. We have all along regarded petroleum as the greatest injury to our business that we have. We see no reason to change our opinion."

G. V. N. LOTHROP

being questioned on the subject, smiled affably and remarked, "I am in my usual good health, sir, and at your service; but I have no opinion to express on the subject of the electric light."

52

The Cost of the Electric Light.—The following particulars of the cost of producing the electric light for factory illumination will be read, says *Engineer*, with considerable interest. The plant consists of one 8-horse power Marshall's engine fitted with automatic expansion gear, two Gramme dynamo machines, two lamps, and one spare lamp. This plant was established one year ago at the pipe foundry of the Stanton Iron Works Company, Limited, near Nottingham, and the following figures show the result of twelve months' working:

	£	s.	d.
Interest and depreciation on £361 10s., first cost at 10 per cent.	36	10	0
Wages of crane tenters attending lamps	15	0	0
Oil waste, repairs to engine, &c. ..	3	12	9
Repairs to machines, cables, &c. ..	1	2	0
" lamps	8	2	6
657½ meters of carbons, at 2s. 2d. per meter	71	4	3
	£131	11	6

The hours booked against the foundry were 3,621 in 302 working days, but the lamps were probably at 4,000 hours; taking the smaller figure the cost is: for the year commencing Oct. 26, 1878 ... for the year ending Oct. 26, 1879 } 4s. 4d. per lamp per hour of 4,000 candles.

[illegible]

THE ELECTRIC LIGHT IN PHOTOGRAPHY.

THE GRAPHIC was the first in this country to use artificial light in photography at night, and it has no difficulty in effecting ... results by its processes. Mr. Clements, formerly in the service of THE GRAPHIC, and now of the firm of Willis & Clements, of No. 17 East Seventeenth street, is not inclined to attach much importance to Mr. Dana's recent exhibition of electric photography, as he believes that after the novelty wears off there will be little or no demand for photographs by this process after nightfall. "A few years ago," he said, "to secure a negative by the old process we had to wait for favorable weather, but such important improvements have been made in the art that now it requires but a few seconds, and almost any kind of weather will answer. The electric light is a valuable auxiliary in photography—particularly in our system which is known as the platinotype. By it we enlarge to life size from photographs of every description, dispensing altogether with the solar camera." The photographic process of Messrs. Willis & Clements is simple and interesting. Their electric light is produced by a Weston Dynamo machine of four-horse power, located in the front office, and connecting by wire with the lantern and camera in a small room in the rear. In this lantern is a condensing lens, in front of which is placed the negative. The light passes through it to the focusing lens, throwing the image on to the disc or screen on which is placed prepared or sensitive paper. Afterwards it is subjected to their process, developing into wonderfully clear and handsome platinotypes.

Mr. Clements said that the system of securing photographs by the electric light was first utilized by a French scientist several years ago, whose system, however, was improved upon by Mr. Vanderweyde, an American, who gave exhibitions in London a year and a half ago. Mr. Dana will not obtain portraits at all comparable with those made during the day unless he diffuses the light so as to give transparency to the shadows; he must also shut off the direct light from the subject, for the glare is more than the average customer can stand.

THE ELECTRIC LIGHT.

[illegible]

MR. EDITOR:—The question is, is the electric light a success? Now I can, as a scientist, satisfy any of your readers right here, that this thing is certainly one thing or the other—a success or not a success. From the roaring accounts given by parties who went to Menlo Park and came back loaded down and boiling over at the brim, I was induced on New Year night to go down to the Electric Depot and make a thorough investigation to satisfy myself as to the marvellous stories told in town, in regard to this tremendous thing. Some of the most enthusiastic advised me to go and investigate, by all means, and never mind the cost, if my finances were shrunk, hypothecate my house, horse, watch or any thing. Well, I hypothecated my jack-knife, realized twenty-five cents, bought a ticket, sat all afternoon in the depot so as to get a good seat in the 7:20 train, p. m., when we sailed out from the depot. I found 160 more blind venturers looking for light. Before we arrived at our destination I was in full possession of all the points of any interest. ... and informed me that a friend of his ... chuck full of the electric light, informed ... that a $100 share was worth $7,000 ... day; would be worth $10,000 in two ... and $100,000 in ten years, he said he ... that his friend was posted and ... earnest, for when he uttered the ... 000 he slammed his fist so hard on the ... ter that the adjoining storekeeper ran out into the street thinking there was an explosion or earthquake near by. I also learned that the Rothschilds had offered $5,000,000 for all Europe, Africa and the state of Maine. Also that Rahway was going to be lit up in two weeks by two lamps placed at the depot, these running in combination with the light God had given us, would give us perpetual daylight from now until doomsday. When we got to Menlo Park there was none of that artificial daylight so much talked about, and we could'nt see to pick up a pin a dark street, any better by the electric light there, than we could by our gas house lightning-bugs here. Like Grant, we saw a great many people, and among them some very bad people, who satisfied us on one point, and that is, if the electric light could not be divided, the electric globes could be, because several of the globes were deposited in the several pockets of three several different persons on that very evening and we are satisfied they were so well divided that they will never get together again. In our ramble through the building we heard several very sensible questions asked that were not answered, such as—"Does Mr. Edison think this is a success?" "Can one of the little globes be attached to a wire clothes-line in the yard and give light?" "Wouldn't these little things bring thunder and lightening in the house?" One sarcastic looking individual said that the latter would not be anything new, as there was plenty of that in some houses now. We would like to have had the pluck to ask if loafers could stop off the lights by laying bars of iron on the wires as effectually as Mr. Edison could, by his regular process. Now, in conclusion, I will say this: if Mr. Edison is not fooling us all the time with gas, instead of electricity, it is all right. Mind, he has gas in there all the time, and some of New York's scientific sons may find out something yet. There is one thing certain and that is, there is such a place as Menlo Park and there is a queer kind of light looming up there.

THE ELECTRIC LIGHT ON WATERLOO BRIDGE.

[illegible] Oct 15 1879

A FURTHER step in the development of the electric light in the metropolis has been effected by the extension of the Jablochkoff system, which has for some time past illuminated the Victoria Embankment, to the lighting of Waterloo Bridge. For this purpose ten lamps had been fitted up with the Jablochkoff electric candle, nine of these being situated on the bridge, and one on the refuge at the Strand end in the middle of the roadway.

In addition there were five Jablochkoff candles fixed in the machinery shed under the Charing-cross railway bridge, thus adding fifteen lights to the forty previously maintained. Fifty-five lights are now sustained by an engine of 20 horse-power nominal, although there were many persons who doubted whether so many as twenty lights could be kept going. Commencing some months ago with twenty, the number of lights was subsequently increased to forty, now to fifty-five, to be soon enlarged to sixty. Three pairs of machines are now at work, each calculated to sustain twenty lights. Preparations are being made to place four lights in the Board-room of the Metropolitan Board at Spring-gardens, and a fifth over the principal entrance to the building.

The effect produced by the lighting up of the bridge is extremely good, and at the Strand end very striking, the illumination of Somerset House being singularly picturesque. Some of the gas lamps on the bridge are necessarily left alight in order to fulfil the terms of an Act of Parliament, which requires that there should be a light at each arch, so as to facilitate the navigation. The absence of these gaslights would have been an advantage to the electric light by allowing the Jablochkoff lamps to present a better *tout ensemble*. But of the practical value of the latter there can be no doubt, whether as to the vehicular as well as the pedestrian traffic over the bridge was evident. The whole of the gas lamps are retained on the bridge, as it is not intended at present to maintain the electric light after midnight, when the four candles contained in each lamp are burned out, which is some little time after midnight. The illuminating power of each of the electric lamps is estimated at 400 sperm candles, subject to a certain percentage of loss consequent on the use of frosted globe. The latter, however, allows a much larger proportion of light to pass through than occurred when the opalescent globes were employed, as in the earlier experiments on the Embankment, the Holborn Viaduct, and elsewhere. A remarkable fact connected with the Embankment trials is the increasing efficiency of the Gramme machines which generate the electricity. There appears to be no doubt that these machines are electrically improved by use, probably owing to the increase in the amount of residual magnetism. Other causes operate in the same direction, as, for instance, the diminished friction of the machinery as the working parts become more adapted to their functions. The Jablochkoff candles have also undergone some improvement. At all events, the encouraging fact is now stated that the engine has lately been maintaining forty lights with an indicated horse-power which is slightly less than that which was formerly required for twenty lights.

The total length of conducting wire now in use for the whole of the Embankment, together with Waterloo Bridge, is 17 miles 361 yards. When the Board-room at Spring-gardens is fitted up, the total length will be about 18½ miles. The lighting of the Embankment by this system commenced on December 13th last year, since which date 28,000 of the Jablochkoff candles have been consumed. M. Berly purposes making some experiments shortly with electric candles of large dimensions, giving lights equal to from 2,000 sperm candles up to 6,000, thus showing that the Jablochkoff system can give a highly concentrated light if desired.

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53

Edison and the Electric Light.—Following up what appeared in our last Saturday's issue with reference to Mr. Edison and the electric light, we insert the following telegram from Philadelphia, which was contained in the *Times* of Monday last:—

Spending Saturday and Saturday night at Menlo-park with Mr. Edison, I thoroughly examined his inventions in electric lighting, comprising four particulars—generator, lamp, meter, and regulator—and providing, in my opinion, a complete substitute for gas. The light produced will be both cheaper and better than gas, being more regular and emitting so little heat that there is no danger of fire. Some of his lights are purposely fixed amid the most inflammable material. I tried igniting paper by them, but the paper remained unscorched. About 60 lights were burning. On Saturday night I saw them burn seven hours. Two have been burning continuously for ten days without injury to the baked cardboard horseshoe in the little glass globe which furnishes the light. Cardboard seems sufficiently durable, successfully resisting quite rough usage, such as dropping, shaking, turning the current on and off thousands of times, and raising the intensity of light to that of 400 candles. All the arrangements are simple. Mr. Edison will put about 800 lights at Menlo-park, while the inventions immediately go into practical operation in New York city. The globe containing the horseshoe is exhausted to one-millionth of an atmosphere by the Sprengel pump, measured by the M'Leod guage. By successfully dividing the electric current Mr. Edison gets individual lamps of 16-candle power, each lamp having 100 ohms resistance. Light is turned on or off, and the current regulated with the same ease as gas is, while the current can be transmitted on wire as small as No. 36. The central regulator maintains an even current, while the meters accurately measure the supply furnished to each consumer. Mr. Edison finds that the best generators are of five to seven horse power, each one-horse power maintaining eight lamps. Each lamp costs about one shilling to manufacture, while a supply equivalent to 10,000ft. of gas can be produced for tenpence or less. Mr. Edison calculates the cost of furnishing light thus—the consumption of 3lb. of coal in a steam engine will maintain eight to ten lamps one hour. Mr. Edison's system also furnishes electric power for small industries such as running sewing machines. Mr. Edison's light is bright, clear, mellow, regular, free from flickering or pulsations, while the observer gets more satisfaction from it than from gas. Mr. Edison lights at Menlo-park dwellings, offices, desks, street lamps, also laboratory and workshop, making it available for every lighting purpose for which gas is used. I ate my supper and wrote a draft of this telegram by Mr. Edison's light last night.

Telegraphic Journal ~~Dec 15~~ 1879

TRIALS OF THE JABLOCHKOFF AND WERDERMANN ELECTRIC LIGHTS IN PARIS.

SOME trials of the Jablochkoff and Werdermann Electric Light systems have recently been made at the French National Opera House, Paris. The experiments took place in the Opera *foyer*, or green-room, in the presence of a large number of persons interested in the result of the trials. The object in view was the comparison of the two systems.

Ten chandeliers were taken for the experiments, four being lighted by each system and the remaining two by gas.

The first experiments were made with the Jablochkoff system, the candles being covered with yellowish coloured glass globes was to cut off as much as possible the violet rays which characterise the light when obtained by the voltaic arc. "The result," says *L'Estafette*, "was to bring out all the defects of the system, as the light continually flickered, changed colour, and produced a disagreeable noise. The Werdermann light, on the contrary, was perfectly steady and quiet in character, but from the absence of glass globes was not quite so warm in tone as its rival. This, however, was an intentional defect, as Mr. Werdermann purposely exposed the light in a naked state so that its natural warmth might be seen; of course, a globe slightly coloured only would tone down the light to the required tint."

As regards steadiness and noiselessness, the Werdermann light unquestionably carried the day. As regards economy, it may be stated that the 12 Werdermann lamps (three for each chandelier) were produced by a steam engine of 6 horse-power, constructed by Hermann-Lachapelle; the 8 Jablochkoff candles (two to each chandelier) were produced by a 12 horse-power Calla engine. The dynamo machine for the Jablochkoff system was turned at a higher velocity than that for the Werdermann system; a difference requisite in consequence of the Jablochkoff candles requiring intensity currents, whereas the Werdermann lamps are worked by quantity currents. This latter fact, although to the advantage of the Werdermann system when the lamps are placed close to the source of power, is a disadvantage when the two elements are distant one from the other, as very thick and expensive conducting wires would be required. Experiments made with the Werdermann light have shown that 5 lights, equal to 25 to 30 gas jets, may be obtained with a 1 horse-power engine.

The outlay incurred by using the Werdermann system is considerably less than that necessitated by the adoption of the Jablochkoff light, and this is no insignificant gain. It remains now for M. Garnier, the architect of the Opera house, to make his report to Government concerning the two systems, and to indicate which, after mature reflection, has the superiority. The result will be looked for with interest.

VOL. XXX.

EDISON'S EFFORTS.

A Detailed History of His Recent Experiments.

HIS NEW ELECTRIC LIGHT.

In What It Differs from Other Lamps—He Claims to Have Surmounted All Difficulties.

The near approach of the first public exhibition of Edison's long-looked-for electric light—announced to take place on New Year's Eve at Menlo Park, on which occasion that place will be illuminated with the new light—has revived public interest in the great inventor's work, and throughout the civilized world scientists and people generally are anxiously awaiting the result. From the beginning of his experiments in electric lighting to the present time Mr. Edison has kept his laboratory guardedly closed, and no authoritative account (except that relative to his first patent, published some months ago in the New York *Herald*) or any of the important steps of his progress have been made public. This course the inventor found absolutely necessary for his own protection. We are, however, now enabled by special enterprise to present to our readers a full and accurate account of his work, from its inception to its completion. Edison's electric light, incredible as it may appear, is produced from a little piece of paper—a tiny strip of paper that a breath would blow away. Through this little strip of paper is passed an electric current, and the result is a bright, beautiful light, like the mellow sunset of an Italian autumn.

"But paper instantly burns, even under the trifling heat of a tallow candle!" exclaims the skeptic; "and how, then, can it withstand the fierce heat of an electric current?" Very true; but Edison makes the little piece of paper more infusible than platinum, more durable than granite; and this involves no complicated process. The paper is merely baked in an oven until all its elements have passed away, except the carbon framework. The latter is then placed in a glass globe, connected with the wires leading to the electricity-producing machine, and the air is exhausted from the globe. Then the apparatus is ready to give out a light that produces no deleterious gases, no smoke, no offensive odors; a light without flame, without danger; requiring no matches to ignite, giving out but little heat, vitiating no air, and free from all flickering; a light that is a little globe of sunshine, a veritable Aladdin's lamp; and this light, the inventor claims, can be produced cheaper than the cheapest oil.

Were it not for the phonograph, the quadruplex telegraph, the telephone and the various other remarkable productions of the great inventor, the world might well hesitate to accept his assurance that such a beneficent result had been obtained; but, as it is, his past achievements in science are sufficient guarantee that his claims are not without foundation, even though for months past the press of Europe and America has teemed with dissertations and expositions from learned scientists ridiculing Edison, and showing that it was impossible for him to achieve that which he had undertaken.

HISTORY OF ELECTRIC LIGHTING.

Before going into a description of Edison's experiments, it may not be uninteresting to briefly review the history of electric lighting in general, pointing out at the same time the leading principles underlying electricity as a medium for illumination. Among its other properties, electricity has that of developing heat. A substance through which an electric current is made to flow, becomes heated to a degree proportioned, first, to the strength of the current, and second, to the size and character of the substance. Substances which readily convey electricity, or, in other words, which offer but little resistance to the passage of the electric current, such as copper, silver or iron, are unsuitable for exhibiting the heating power of electricity, while substances which offer much resistance to the passage of the current, such as platinum or carbon, show this heating power quite strongly. Either of the latter substances becomes heated to incandescence the moment a strong current of electricity is passed through them, which incandescence gives out a beautiful and pleasant light. This method of obtaining light from electricity has been known for many years, and is called the incandescent method. A second method, known as the Voltaic arc method, from Volta, an eminent electrician, is the passing of a powerful electric current between the points of two sticks or rods of carbon, slightly separated from each other. The passage of the current between the two causes an intensely brilliant light, many times more intense than that produced by incandescence. It is estimated to be about one-half the intensity of sunlight on a clear day.

The accompanying illustration shows the form of the Voltaic arc playing between the points of two carbon rods. When carefully studied on a screen—for the brilliancy of the light prevents continued observation by the naked eye—there will be seen hosts of little jets of carbon, constantly passing in the form of an arc between the two carbon points. The problem, then, of utilizing electricity for the purposes of illumination presents two avenues of attack—one by way of the Voltaic arc, or intense light, and the other by way of incandescence, or milder light.

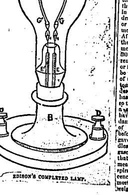
VOLTAIC ARC. Considering first the Voltaic arc system, we find that as early as 1840 it began to attract the attention of inventors. Probably its first use outside of the laboratory and class-room was in the year 1846, when it was employed at the opera in Paris to produce the effects of the rising sun. Its success in this role was so satisfactory that before long enterprising managers had extended its field of usefulness by means of lenses and prisms to the production of luminous fountains, artificial rainbows and lightning. At this period, however, facilities for obtaining steadiness and uniformity of the light were exceedingly crude, and some mechanical device to keep the carbons at the same relative distance from each other was indispensable. The first contrivance, or regulator, as it was called, for this purpose was made in 1845 by Wright of London, and consisted of discs of carbon, having their circumference cut to a V shape, and receiving motion from well-known mechanism. The following year Staite and Edwards in London patented several regulators, the principle underlying them being the inclosing of the carbons in small cases, which made the carbon-points meet obliquely. In 1848, Foucault in France and Petrie in England made further improvements, by which the adjustment of the carbons was made quite reliable. Then followed numerous others, extending to the present time, of more or less perfection. Among them may be mentioned Archereau's, Lacassagne's, Thiers', Serrius', Duboscq's, Farmer's, Brush's, Maxim's and Fuller's. In the year 1876 a new departure in the form of regulators was made by M. Jablochkoff, a Russian engineer, who, instead of placing the carbon rods vertically to each other, placed them side by side, with a thin insulating substance between. In this form, the Voltaic arc playing between the extremities of the carbons gradually consumed them downward, like a flame consumes a candle. Indeed, so analogous was the invention to a candle that it soon became known as the Jablochkoff candle, a name it still bears. The incandescent method of electric lighting was first successfully shown by King in 1845. He placed a rod of carbon in a globe of glass, from which the air had been extracted, and passing a current of electricity through the rod caused it to become heated to such a degree that one could read large print a considerable distance away by the light emitted. His labors, however, were productive of no practical results, and while his theory for producing light was regarded as a pretty one, few were so bold as to predict that it would ever develop into an economical and efficient method of illumination.

THE USE OF NITRO-MURIATIC ACID.

The following year Greene and Staite filed a patent for a lamp analogous to that of King, pointing out that they freed the carbon, before, from impurities, by treating it with nitro-muriatic acid. In 1849 Petrie obtained patents for the same purpose, concerning which he wrote as follows: "A light may be produced by passing an electric current through a short and thin conductor, which heats and becomes luminous, but the majority of substances fuse and burn rapidly. However, I obtain a good light by using iridium or one of its alloys. Iridium may be fused so as to produce an ingot, whilst it is submitted to the heat of the Voltaic arc; afterwards it may be decarbonized and rendered more malleable. It can be cut into small pieces that can be fixed upon two insulated metallic supports, which are in connection with the two wires of a battery. Then there is produced a beautiful light." From this time until 1878 electric lighting by incandescence made little progress, inventors regarding the incandescent method as much inferior to that of the Voltaic arc. In the latter year, however, interest in the incandescent method was a little revived by an invention of M. Lodyguine, who made a lamp that overcame many of the difficulties previously deemed insurmountable. Concerning this invention the report to the Imperial Observatory of Paris said: "The sole inconvenience of the use of carbon instead of platinum consists in the fact that in the combustion the carbon combines with the oxygen of the air, and is thus gradually consumed. M. Lodyguine has avoided this inconvenience by inclosing the carbon heated to whiteness by the electric current in a glass vacuum hermetically sealed, and from the interior of which the oxygen is expelled by a most simple process." But improved as was this arrangement over those that had gone before, practice demonstrated that there were still many serious difficulties it did not meet. Among other things, the carbons presented obscure spots, indicative of non-homogeneity; minute cracks also occurred in the carbon and rapidly disintegrated the same. The vacuum likewise was very imperfect, and there was produced within the glass globe a kind of evaporation, that tended to slowly destroy the carbon rods. The evaporation also left a pulverized deposit of sublime carbon on the inside of the glass globe. Within the past few years various English and American inventors have overcome many of these difficulties, but there still remained enough to render incandescent electric lighting impracticable. While inventors were busy, both on the Voltaic arc and incandescent methods, progress was far from slow on the means for producing or generating the electric current.

PRODUCING ELECTRICITY BY THE ROTATION OF MAGNETS.

At an early day it was evident to experimenters that to produce the Voltaic arc or incandescence with any degree of economy, a different method of generating the electricity than that afforded by the chemical batteries in use was necessary. An important discovery by Ampere in 1820, developed almost simultaneously by Oersted and Arago, and later by Faraday, to the effect that powerful currents of electricity could be produced by the rotation of magnets near each other, opened an opportune field for purposes of electric lighting. Pixii, a manufacturer of physical instruments in Paris, in 1832, was first to practically apply the discovery. He constructed a machine consisting of an electro-magnet and a permanent magnet, with mechanism for revolving one directly in front of the other, which revolution induced strong currents of electricity that could be carried off by wires and made to give light. The invention of Pixii was followed by improvements by Nianel, Holmes, Ladd, Wilde and Siemens, and in late years by Gramme, Fuller, Brush, Holcomb, Maxim and others. The invention of Gramme, owned and used extensively in this country for the Voltaic arc system by the Fuller Electrical Company, involved several important new principles that gave a marked impetus to the system and made possible the production of torrents of electricity at a comparatively small cost.



EDISON'S COMPLETED LAMP.

Edison began his experiments in September, 1878. His self-appointed task was to produce a pure, steady, reliable light from electricity on a scale of cheapness that would enable it to compete with gas for purposes of general illumination. He chose the incandescent system as his field of operations. His experiments with platinum were countless, and involved the invention of many mechanisms to aid the work. For two months he toiled day and night, only to find that as he had been using platinum it was entirely worthless for incandescent lighting. He arrived at the true cause of its defects, and hastened to apply the remedy. "I have found," he writes, "that when wires or sheets of platinum, iridium or other metallic conductors of electricity that fuse at a high temperature are exposed to a high temperature near their melting point in air for several hours by passing a current of electricity through them, and then are allowed to cool, the metal is found to be ruptured, and under the microscope there are revealed myriads of cracks in various directions, many of which reach nearly to the center of the wire. I have also discovered that, contrary to the received notion, platinum or platinum and iridium alloy loses weight when exposed to the heat of a candle; that even heated air causes it to lose weight; that the loss is so great, a hydrogen flame is tinged green. After a time the metal falls to pieces, hence wire or sheets of platinum or platinum and iridium alloy, as now known in commerce, are useless for giving light by incandescence; first, because the loss of weight makes it expensive and unreliable and causes the burner to be rapidly destroyed; second, because its electrical resistance changes by loss in weight, and its light-giving power for the total surface is greatly reduced by the cracks or ruptures."

DISCOVERIES CONCERNING PLATINUM.

"The melting point also is determined by the weakest spot of the metal. By my invention or discovery, I am able to prevent the deterioration of the platinum or its alloys by cutting off or intercepting the atmospheric action. A spiral wire, or other form of platinum, is placed in a glass tube or bulb, with the wire near its ends, passing through and sealed in the glass, and the air is exhausted from the glass. The platinum wires of the spiral are then connected to a magneto-electric machine or battery, the current of which can be controlled by the addition of resistance. Sufficient current is allowed to pass through the wire to bring it to about 150 degrees Fahrenheit. It is then allowed to remain at this temperature for ten or fifteen minutes. While thus heated, both the air and gases confined in the metal are expelled by the heat or withdrawn by the vacuum action. While this air or the gases are passing out of the metal, the mercury-pump is kept continually working. After the expiration of about fifteen minutes, the current passing through the metal is augmented so that its temperature will be about 800 degrees Fahrenheit, and it is allowed to remain at this temperature for another ten or fifteen minutes. The mercury-pump is to be worked continuously, and the temperature of the spiral raised at intervals of ten or fifteen minutes until it attains vivid incandescence, and the glass is contracted where it has passed to the pump and melted together, so that the wire is in a perfect vacuum and in a state heretofore unknown, for it may have its temperature raised to a most dazzling incandescence, emitting a light of twenty-five standard candles, whereas before treatment the same radiating surface gave a light of only about three standard candles. The wires, after being thus freed from gases, are found to have a polish exceeding that of silver, and obtainable by no other means. No cracks can be seen even after the spiral has been raised suddenly to incandescence many times by the current, and the most delicate balance fails to show any loss of weight in the wire, even after it has been burning for many hours. I have further discovered that if an alloy of platinum and iridium, coated with the oxide of magnesia, be subjected to the vacuum process described, a combination takes place between the metal and the oxide, giving the former remarkable properties. With a spiral having a radiating surface of three-sixteenths of an inch, light equal to that given by forty standard candles may be obtained, whereas the same spiral not coated by my process would melt before giving a light of four candles. The effect of the oxide of magnesia is to harden the wire to a surprising extent and render it more refractory. A spiral made of this wire is elastic and springy when at high incandescence. I have found that chemically-pure iron and nickel, drawn in wires and subjected to the vacuum process, may be made to give a light equaling that of platinum in the open air. Carbon sticks also may be freed from air in this manner and be brought to a temperature where the carbon becomes pasty, and on cooling it is homogeneous and hard." About this time another truth dawned on the inventor, namely, that economy in the production of light from incandescence demanded that the incandescent substance offer a very great resistance to the passage of the electric current.

One by one Mr. Edison had overcome the many difficulties that lay in his path. He had brought up platinum as a substance for illumination from a state of comparative worthlessness to one of well-nigh perfection. He had succeeded by a curious combination and improvement in air-pumps in obtaining a vacuum of nearly one-millionth of an atmosphere, and he had perfected a generator or electricity-producing machine (for all the time he had been working at lamps he was also experimenting on magneto-electric machines) that gave out some 90 per cent in electricity of the energy it received from the driving engine. In a word, all the serious obstacles toward the success of incandescent electric lighting he believed had melted away, and there remained but a comparatively few minor details to be arranged before his laboratory was to be thrown open for public inspection, and the light given to the world for better or for worse. There occurred, however, at this juncture a discovery that materially changed the system, and gave a rapid stride toward the perfect electric lamp. Sitting one night in his laboratory, reflecting on some of the unfinished details, Edison began abstractedly rolling between his fingers a piece of compressed lampblack, mixed with tar, for use in his telephone. For several minutes his thoughts continued far away, his fingers meantime mechanically rolling out the little piece of tarred lampblack, until it had become a slender filament. Happening to glance at it, the idea occurred to him that it might give good results as a burner, if made incandescent. A few minutes later the experiment was tried, and, to the inventor's gratification, satisfactory, although not surprising, results were obtained. Further experiments were made with altered forms and composition of the substance, each experiment demonstrating that at last the inventor was upon the right track. A spool of cotton-thread lay on the table in the laboratory.

A MARVELOUS DISCOVERY.

The inventor cut off a small piece, put it in a groove between two clamps of iron, and placed the latter in a furnace. The light obtained from the tarred lampblack had convinced him that filaments of carbon of a texture not previously used in electric lighting were the hidden agents to make a thorough success of incandescent lighting, and it was with this view that he sought to test the carbon remains of a cotton thread. At the expiration of an hour he removed the iron clamps containing the thread from the furnace, and took out the delicate carbon framework of the thread—all that was left of it after its fiery ordeal. This slender filament he placed in a globe and connected it with the wires leading to the machine generating the electric current. Then he extracted the air from the globe and turned on the electricity. Presto! a beautiful light greeted his eyes. He turns on more current, expecting the fragile filament instantly to fuse; but no, the only change is a more brilliant light. He turns on more current, and still more, but the delicate

thread remains entire. Then, with characteristic impetuosity, and marveling at the strength of the little filament, he turns on the full power of his machine and eagerly watches the consequences. For a minute or more the tender thread seems to struggle with the intense heat passing through it—heat that would melt the diamond itself—then it quivers and succumbs and all is darkness. The powerful current had broken it in twain, but not until it had emitted a light of several gas-jets. Eagerly the inventor hastened to examine under the microscope this curious filament, apparently so delicate, but in reality much more infusible, when in a vacuum, than platinum, so long considered one of the most infusible of metals. The microscope showed the surface of the filament to be highly polished, and its parts interwoven with each other; it was also noticed that the filament had obtained a remarkable degree of hardness compared with its fragile character before it was subjected to the action of the electric current. Night and day, with scarcely rest enough to eat a hasty meal or catch a brief repose, the inventor kept up his experiments and from carbonizing pieces of thread he went to splinters of wood, straw paper and many other substances never before thought of for incandescent lighting. The results of his experiments showed that the substance best adapted for carbonization, and the giving out of incandescent light, was paper, preferably thick like card-board, but giving good satisfaction even when very thin. The beautiful character of the illumination and the steadiness, reliability and non-infusibility of the carbon filament, were not the only elements incident to the new discovery that brought joy to the heart of Edison. There was a further element not the less necessary because of its being hidden, the element of a proper and uniform resistance to the passage of the electric current. The inventor's efforts to obtain this element had been by far the most laborious of any in the history of his work, and without it absolute success in electric incandescent illumination could not be predicated, even though all the other necessary preparations were present in the fullest degree.

EDISON'S PERFECTING LAMP.

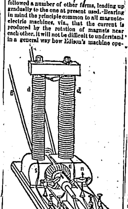
Passing over the scores of experiments made since the discovery that the carbon framework of a little piece of paper or thread was the best known substance for incandescent lighting, we come to consider the way in which the same is prepared at the present time in the Menlo Park laboratory. With a suitable punch there is cut from a piece of "Bristol" card-board a strip of the same, in the form of a miniature horseshoe about two inches in length and one-eighth of an inch in width. A number of these strips are laid flatwise in a wrought-iron mold about the size of the hand, and separated from each other by tissue paper. This mold is then covered and placed in an oven, where it is gradually raised to a temperature of about 600 degrees Fahrenheit. This allows the volatile portions of the paper to pass away. The mold is then placed in a furnace and heated almost to a white heat, after which it is removed and allowed to cool gradually. On opening the mold the charred remains of the little horseshoe card-board are found, and must be taken out with the greatest care, else it will fall to pieces. After being removed from the mold it is placed in a little globe and attached to the wires leading to the generating apparatus. The globe is then connected with an air-pump, and the latter is at once set to work extracting the air. After the air has been extracted the globe is sealed and the lamp is ready for use. The accompanying illustration shows the lamp complete. A is a glass globe from which the air has been extracted, resting on a stand, B. F is the little carbon filament connected by fine platinum wires g 1. g, to the wires E E leading to the screw posts D 1, D, and thence to the generating machine. The current entering at D passes up the wire E to the platinum clamp G, thence through the carbon filament F to G 1, down the wire E 1 to the screw-post D 1, thence to the generating machine. It will be noticed, by reference to the illustration of the complete lamp that it has no complex regulating apparatus, such as characterized the inventor's earlier lamps. All the work Edison has done in regulators was practically wasted, for he had only then realized that they were not at all necessary, no more so than a fifth wheel is to a coach. He finds that the electric current can be regulated with entire reliability at the central station just as the pressure of gas is now regulated. By his system of connecting the wires the extinguishment of certain of the burners affects the others no more than the extinguishment of the same number of gas-burners affects those drawing their supply from the same main. The simplicity of the completed lamp seems certainly to have arrived at the highest point, and Edison asserts that it is scarcely possible to simplify it more. The entire cost of construction is not more than twenty-five cents. The lamp shown in the illustration is a table-lamp. For chandeliers it would consist of only the vacuum globe and the carbon filament attached to the chandelier, and connected to the wires leading to the generating machine in a central station, perhaps half a mile away, the wires being run through the gaspipes, so that, in reality, the only change necessary to turn a gas-jet into an electric lamp, is to run the wires through the gaspipe, take off the jet and screw the electric lamp in the latter's place. Although the plans have not yet been fully consummated for general illumination, the outline of the probable system to be adopted is the locating of a central station in large cities, in such a manner that each station will supply an area of about one-third of a mile. In each station there will be, it is contemplated, one or two engines of immense power, which will drive several generating machines, each generating machine supplying about fifty lamps.

THE GENERATING MACHINE.

Mr. Edison's first experiment in machines for generating the electric current did not meet with success. His primal apparatus was in the form of a large tuning-fork, constructed in such a way that its ends vibrated with great rapidity before the poles of a large magnet. These vibrations could be produced with comparatively little power. Several weeks of practice proved, however, that the machine was not practical, and it was laid aside. Then

SAN FRANCISCO

followed a number of other forms, leading up gradually to the one at present used. Bearing in mind the principle common to all magneto-electric machines, viz., that the current is produced by the rotation of magnets near each other, it will not be difficult to understand in a general way how Edison's machine operates.



THE FARADAY OR GENERATING MACHINE.

The preceding illustration shows the generating or Faraday machine, as Edison terms it, in honor of Faraday, complete. A A are two upright iron columns three feet high and eight inches in diameter, wound with coarse wire, and resting upon the base, N and S, which form its magnetic poles. This part of the apparatus is called the field of force-magnets. Fixed on an axle so as to freely revolve between the poses N and S, is a cylinder armature of wood, E, wound parallel to its axis with fine iron wire. When this cylinder or armature is made to revolve rapidly between the magnetic poses N and S, by means of the belt B, driven by an engine (not shown in the cut), there is generated in the wire surrounding the armature E strong currents of electricity, which are carried off by the wires W W to the electric lamps. The apparatus for measuring the amount of electricity used by each householder is a simple contrivance, consisting of an electrolytic cell, and a small coil of wire appropriately arranged in a box, the latter being about half the size of an ordinary gas meter, and, like a gas meter, it can be placed in any part of the house. The measurement is obtained by the deposit of copper particles on a little plate in the electrolytic cell, such deposit being caused by the electric current passing through the cell. At the end of any period, say one month, the plate is taken by the inspector to the central office, where the copper deposit is weighed, and the amount of electricity consumed determined by a simple calculation. In addition to the various parts of the system above described, there are a number of other details, not so important, to be sure, as those of which sketches have been given, but nevertheless essential to make up the complete plan of economical electrical illumination. A description of these latter will not be attempted, as a proper understanding of them involves a technical knowledge of the laws of electricity. The entire system embraces an amount of work so extensive that one naturally wonders how a single man, in such a brief space of time as fifteen months, could possibly have planned out and perfected it all; and the surprise becomes greater when it is considered that during this period Edison found time to make other inventions. A sextuple telegraph, or apparatus for sending six messages on one telegraph wire in opposite directions simultaneously, saw light during the progress of the electric light, patents for the same having only just been issued.

EDISON'S INVENTION FOR EXTRACTING GOLD FROM "TAILINGS."

Several new and important improvements in his chalk telephone, by which the efficiency of that invention is greatly increased, also attest his industry and versatility of genius. But perhaps the latter quality is more strikingly exhibited in his Polyform, a preparation by which he is enabled to bid defiance to sick headaches, neuralgia and other nervous diseases, and to make himself largely independent of physicians in times of ailment. The Polyform grew out of necessity. Being considerably afflicted with neuralgia and obtaining no relief from his physician, Edison set out to become his own doctor. His chemical laboratory, one of the most complete in the United States, furnished him an ample field from which to draw. Experiment followed experiment, the inventor becoming more determined in proportion as his neuralgia grew more painful. At last he obtained a combination of chemicals, a slight application of which to the face, immediately relieved his pain. Gratified at his success, but hardly yet convinced, he tried the application on others similarly affected, and with equally satisfactory results. About this time there happened to stroll into the laboratory one day a tramp on his periodical begging expedition from place to place. Now this tramp was a particularly unfortunate one, his poverty being hardly more distressing than his physical ailments. One of his legs was swelled with rheumatism, neuralgia coursed along his face, and a dozen or more sores and bruises made him a veritable Job. Edison saw in him a most excellent subject for further polyform experiments. A hearty meal and a little cash readily procured the tramp's consent, and soon the inventor was subjecting his new acquaintance to all sorts of chemical experiments. For more than a week the tramp found food and lodging in Menlo Park, giving in return a few hours of his time every night to be experimented upon. By the time his engagement was over his rheumatism and neuralgia had disappeared and his sores were well-nigh healed. The news of the tramp's good fortune soon spread, and now it is no uncommon thing for neighbors to come to the inventor's laboratory from miles around to request a little polyform, a request which the inventor good naturedly complies with. The very, very latest enterprise of the indefatigable scientist is a scheme for obtaining gold out of "tailings," or the sand thrown away by miners as having been worked out. Rumor has it that Edison has succeeded in obtaining a chemical preparation which will take from $200 to $300 per ton out of "tailings" from which the present processes can obtain nothing. The matter, however, is as yet a profound laboratory secret.

Recent Advances in Electric Lighting.

By J. N. SHOOLBRED, C.E.

THE author said that twelve months ago very little was, comparatively speaking, known of the electric light, whereas now there was no town in England of any magnitude in which experiments had not been made. The progress in the electric light had been very great. The great desideratum was the production of a number of smaller lights of less intensity in place of producing one light only of great intensity, and great progress had been made towards the solution of the difficulty. The question of the relative sanitary effects of the illumination by electricity and also by gas had received considerable attention, and the result had been considerably to the advantage of electric illumination. The author then gave an explanation of the various processes of electric lighting now in vogue, in the course of which attention was drawn to the lamp of M. Heinrich, a description of which we illustrate elsewhere.

PUBLIC LEDGER AND DAILY TRANSCRIPT.

Philadelphia, Monday, Dec. 29, 1879.

MENLO PARK LIGHTED.

Seven hours with Mr. Edison, at Menlo Park, were spent by a representative of the LEDGER on Saturday, and what the latter has to say on the subject of the electric light will be found in another column. It will be remembered by those who keep track of progress in this very interesting matter that when public announcement was made that Mr. Edison had found the right material for his incandescent electric lamp—by using a thread-like loop of charred or carbonized pasteboard—a challenge came from a skeptical expert in electric lighting that Edison could not keep a light going for three hours in a lamp so constructed. How little force there was in that criticism was brought visibly to the notice of our representative, for he saw a number of the new electric lamps burning for a period of seven hours on Saturday. This much he witnessed, and was told, what he had no reason to doubt, that some of them had been in operation for two weeks.

In order to explain the present condition of the effort to use electricity for ordinary purposes as an illuminating agent, we shall have to recall a few points to the memory of the reader. That electricity is convertible into light was known long ago; that it was possible to utilize the light so produced for illumination as a substitute for oil, candles or gas, is a piece of knowledge that dates back more than a generation. But because of many difficulties, this use of electricity has never been brought into practice in a general way, until within a few years. The chief difficulties were these: first, the electric current passing along a wire leading to an electric lamp, was not then divisible so as to feed a number of lamps of the capacity of an ordinary gas jet; but, instead of these, there was one dazzlingly-bright light, far more intense than was needed for a limited space like the interior of a building; second, the light was fitful and uncertain, instead of being steady like a gaslight; third, when any substance was consumed in getting the light, such as the carbon sticks of the "Jablochkoff candle," and other equivalent devices, another element of difficulty was introduced requiring delicate mechanism to overcome, or alternating currents of electricity, or something of the kind; fourth, none of the lights were manageable like gas jets in regard of being turned up or down to regulate the degree of light needed; and, fifth, all of the lights were more expensive, as well as less convenient than gas.

It was to overcome these chief difficulties, and many smaller ones, that Mr. Edison, in common with other ingenious men, set his wits to work. There are three forms in which the electric light has been used experimentally for illuminating purposes: the electric flame itself (or "arc," as it is called), which is produced when the current is forced to leap over a short break in the line of conducting substances; next, the light produced by the electric burning of a substance like carbon, in which the material is actually consumed like a candle or lamp wick; and third, by "incandescence," or by heating some substance to a white heat, as when a rod of iron is thrust into a glowing fire and brought out white hot. Most of the recent work towards getting a practicable electric light for common use has been devoted to the first two of the forms mentioned—the electric arc and the burning candle. Mr. Edison devoted his experiments exclusively to the third—procuring a light by "incandescence," or heating some substance to a glowing white heat. This form got rid of many difficulties inherent in the others; but the problem was to find the substance that would stand the intense heat required without burning, melting, or otherwise disintegrating. He tried nearly every available substance, giving much time to platinum and its alloys with a promising degree of success; but finally settled upon the little strip, or thread rather, of charred pasteboard heated to an intense white heat in an exhausted glass bulb, as described in the account of our representative's visit to Menlo Park. This works so well that the laboratory and workshops at that place are lighted with this form of electric lamp, and several private residences besides. In fact the course of experiment seems to have reached that point where the mere laboratory study of the subject ends, and where the test of time and experience and growth by use begins. Any one may go to Menlo Park of nights this week and see parts of that place lit up by Edison electric lamps—lamps outdoors as well as indoors—lamps of the dimensions needed for household purposes and for street illumination. This is the condition now of Mr. Edison's inventions, which include many other things besides the substance and form of the lamp itself. Crucial tests are now to be applied—the test of time as to durability of the lamp—the test of experience in its manageability in actual use, and the money test, applied to its commercial economy. As to the first there is but little reason to apprehend failure, for the lamp is simple and inexpensive (costing but twenty-five cents), easily removable, and renewable in case of wearing out or breakage by accident. As to the second, something more than has thus far been shown has yet to be done before the lamp can be considered as ready for universal use or as manageable as a gas-light. With regard to the third, or the comparative cheapness of the lamp as compared with a gas-light, Mr. Edison claims that it need not cost more, at the outside, than half the average price of gas in the United States, but this question of cost remains to be demonstrated. Meanwhile, there are the houses and open spaces at Menlo Park actually lighted up, as the substance of the thing hoped for by those tired of the exactions of Gas Trusts and Gas Companies, and these are legion wherever gas is used for the purpose of illumination; and meanwhile, also, it will no longer be in order for theoretical objectors, or the proprietors of "shops over the way," to be firing off their criticisms in the newspapers unless these first go to Menlo Park and see what is actually going on.

Public Ledger Dec 29 1879

EDISON'S ELECTRIC LIGHT.

A VISIT TO MENLO PARK—THE BUILDINGS ILLUMINATED WITH A MELLOW, STEADY LIGHT FROM STRIPS OF CARDBOARD.

MENLO PARK, N. J., Dec. 27, 1879.

MR. EDITOR:—Writing the notes of this letter from Edison's office, by the light of his wonderful electric lamp, I am obliged to pronounce it satisfactory, and fitted at once to take its place as the rival of gas—provided, of course, that it shall prove as cheap, or cheaper, as Mr. Edison declares it to be. The lamp is the most interesting feature of the apparatus employed, so that I shall describe it first, although, in logical sequence, it is the last of the four inventions which make up Edison's system of electric lighting.

EDISON'S LAMP AND THE LIGHT IT GIVES.

In most of the systems of electric lighting heretofore shown to the public, the light has come from the combustion of carbon in the voltaic arc. Two rods of carbon, between which the passage of the current sets up the arc, are gradually consumed, and require special machinery or its equivalent, to maintain the ends or edges of the carbons in the same relative position. The light thus furnished is of very great candle power, from 400 to 2,000 or more, and is objectionable on that account, and entirely unfitted for use in dwellings. Edison has sought from the first to produce his light by incandescence, making either platinum or carbon white-hot, but without combustion, thus making the lamp more or less permanent, and doing away with machinery for regulation. The platinum light was abandoned a few weeks ago for one made of carbon, prepared in a peculiar way, and this carbon lamp is the one now exhibited at Menlo Park with great success.

HOW THE LAMP IS MADE.

A piece of cardboard (Bristol board) is cut in the shape of a horseshoe about two inches high and one and a quarter inches across. The horseshoe is about one thirty-second of an inch wide on its face, and is therefore very delicate looking even before it has been baked. Three of these horseshoes are put in an iron mould in alternate layers of the horseshoe, a sheet of tissue paper and a block of carbon, the object being to keep them flat while they are being baked. The moulds or retorts are first raised to about 300 degrees Fahrenheit over a gas flame to drive the volatile matters from the cardboard, and are then put in a furnace, where they are raised to a white heat, not being removed in fact till the iron box shows signs of being about to melt. They are then allowed to cool gradually, and, on being opened, the charred remains of the horseshoe are found. It has shrunk one-third in size and is now not more than an inch and a half in height, and about the thickness of a coarse horse hair. It is of course very delicate and has to be handled with care, but is not likely to be broken except when an attempt is made to open the horseshoe by separating the two ends. It is then very easily parted, but is reasonably tough when subjected to other movements. This frail piece of carbon, the equivalent, if stretched out, of a piece of horse hair about three inches long, is to furnish Edison's electric light when made white hot by the passage of the electric current. It is mounted in a glass "globe," shaped like the air-chamber of a force pump, and, when in position, the curved sides of the globe or bulb of glass, are almost parallel to the line of the horseshoe. The globe has a neck, through which wires pass, to which the horseshoe is attached by platinum tips. The bottom of the globe is sealed up, with the wires, by a small bell-shaped structure of glass occupying the neck. Sprengel pumps are used to exhaust the air from the globe containing the horseshoe, until McLeod's gauge shows a vacuum of one-millionth of an atmosphere has been reached. The globe having then been sealed, it is ready for use.

WHAT THE LAMP LOOKS LIKE.

As completed, the lamp is nothing more than a glass bulb, probably two and a half inches in diameter, having a neck extension, making the lamp altogether about five or five and a half inches high. Inside of this we see wires leading up from the base, where they terminate in copper tips, to the almost invisible carbon horseshoe which connects them together. To light the lamp the copper strips at the bottom must be connected in some way with the wire on which the main current is passing. Then the electricity will pass up one wire through the carbon horseshoe, and down the other wire, making the carbon horseshoe red or white hot, according to the resistance it may offer. The resistance of most of the lamps in use here to-day was 100 ohms, but experiments are being made with lamps of higher resistance, and some of those exhibited reached 160 ohms. The lamps can be attached to the conducting wires in any position, and used in study lamps, gas

brackets or chandeliers. Sixty or more were burning here to-night, and all of them were satisfactory. In Mr. Edison's parlor there were six, divided between two chandeliers, and they illuminated the room with a beautiful soft, mellow light, absolutely steady and not in the least affected by jarring movements on the floor above. While in Mr. Edison's parlor considerable amusement was afforded by the reading of a published challenge to Mr. Edison to keep his lights burning twenty minutes. As the visitors had then seen the lights continuously burning from two to seven hours with no sign of failure, the challenge, although coming from a professed electrician, appeared very absurd.

THE LAMPS IN USE.

Each lamp gives forth, or is intended to give forth, the light of sixteen standard candles, but owing to the varying resistance of the imperfectly made carbonized cardboard horseshoes now in use, some gave forth more and some less than the standard light. It is Mr. Edison's intention to make the resistance uniform in all the lamps, as soon as he has determined what it shall be, and, with a view to finding this out by experiment, the resistance of each is measured and marked upon it before it is put into use. Mr. Edison desires eventually to have no greater range than five ohms between them. Besides the private houses lighted with electricity, the laboratory and workshop contained a large number, each work bench in the latter place having a separate lamp, by the light of which the men were working far into the night. In front of the other there were two street lamps burning brightly and apparently with more ~~[illegible]~~ than gas, but this could not be very clearly determined on account of the bright moonlight. In the second story of the laboratory, where the lamps are made and the air pumped from them, many experimental lamps could be seen strung along on wires in various positions and all glowing with light. On a long table, probably 40 feet in length, the main conductors were run in parallel lines, and only three or four inches apart. The lamps when completed were brought here and laid between the conducting wires. As soon as the wires of the lamps were connected with the conductors the carbons glowed with a brilliancy proportioned to the resistance they offered. Here, with a dozen or more lamps ranged on the wires, the varying qualities of the light of each could be noted, and here also the best demonstration was given of the complete mastery claimed over the problem of dividing the current. The light of the remaining lamps was not effected in the slightest degree by the removal of one or more from the circuit, Edison's "regulator," hereafter described, compensating for the extinguishment of any number of lights or the introduction of new ones in the circuit. When giving forth the light of one gas jet one sees in the lamp the thin bright line of the horse-shoe, [illegible] it may be viewed with a ring of light reflected in the wire of the enclosing globe. As the light is increased (for experimental purposes) by an increase of current, the rings of light become imperceptible, merging in the general glow of the entire lamp. Mr. Edison undertook to break one of the lamps by putting on more current than he supposed it could bear, but was surprised to find that it successfully resisted the whole current from his generating machine. The single lamp, in this experiment, illuminated the dark laboratory room, which is probably 75 feet long, so that small newspaper type could be read in the furthest corner. It is not intended in practice to run the lamps above the standard of 16 candles, but this experiment showed that the carbon possesses a large margin of endurance against accident arising from an increase of the current beyond its normal strength.

TESTING THE STRENGTH OF THE LAMP.

To test the effect of the frequent heating and cooling to which the lamps will be subjected in practice, a boy was set to work, some time ago, alternately lighting and extinguishing one of the lamps. It has been lighted now nearly 5,00 times, and is "none the worse for wear." To test the liability of the lamps to destruction by accident, one of the globes was at my request dropped a distance of six feet to the hard board floor. This was repeated three or four times, but the glass shade did not break, its arched sides giving it great strength. It was suggested the carbon filament would probably be destroyed by such rough usage, and thereupon one of the finished lamps was dropped upon the floor. As every one expected to see the thread-like piece of carbon break with the shock, the lamp was held only three or four feet from the floor the first time, but as it stood intact the height of fall was increased until it had fallen several times from a height of six feet, and still it remained intact, giving forth a perfect light as soon as it was attached again to the conducting wires. While the lamps were burning the writer tested their ability to withstand jars, pounding on the table on which they stood without doing them any injury, or affecting the steadiness of the light in the slightest degree. As the incandescent carbon is enclosed in a glass bulb, the light is, of course, unaffected by wind. It gives forth comparatively little heat, the glass never becoming as hot as the chimney of a coal oil lamp.

THEORISTS' OBJECTIONS ANSWERED.

The question of the permanency of the lamp can only be settled by lapse of time, but two or three objections of theorists have been made to appear trivial by the experiments carried on thus far. As heretofore stated, one electrician denied absolutely that the lamps could be run for three hours, and challenged Edison to keep them lit for even twenty minutes, and another declared that the carbon would be gradually destroyed and deposited on the sides of the glass globe; also, that the vacuum could not be maintained, air being gradually admitted. The writer saw lamps burning continuously for nine hours, except during the dinner hour, and one hour in the afternoon, when generators were being changed. One of these lamps had been kept burning day and night (except for such interruptions) for two weeks, according to the statements of Mr. Edison and his assistants. I examined this lamp with great care, and found no signs of a disintegration of the carbonized horseshoe, and no trace of deposited carbon on the glass. The vacuum had not been destroyed to any appreciable extent, after two weeks of trial, else the carbon would have been consumed in the heat of the current.

SMALL CONDUCTORS AVAILABLE.

One of the objections to electric lighting has been the alleged great cost of the conductors required for an extensive system. Mr. Edison, to show that very small wires would suffice to carry the current to single lamps, made attachments by means of No. 36 wire, which is probably as fine as a cambric thread, and the current passing through this served to light two lamps. No. 36 copper wire weighs about a quarter of a pound to the mile.

THE LAMPS IN POSITION.

Only temporary fixtures have been prepared for the electric lamps, these being generally made of existing gas fixtures, through which the service wires are run. These are provided with a screw button, with which contact is made or broken, and the light turned on or off. The lamps, as explained before, are complete in themselves. Having been set in the cup in which the gas fixture, whatever its form, terminates, the turning of the button makes or breaks contact. With the rough fixtures now in use, it was not an easy matter to regulate the light, that is, to turn it down without extinguishing it, but there was no difficulty about either lighting the lamp or putting it out. As to that, it was quite as manageable as gas. It is, of course, very desirable that fixtures should be adapted to the uses of the electric light, but this is far from being necessary, as Mr. Upton, the mathematician of Menlo Park, has demonstrated, in his house, which is over thirteen hundred feet—a quarter of a mile from the generator, the lamp in the hallway is suspended by the conducting wire from the ceiling, and hangs what may be called upside down, the globe being below the neck. Attached to the wire and concealing it is a bunch of Pampas grass reaching to the globe. A [illegible] being inserted in its place, [illegible] the library [illegible] a short wire to the side of the [illegible] hanging lamp is [illegible]. There is a similar arrangement in his parlor, the wire in this case being festooned with smilax and artificial flowers, forming a much handsomer chandelier than the most ornate of metal ornaments. In addition to this central light, Mr. Upton has two, in opposite corners of the room, in the cove of the cornice. All of these lamps are lighted or extinguished at will by means of circuit-closing plugs, fastened, within easy reach, in the window frame. We visited Mr. Upton's house after dark, and he invited us to go out in the yard, to see how the wires were brought in from the laboratory. It was quite dark, but that proved no obstacle to our seeing. He brought with him one of the lamps, and, when he reached the wires, he simply hung the lamp to them, thus making the necessary connection, and it was instantly lighted. The wires were carried overhead to the house, and thence passed down into the house by the cellar window, under the floor, and up the walls, wherever necessary they should be carried.

EDISON'S OTHER INVENTIONS.

Although the lamp is a very important part of the system—the result for which every one looks—it would be of no practical value without the apparatus to generate the current, to regulate it and to measure the amount served to each consumer. The generator, the regulator and the meter have also been perfected, and are open to public view.

58

THE GENERATOR

is a dynamo-electric machine, not differing in essential features from others now in use, but still having points of difference which are said to make it much more efficient. Although the armature which revolves between the poles of a magnet is no larger than that of a Gramme machine, the magnet is very much larger and heavier, and this gives it a much different appearance from the Gramme or the Brush machines. The upright iron columns of the magnet are three feet high and eight inches in diameter, and each is wound with sixty-five pounds of coarse copper wire. The columns are united at the top by a heavy piece of iron weighing several hundred pounds and stand upon other equally heavy pieces forming the poles between which in the magnetic field the armature revolves. This armature is made of wood covered with fine wire wound parallel to its axes. The armature is revolved rapidly by steam power between the magnetic poles, and there is thus set up in the coil of wire surrounding the armature a uniform and constant current of electricity, which is carried off for use in lamps, (or motors) by wire brushes connected with the "distributing main" or wire. Mr. Edison's generator does not appear to differ materially from other dynamo-electric machines except in the great weight of the magnets and the fact that they are charged from a separate machine. When a central office having forty or more generating machines has been established, one will be used exclusively for charging the magnets of the others.

THE ELECTRIC MOTOR.

Intimately connected with this generator is the domestic motor, which is simply the generator reversed, the electric current being here converted into motion instead of motion into electricity. For convenience, the magnet of the motor is placed horizontally on the [illegible] and instead of vertically as in the generator. The resistance of the wire enclosing the magnet is made equal to that of one of the lamps, so that the use of the motor involves the consumption of no more electricity than is required for a lamp equivalent to a gas jet. In Mr. Edison's office there was a sewing machine attached to one of the domestic motors, the latter being placed in a box about eighteen by thirty inches and [illegible] inches high, behind the machine. When removed an electric lamp from its socket in a table stand and inserted a wooden plug of similar shape carrying the wires of the motor. This established the connection, and the sewing machine started to run at full speed, which, however, could be delicately regulated by a brake. [illegible] substitution of the lamp for the motor [illegible] wires instantly changed the manifestation of electric force from motion to light. [illegible] again illustrate the divisibility of the [illegible] Mr. Edison attached the wires of [illegible] leading to the lamp, and [illegible] when we had the light and the work of the sewing machine at the same time. Another of these motors, said to be equivalent to a single lamp, is employed in the workshop to run a force pump.

THE REGULATOR.

This is intended to regulate the amount of current delivered to the lamps, so as to keep them at a constant degree of illumination. There is a galvanometer which indicates by a point of light on a graduated scale the amount of resistance offered. A certain point is taken as the standard at which resistance shall be maintained. As consumers turn on the electric light the man having charge of the regulator, by turning a wheel, compensates for the gain or loss of resistance by taking off or putting on resistance in the form of resistance coils. These are simply long coils or bobbins of wire, offering a known amount of resistance to the passage of the current. They are or may be put in circuit, and the resistance will vary according to the number and size of the coils through which the current passes. When he turns his wheel, which [illegible] the central office [illegible] point of light moves on the scale, he simply increases or decreases the length of the circuit and brings the point of light back to its standard and so compensates for variations in the amount of electricity being used in the lamps. The galvanometer, with its point of light on a scale, serves a similar purpose to the piece of lead on the bellows of a church organ, indicating to him the rise and fall of resistances.

THE METER

is important to the company furnishing the electric light, that an accurate record may be kept of the amount of electricity consumed. It is very ingeniously constructed. One five-hundredth part of the electricity ~~carried over the service wire of a house passes~~ into an electrolytic cell, where it is set to work depositing copper on a plate. At the end of the month or quarter, when a bill is to be made out, the plate on which the copper has been deposited is taken out and a new one put in its place, the old plate being returned to the office, where it is weighed to ascertain the amount of copper deposited during the term. One gramme of copper deposited is to represent and be the equivalent of 1000 cubic feet of gas consumed, and when that much is deposited on the plate, it will show that electricity equivalent to 500,000 cubic feet of gas has passed into the house. No one yet knows what the charges are likely to be per gramme or milligramme of copper deposited.

ESTIMATES OF COST.

Mr. Edison says that estimates have been made of the cost of the electric light, which is far below that of gas, but these estimates are the property of the Electric Light Company, and he does not feel at liberty to make them public. The idea that experiments are conducted at Menlo Park haphazard, without regard to cost is a very erroneous one. By correspondence and an exhaustive examination of reports and statistics, there has been collected a vast amount of information about the cost of making gas in different cities, and also the cost of horse power from large engines in manufactories here and in England. These figures and estimates have been tabulated by Mr. Upton, so that comparisons can be made as to the relative cost of gas and electric lighting. The statistics regarding the manufacture of gas in Paris, where the cost of making a thousand cubic feet of gas is comparatively small, are said to be very complete, enabling Mr. Upton to ascertain all the elements, and prove the results. While expressing his admiration for the fullness of these returns, Mr. Edison incidentally mentioned that he had a report of the Philadelphia Gas Trust, but could make nothing out of it. He doubtless felt comforted when told that in that respect at least he resembled his Philadelphia visitors. Mr. Edison's argument to show, without committing himself to figures, that the electric light can be furnished more cheaply than gas is this:

The plant does not cost more than half that of gas works. The depreciation is less than half that of the plant of gas works. One pound of coal produces one standard gas jet, one hour, while Mr. Edison claims that three pounds of coal will maintain eight electric lights one hour, each light being equal to a single gas jet.

Another statement made by one of Mr. Edison's assistants is that the equivalent of 1000 cubic feet of gas can be furnished "for less than fifty cents and pay ten per cent. interest on the plant."

Another statement is this:—It is found economical to work generators requiring from five to seven horse-power to drive them, and to take from them about eight lamps per horse-power. A calculation based on this statement (but not by Mr. Edison) would make the cost *of power alone* equivalent to from 12 to 15 cents per 1000 cubic feet of gas. The cost of horse-power seems, however, to be an unknown quantity. Statistics as to this have been collected by Mr. Edison, and much stress is laid by his assistants on a return from a large cotton mill in Manchester, England, where the cost per horse power per hour is said to be only half a cent. Estimates from large manufactories in this country have been made (some of them for the LEDGER), where the cost appears to be as high as 2¼ cents per hour per horse power. On this depends much of the cost of the electric light, but supposing the other statements to be true, and the power to cost the higher sum (2¼ cents), the power to produce light equivalent to that furnished by 1000 cubic feet of gas would cost 30 cents.

As to these matters it should be remembered, however, that I have only such information as was given to me by Mr. Edison and his assistants. There is no difficulty in the way of ascertaining the exact cost, and doubtless capitalists before they organize electric light companies, will have records kept of the amount of coal consumed, cost of attendance, &c., which alone can give reliable data. The rough calculations here made are only intended to show, that, if the statement is true, that eight lamps can be maintained for one horse power, the claim as to the relative cheapness of the electric light is not unreasonable.

One other thing must be remembered as helping to cheapen the cost. Interest on plant goes on night and day, whether the plant is earning money or not, but the general introduction of the electric motor, which is expected to be coincident with that of the electric light, would enable the plant to earn money day and night.

THE PLANT.

The engine, generators and conducting wires will represent the chief cost of the plant. The generators are to be made as cheaply as possible, without extra finish, and, although necessarily costly, will be sold "at a much less price than that now charged for dynamo electric machines." An experiment, described above, shows that the conducting wires need not be very large. These facts are the basis of the claim that the plant will cost only half that of gas works. As to the cost of maintenance being less, that is probably based on the fact that the most costly parts of the generators are not subject to much wear and tear. The lamps can certainly be made for twenty-five cents each, although the platinum clips alone cost 8 cents.

PLANS FOR THE FUTURE.

Mr. Edison is now building six new generators, one of which was completed and set at work on Saturday, taking the place of an earlier one that was not doing satisfactory work. About twenty-five lamps are made daily, and these are put in use as soon as completed. It is Mr. Edison's expressed intention to put his generators and lamps at work as soon as they are completed, until he has probably 800 lamps burning night and day in Menlo Park. If the lamps burn continuously for a month without accident, Mr. Edison thinks they will have seen the service required of them in six months of average use. They will then be tested to see whether the carbon horseshoes have undergone any change in resistance, and if not, he will feel satisfied that they can be made to last for years. As heretofore stated, one of the lamps has been burning almost continuously for two weeks. This alone represents probably two months' of average use. Work is carried on night and day at the laboratory and workshop, the greater part of the work being done at night, the only time when the laboratory and workshops are free from visitors. It is said that before spring an office will be opened near Madison Square, New York, and the houses in that vicinity lighted with electricity to demonstrate in practice the value of the new system. The Electric Light Company expects to sell rights in the principal cities, and will institute this experiment to demonstrate the practicability of the invention. It is also reported that prior to that demonstration a room in New York will be lighted from the generators at Menlo Park, twenty-four miles away, the current being carried over a Western Union wire.

MENLO PARK AND MR. EDISON.

I have written so much about the electric light that I can spare only a few words for a subject of interest only inferior to that—Menlo Park and its proprietor. Mr. Henry H. Bentley, the electrician, of this city, and a warm friend of Edison's, escorted the representatives of the LEDGER and London *Times* to Menlo Park, and it was through his assistance that we were enabled to make a thorough examination of everything about the place. Menlo Park is a few miles above New Brunswick, on the Pennsylvania Railroad line to New York. It exists only because of Edison's home and workshops being there. The buildings comprise seven workshops, &c., some of them very large, three handsome dwellings, belonging to Mr. Edison and his assistants, and a few smaller ones, occupied by workmen. What is known as the laboratory is a very large two-story frame building, and, with the brick workshop, engine house, &c., constitutes the establishment. In front of these is the office, a two-story building, the second floor being Edison's private office and library. I glanced over the books on the shelves, and found them to be works on electricity in all languages—probably 500 volumes or more, and some of them very costly. In this office Edison very frequently sleeps on a lounge instead of going home to bed. He was asleep here when we arrived, at half-past eleven Saturday morning, having worked all night and laid down to rest in his clothes after reading the morning papers from New York. When we returned to his office in the afternoon, a servant was clearing away the remains of his lunch, eaten between the calls of visitors. He was kept very busy during the afternoon between visitors and the superintendence of work on his new generator, then being put together, and when in the evening he took us to his home to show the electric light there, his wife remarked that she had not seen him since the morning before, and yet, during all that time, he had not been more than a stone's throw away from home. He is quite as careless of his personal appearance and of his diet as he has been reported to be, but wins and keeps the respect of every man whom he meets by his marked good humor, his earnestness and

59

his keen good sense. When he is listening to any one his partial deafness increases the naturally thoughtful appearance of his strongly-marked face, and he then looks much older than he is. But when he smiles, as he does very frequently, for he is fond of fun, his cleanly-shaven face looks like that of a boy. He is wonderfully well informed, and answers a question involving formulas and mental calculations instantly and with great clearness, provided it relates to anything electrical.

His thirty-five or more workmen and especially his assistants, who are brought into closer relationship with him, are evidently fond of him personally and standing in his workshop directing or talking to either men or boys he appears like one of them. His carelessness as to appearance extends into his workshop, where there is evidently little attention paid to outward looks. A splendid binocular microscope, worth several hundred dollars, standing on a window ledge, had its lenses in good condition, but the polished brass surfaces had disappeared.

The habits of the master in respect to working hours rule many of the men. Nearly all the work is done at night, and at midnight hot suppers are served in the second story of the laboratory building. Here there is an organ, with other musical instruments, a rifle gallery, &c., with which the men can while away an hour or more of midnight rest. So many strangers visit Menlo Park that it has been found necessary to establish a restaurant, which does a flourishing business with reporters and others.

Mr. Edison's chief assistant, Mr. Batchelor, is a mechanic of great ability, who has done most excellent work in carrying on experiments and perfecting inventions. Mr. Upton is the mathematician, who makes all the theoretical calculations, and ascertains by formulas and electrical laws the "reason why" of failures and successes. All work together harmoniously, and Mr. Edison does not fail to give praise and substantial interest in his inventions to those who aid him.

Immense sums of money are expended for experiments alone, much of the material required being very costly. The pay roll of the workmen now amounts to about $800 per week. In the workshops, however, a few of the men are employed exclusively in making Edison's chemical telephone, some of them on an order from the London *Times* office.

The workshops and laboratory at Menlo Park appear to be entirely open now to the public, Mr. Edison having extended a general invitation to any scientist, who desires to make an investigation of his lamps and generating apparatus, to come to Menlo Park and examine for himself. The electric light cannot, therefore, be classed with such inventions as the Keely motor.

A. R. H.

60

ON FLAMES AND THE VOLTAIC ARC.

Eng Mechanic Dec 12/1879

THE thermal absorbent and emissive power of flames and the temperature of the voltaic arc have been recently a subject of numerous experiments by M. Rosetti. His conclusions are given in a letter to M. Cornu, and are as follows:—

1. The transparence of flames is very great: hence they exert very small absorption on thermal radiations which traverse them. If the radiation be from a flame of the same nature, and if the flame traversed have a thi[ckne]ss of 0·01m., the co-efficients of transpare[nce] and absorption are represented respectively [b]y the numbers 0·865 and 0·135, and this b[e] in the case of white flames of ordinary lightin[g ga]s and the pale blue flame of Bunsen burner[s].

2. The transparence diminishes and the absorption increases proportionally if the thickness of the flames be increased. If a flame be of infinite thickness it is athermanous; that is, it absorbs all the thermal rays coming from a flame of the same nature; the transparence is *nil*, the absorption equal to unity. These limits are, however, nearly attained with finite thicknesses, which are not very great either. One metre of thickness already suffices to render a flame almost completely athermanous for rays from another flame of the same nature.

3. The formula $y = a \dfrac{1 - k^{\epsilon}}{- \log k k}$ represents very well the intensity of the thermal radiation emitted by flames of any thickness ϵ, the coefficient of transparence being $k = 0{\cdot}865$, the thickness ϵ being expressed in centimetres, and a being a constant quantity, the value of which depends on the nature of the flame.

4. The absolute thermal emissive power of *white* flames produced by ordinary lighting gas (that is to say, the intensity of radiation of a flame of this nature having an infinite thickness compared with the intensity of radiation emitted by soot at a temperature equal to the mean temperature of the flame) is equal to *unity*. The absolute thermal emissive power of the *pale blue* flames of Bunsen burners is represented by the fraction 0·3219, that is to say, it is nearly *the third* of the emissive power of white flames of coal-gas.

5. The *relative* emissive power of a flame of given thickness may be obtained by multiplying the ratio between the intensity of its radiation and the *maximum* intensity (intensity of radiation of the same flame if its thickness were infinite) by the number which represents the absolute thermal emissive power of this kind of flame. A pale blue Bunsen flame of 0·004m. thickness has its thermal emissive power expressed by the number 0·01744, that is to say, that soot raised t[o] the same temperature gives a thermal radiation the intensity of which is $\dfrac{1}{0{\cdot}01744} = 57{\cdot}73$ wit[h] reference to that of the flame.

6. The electric light comprises, it is know[n], two kinds of radiations, viz., rays emitted by th[e] incandescent carbon, and rays emitted by the vol[taic] arc between the carbons. The former give [a] white light, the latter a blue-purple light; th[e] resultant light is bluish white.

7. The two polar extremities of the carbon[s] have temperatures very different. The number o[f] degrees which expresses their temperature may b[e] deduced from the formula $y = m T^2 (T - \theta) - \ldots (T - \theta)$, supposing the carbons have the *maximu[m]* emissive power.

8. The voltaic arc has a very small therma[l] emissive power comparable to the emissive pow[er] of the pale blue flame of the Bunsen burners. The temperature of the voltaic arc may also b[e] obtained by means of the preceding formula, i[f] there be introduced into this the value of th[e] thermal emissive power of the voltaic arc relative to its thickness.

9. A large number of experiments have given, for the positive polar extremity of the carbon, the *maximum* temperature of about 3900° C; for the negative polar extremity, the temperature of about 3150° C. For the voltaic arc between these extremities the temperature has always been found about 4800°, whatever the thickness of the arc and the intensity of the current.

EDISON'S CAT.

Evening Bulletin Phila Jan 7 1880

The world has learned to have great dea[l] of faith in Edison. He may not always [suc]ceed in reaching the ends he aims at, [but] he has succeeded in doing some things which seemed preposterous when they were proposed; and when he says he is going to do a certain thing everybody believes him. That is, everybody but the scientists. The quality in which scientists are lacking is faith. As soon as Edison invents anything and puts it into practical operation the scientists invariably come forward wi[th] ...atical, chemical and philosophical demonstrations that that particular contrivance is a practical impossibility. The demonstrations are always lucid and conclusive; and they would be convincing if Edison did not persist, in a peculiarly offensive manner, in permitting the invention to do its work regularly and effectively just as if there were n[o] argumentative scient[ists] anywhere abou[t]. We have no doubt at all that he will behave in precisely the same manner when his new machine for the utilization of cats is fully developed and placed in operation. This promises to be one of the greatest of the many boons that he has conferred on mankind. The field in which he has been exploring has been examined many times before. More than one other fruitful and ingenious mind has attempted to solve the problem of the profitable employment of cats; but nothing has been achieved beyond the occasional construction of veal pies and the use of the fur for the manufacture of Siberian squirrel muffs. Mr. Edison, in investigating the matter, not unnaturally had his attention directed to the cat as in a certain sense a source of electrical power; his mind reverting to the days of his childhood when he produced brilliant electrical coruscations from the spinal column of the household cat by a simple process of friction. The thought occurred to him that this electrical element in the cat might possibly be adapted and controlled in some manner to the benefit of man.

While he was perfecting his electric light, therefore, he concluded to try to ascertain whether the introduction of a cat into the circuit would in any manner contribute to the luminosity of the effulgence, if we may be allowed to strain after an expression. Accordingly Edison procured a cat of unusual size and ferocity and affixed the wires to it, using as electrodes one of its fore paws and one of its hind paws. Then he turned on the current. The rumor wh[ich] c[irc]ulated about Menlo Park for a day or two afterwards, that a murder had been committed, when traced to its source proved to have been merely the result of a wild wail of anguish which was heard by the people o[f] the place at the instant the circuit was completed. The cat was endeavoring to express its view of Edison's proceeding. But Edison had his eye upon the light and he was overjoyed to observe that whereas it used to have a power of one hundred and twenty candles, the presence of the cat had intensified it to a power of one hundred and seventy candles and nine students' lamps. Stimulated by the success of this experiment, he procured seven other cats and strung them together with copper wire. When the current was turned on the people of Menlo Park, frenzied with the thought that a tragedy of a bloody nature was being enacted, rushed out with shotguns. But Edison calmly obs[erved] his carbon-horse-shoe in the exhausted receiver and perceived that the power of the light had been increased an incalculable number of times. While he was explaining to a friend that the power could be accurately calculated and defined by multiplying the distance by the square of the cats, or the cats by the square of the distance, or in some such manner, he inadvertently laid his hand upon the back of the largest cat. Instantly the light was extinguished, Edison's hand was badly injured and the cats, breaking from the circuit, fled through the windows.

There is an uncertainty as to whether the laceration of his hand was caused by an electrical discha[r]ge or by the claws of an infuriated animal; but the question of the utilization of cats was solved. Give Archimedes a fulcrum and he would move the world. Give Edison cats enough and he will reduce the Sun to a spot of blackness in the sky. And so, unless the Woman's Branch of the Society for the Protection of Animals from the Cruelty of Inhuman Persons who subject them to Torture under Pretense of making Scientific Investigation and of enlarging the general Sphere of Human Knowledge, shall interfere, there can be little doubt that, sooner or later, the harmless necessary cat, in every household, will soon be wired up, when the gloaming comes, and compelled to supply illumination to the family circle. This is Edison's last, best gift to man. The cat, instead of spending its evenings lawlessly and vociferously, poised upon the summit of the midnight fence, will beam lustrously in the sitting-room, flood the h[a]ll with radiance and make the dismal recesses of the kitchen bright with a noonday glory. Edison, no doubt, is the most extra[ordin]ary man now on earth.

61

Telegraphic Journal

ELPHINSTONE AND VINCENT'S DYNAMO-ELECTRIC MACHINE.

Dec 1 1879

THE object of this invention is to obtain electric currents with a less expenditure of motive force than has hitherto been required in working dynamo-electric and magneto-electric machines. To this end an arrangement of rotating coils is employed, so applied as to cut the lines of magnetic force, and thereby induce in the coils powerful currents of electricity, which may be used as intensity or as quantity currents.

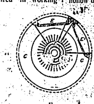


FIG. 3

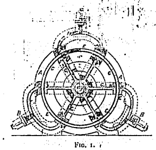


FIG. 1.

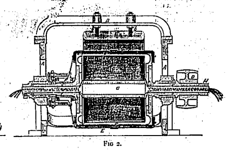


FIG 2.

Fig. 1 is a transverse vertical sectional view; and Fig. 2, a longitudinal vertical section taken through the centre of the machine. In these Figs., A, A, are two standards connected together by the bridges B, B, B, so as to form the framing of the machine. Mounted in bearings in the standards A, A, is a hollow drum C, made of brass or some other non-magnetic material, and provided with hollow journals c, c, which project from the closed ends of the drum. Upon one of these journals, and external of the framing, is keyed a driving pulley D. On the outer periphery of this drum any suitable number of coils of insulated copper wire E, E, is placed.

The method of laying the coils will be better understood by referring to Fig. 3, which represents an end view of the drum and commutator detached, and with two coils placed on it. The wires forming these coils are laid parallel with the axis of the drum from end to end, and over the ends or heads of it, E representing the end of one coil, and E¹ the end of another coil, the free ends of each coil being connected with a commutator F.

By this mode of forming the armature coils, a large proportion of the wire is rendered efficient, and the amount of useless internal resistance is consequently reduced.

Mounted upon a dead shaft G, which passes through the hollow journals of the drum C, is an electro-magnet G¹. This magnet is formed of pairs of radial plates of soft iron, which stand out from the central axis, and are each wound around with insulated copper wire from end to end, as shown in the Fig., and in such a manner as to ensure that upon the passage of a current of electricity through the wire, their outer extremities will become alternately of north and south polarity, as indicated by the letters N and S (which mode of winding is well understood by electricians). The terminals of these wires are brought out through grooves or holes formed longitudinally through or upon the ends of the shaft G, which is kept from rotating with the drum C by means of the bridge piece H, to which it is secured by set screws or otherwise.

Outside the drum C, and in close proximity to it, are placed three electro-magnets I, I, I. These magnets are secured to the bridge B, B, of the main frame by the bolts and nuts b, b, by which they can be adjusted, and they are so placed with respect to the radial plates of the magnet G¹ that their poles are opposed to the poles of the magnet G¹.

The magnets I, I, I, are wound with insulated wire in such a direction that upon the passage of the current their poles will be in opposition to the poles of the magnet G¹, as indicated by the letters N, S. The commutator F is formed of thin plates of metal placed radially around the hollow journal of the drum C, and insulated from each other and from the journal by vulcanite or other suitable material. The brushes for collecting the induced currents are carried by a ring K, secured to the main frame of the machine, but insulated from it; they do not possess any special feature above those ordinarily employed for such purposes.

62

The Times
Sat Jany 10th 1880

THE WONDERS OF LIGHT.—Last night Mr. W. H. Preece, Electrician to the General Post Office, followed up the former of his two lectures to young people, under the auspices of the Society of Arts, which was on "Recent Wonders of Sound," by the second, entitled "Recent Wonders of Light." Lord Alfred Churchill, Chairman of the Council, presided. Mr. Preece began by pointing out the analogies and differences between sound and light. Like sound, light varied in pitch, intensity, and quality. But the velocity of light, no less than 180,000 miles a second, was inconceivably greater than that of sound, which was but 1,100ft. in the same space of time. Again, while the length of a sound wave produced by the voice varies between one foot and 17ft., that of light varies between the thirty-[illegible] thousandth and the sixty-thousandth part of an inch. The fewest vibrations the ear is struck by at once are but 16, the lowest number received by the eye is 500 millions of millions. The composition and decomposition of light were illustrated by the [illegible] experiments. The softest light was that due to phosphorescence, seen sometimes in the sea as well as in fireflies and glow-worms. This was caused by sheer vibration set up in certain bodies by light itself, and was well exemplified by the new luminous paint. A surface covered with this paint needed but an instant's exposure to the action of light to become permanently phosphorescent. This invention might be utilized for life-buoys at night; to enable us to find our Bryant and May in the dark; and, as the experiment of "the writing on the wall" showed, for making the names of streets legible without the help of gas. In speaking of the uses of light, Mr. Preece sketched slightly the history of illumination from the days when savages first struck out sparks and flame by friction till men learnt to burn oil, wax, and tallow—nay, until they used for the purposes of illumination gas and electricity. London was first lighted by oil lamps in the reign of Charles II. (1684); gas was first employed for the purpose in 1813; electricity on the Thames Embankment and Holborn Viaduct not before last year. The constantly accelerated improvement in burners and in the plant and processes employed in the manufacture and distribution of gas in modern times was profusely exemplified. The only experiment which signally broke down was that so common among boys—the distillation of coal in the bowl of a tobacco-pipe. The youngsters, of course, lauched heartily at the failure. Mr. Preece remarked that in nothing are householders so neglectful as in regulating the supply of gas to their dwellings. The great increase in cost last year was due to a necessarily increased pressure at the works, which ought to have been, but was not, compensated for at home. The waste of gas, and consequent loss of light, were fabulous, owing to the absence of any means to regulate the consumption at the burners. Gas burning 5ft. per hour should give 15-candle light. As was proved by experiment, flame implied something to burn and something to burn it with. The pale light from the spirit lamp became immeasurably brighter when Mr. Preece fed it with fuel blown from a tube. The combustion of carbon in oxygen and of magnesium wire in common air, with other like experiments, illustrated the nature of flame, and the inseparable connexion between motion, light, and heat. In fact, heat and light were identical, and the greater the heat, the greater the light. The solution of the problem of the best luminant depended on our being able to concentrate the greatest heat on the smallest particles of matter. This was best effected by electric currents. The mightiest currents were produced by moving coils of wire with the greatest velocity through the strongest magnetic field. The light produced varied with the strength of the current. The various systems for producing the electric light were then briefly reviewed and illustrated experimentally. At a given instant, four lamps in the theatre and one on the stairs were lighted up with electricity pumped up by the Embankment works at Charing-cross. The lecturer ridiculed the latest news of Edison's asserted triumphs. The Menlo-park achievement of obtaining 128-candle light from a single horse-power had been already exceeded tenfold on the Siemens system.

Manufacturer & Builder

Light and Heat.

Dec. 1879

Our attention was attracted by the above title to an article by Henry Raymond Rogers, M.D., of Dunkirk, N. Y., first published in the Buffalo *Sunday Courier*, and reprinted in the *Journal of the Telegraph*. A country paper, not claiming to be scientific, might be pardoned for inserting the article referred to, written by a man who, in almost every sentence, proves that he knows very little of the subject he treats, and who makes several statements contrary to what science has demonstrated; but that a journal published in the metropolis of the American continent, and claiming to be scientific, should have no one on its editorial staff who is enough of a scientist to see the utter worthlessness of the whole article in question, and publishes all its nonsensical utterances without comment, is a disgrace to the scientific reputation of the United States, while at the same time much harm is done by the diffusion of erroneous theories and of statements which are utterly untrue.

We feel ourselves called upon to correct the theories and statements referred to. The writer begins by reproaching scientists for having thus far ignored the two forms of light and heat, which he holds to be combustion and magnetism. By the latter he means the light and heat produced by electric currents, which do not appear at the seat where they are generated, like the light and heat of combustion, but, as the writer expresses himself, "this magnetic force, while permitted to flow freely through a perfect conductor, is never developed into light and heat, but is only concerted into these forces as the current encounters and overcomes resistances." He further says: "They are transmissible in any direction, and by any pathway, and have scarcely any terrestrial limits. They are transported by wires over continents and beneath oceans, and many miles of space have been transversed by them without any visible means of conduction; but, unlike the former, they do not pass as sensible light and heat. Their functions differ; the light of combustion is feeble in power, while the magnetic form of light may be employed in photography, and by it the various shades of color may be discerned in the night season. In strength and brilliancy the magnetic light resembles the sunlight."

The writer, when he states that the light and heat of combustion do not appear at the seat where they are generated, forgets the works in which gas is generated, while the light and heat which it contains in a latent condition are often evolved miles away from the place of generation. In fact, we now know that there is far less loss in transmitting light and heat in the form of gas than there is in transmitting them in the form of electricity, which do not at all "flow so freely," and have decidedly a very contracted "terrestrial limit," as those who professionally exhibit electric lights have learned to their great annoyance. To say that electricity can traverse space "without any visible means of conduction," is downright nonsense.

It also appears that the writer desperately confounds electric currents and magnetic force, which are by no means the same thing, however closely they may be related. He persists in calling the electric light "magnetic light," while it is well known that it can be, and was at first, exclusively produced by simple galvanic batteries, without the aid of any magnetism, and that only at a later date, after it was found that magnetism could produce electric currents, were magneto-electric machines used to develop electric currents. To say that it is magnetic force that flows through conductors displays as much ignorance as when he says that the light of combustion is feeble in power, while the "magnetic form of light may be employed in photography." The fact is that the light of combustion may be made as strong and as well suited to photography as the electric light, the combustion of magnesium metal, of bisulphid of carbon with nitrogen, of phosphorus in oxygen, or of oxygen gas blown upon burning sulphur, which are all adapted for photography, while only a strong electric light will answer the purpose. It is not a question of the origin of the light, but of its temperature.

The writer wants to deduce the conclusion that the sun shines by "magnetic light," and tries to obtain another argument from the fact that by the "magnetic light colors can be distinguished." Unfortunately for his theory, the light of burning magnesium shows colors just as well as the electric light; so does the light produced by the ignition of many other substances, if it is only pure white light, and not yellow, like that given by our ordinary gas, lamp and candle lights. He thinks it "a great relief" to suppose that the solar light is magnetic, as then he says "we are eased of the great burden of finding adequate supplies of material to keep up the vast conflagration supposed to rage at the sun;" and then expounds in regard to the tax of the old theory upon the ingenuity which "neither we nor our scientific fathers have been able to bear." He says that if we only adopt his magnetic theory, the trouble about the "waste involved in the theory of combustion process, enormous beyond computation," will all be relieved, and the great law of the conservation of force, which was jeopardized, be maintained.

Does Dr. Rogers then think that he gets his magnetic (electric) light for nothing? Does he forget that for its production he needs a colossal galvanic battery consuming zinc and acids by the pound? or that he wants a steam engine to drive the dynamo-electric machine producing the light? so that in the end he needs a combustible material as much as if he made a fire and used its more diluted heat and light directly, without the intervention of electric currents; and we ask him: Where is the galvanic battery or the dynamo-electric machine, with the power driving it, which supplies the solar magnetic (electric) light? It is easy enough to pretend that the source of solar light and heat is electric or magnetic if you choose, but this explains nothing if no further explanation is added in regard to how the electricity is generated.

We pass by some other confused notions expressed by Dr. Rogers, and will only mention the analogy he finds between the attraction of our little magnetic batteries and the attraction or gravity of the great sun battery, as he calls it, and which attraction, he says, "is likewise an integral constituent with sunlight and sun heat." Unfortunately for such speculation is the well proved fact that gravitation is entirely independent of heat and light.

But the worst is yet to come. In his eagerness to

63

The Great Discoveries of Edison and Mege in [illegible] Laws of Nature, and Utilizing Them for the Benefit of the Human Race.

Daily Inter Ocean [illegible]

Edison is widely celebrated for the many advantages secured to mankind by his wonderful discoveries. He has found the means for utilizing electricity in [illegible] years ago, and when the grand result of his inventions is summed up it strikes thinking men with amazement.

The brilliancy and utility of his achievements are undeniable. Nobody questions them. The world is ready to accord them due commendation and encouragement. If he does nothing beyond what he has already accomplished, the measure of his fame will be as complete as that of any scientist of the nineteenth century. And yet there are others who deserve well of mankind—who have conferred inestimable benefits upon the world by their less recent discovery.

Among these the name of Mege is at once suggested. His invention is of great and permanent value. He discovered that the article of food known as butter has its origin in the fat of the animal; that this fatty matter in cattle is the source of what we call "cream," and that its manufacture into butter may be made more cleanly and profitably than the product of the dairy by the old process. [illegible] It is not necessary [illegible] that for a time existed against it has passed away in the light of experience, and it has become one of the great staples of commerce. Of course there are some good people who have not observed its triumphs, and are therefore yet in the dark regarding its value. There are others who were permanently blinded by prejudice at the start, and who will not admit the light of knowledge into their minds. But the people have learned that such butter, or butterine, as it is called, is, in all points relating to its wholesomeness and legitimacy, quite as worthy of attention as the butter produced from the milk of the cow, and that in many localities it is preferred to the cow butter. They have learned that it is approved by scientific analysis, and that it is sought after by consumers. The demand largely exceeds the supply. As an instance of this we may mention that a company just formed for its manufacture were offered an order for enough of the product to keep them running six months to produce before they started their machinery, and that large orders are refused by the factory in this city every week.

Still we hear that dairymen are organizing a raid against butterine because its sale keeps down the price of their butter, and they are still further invoking the aid of legislation to hamper, if possible, the manufacturers of butterine. What if the gas companies were to pursue the same policy regarding Edison's electric light? Would the people justify them in doing so? And yet the logic of the two cases is identical. The dairymen desire a monopoly to enable them to keep prices at a high figure. The manufacturers of gas are animated by precisely the same motives, but they are more discreet. They do not move for legislation against the electric light, but for special privileges to enable them to keep their prices up to a profitable figure. The two classes of would-be monopolists are equally worthy of public condemnation, and they are destined to secure it according to their deserts.

In the various attacks against butterine which have been made from time to time, the people of this city are surprised to see that they are aimed at an industry in which some of our most reputable citizens are engaged—citizens who have won the respect and confidence of the community by lives of probity. It is not believed they are willing to forfeit their characters for a business which their opponents stigmatize as disreputable. It is not for a moment imagined they are doing acts which imperil the public health or set at defiance the laws of the land. No citizens are more law abiding nor more conservative of right. If they are not engaged in a strictly legitimate and creditable industry, then no industry which furnishes a product which the people demand is legitimate or creditable. We are far from believing that either they or their business require championship at our hands, but we see that an additional attack upon them already commenced in the Legislature, and it should be promptly condemned by intelligent men and women everywhere. It is a movement which finds its exclusive countenance in envy, or fear, or ignorance, and will be disastrously vanquished whenever the rays of truth are permitted to prevail in the ordinary intellect.

So grand a discovery as Edison's is not grasped by the ordinary mind, and we can not expect it to be comprehended except by the more intelligent. In consequence of this want of appreciation by narrow minds there are innumerable flings and sneers at this great inventor by would be scientists, jealous of his fame, who can not comprehend [illegible] remains [illegible] has been revealed and [illegible] to come will prove [illegible] So it was with the [illegible] first made his an[illegible] preconceived [illegible] food known as b[illegible] He was held up [illegible] of mankind. [illegible] him took pract[illegible] beef cattle, bri[illegible] by a me[illegible] germ of truth [illegible] minds it was [illegible] ing must disap[illegible] It led to organ[illegible] dealers throughout the land, the most powerful and hostile ever arrayed against any enterprise. [illegible] in individual and concerted action they [illegible] to State legislation, securing by [illegible] and falsehood the enactment and [illegible] of laws that are a disgrace to the statute [illegible] should be condemned and repudiated by [illegible] intelligent people. His discovery has [illegible] vast industry, employing thousands of peo[illegible] large capital, which have added not only [illegible] wealth of this land, but to the commerce o[illegible] world. And so we predict the scientific researches and struggles of Edison will be equally grand, and as far reaching in practical results to the masses of mankind.

EDISON'S ELECTRIC LIGHT EFFECT ON GAS.

[illegible]

The latest intelligence from Menlo Park confirms the first announcement of the success of Mr. Edison's electric lamps, notwithstanding the persistent declarations of his critics and cavilers that they would not succeed. Mr. Sawyer, the self-claimed New York electrician, has affirmed in a testy and confident manner that the little carbon horseshoes would not burn an hour, but in Edison's laboratory they have been burning a week, and there is apparently no reason why they should not burn for an unlimited time.

A French electrician in New York has declared with equal volubility that Edison could not make a perfect vacuum in his globes, since the air would creep in at the point where the wires enter from the battery to the horseshoe, and the moment that oxygen entered the carbon would crumble and the light would instantly be extinguished. Edison has shown, however, that the carbon continues to give forth light, and consequently that the vacuum is perfect. To their confident declaration, "You cannot do it," he can answer, "I have done it," much as the woman confounded the lawyer who assured her that her husband could not be put in jail with the declaration that he *was* in jail. Against their theories he opposes the accomplished fact, and the world is already congratulating the skillful young electrician upon his marvelous and brilliant success.

One of the foundation elements of that success may not be completely understood by our readers, and that is, how the light is produced. The horseshoe is made of carbonized pasteboard, inclosed in a small hermetically-sealed globe, from the prongs of which platinum wires, also in the vacuum, connect with copper wires outside the lamp, these in turn uniting with iron or steel wires leading to the battery. The electricity traverses the latter wires with the usual velocity, amounting to many thousand miles a second. They are so perfect conductors that the resistance is not appreciable. The platinum wires, on the other hand, are poor conductors. They probably give ten thousand times more resistance than iron or copper; while the carbon is so poor a conductor that the electric current can hardly creep around the horseshoe. The progress of the current in making its circuit may be compared to a skater flying at great speed over very smooth ice, who suddenly strikes upon a bit of bare ground. His speed is at once so retarded that he only goes a foot or two and strikes fire at the same moment. To appreciate the influence of the carbon upon the current, suppose that this same skater were to suddenly, at his moment of swiftest speed, strike upon a surface of sandstone. He is not only instantly stopped, but much heat and flashes of flame are generated by the frictional contact, and bright sparks fly thick and fast under his feet. So with the electricity. Flying with inconceivable rapidity and force over the iron and copper, it suddenly encounters the non-conducting platinum and the tremendous resistance of the carbon. Force, when met with resistance, always converted into heat, and, if the motion is great and the resistance is strong enough, into light. If it encountered the platinum alone, heat would be generated sufficient to fuse the metal, as Edison found in his earlier experiments; but, with the carbon, whose non-conducting resistance and infusibility are still greater, it not only [illegible] heat, but light of a beautiful, mellow, [illegible] at the same time brilliant, radiance. [illegible] has ascertained that fully nine-tenths of the velocity force of the electric current percolates into light, and but one-tenth into heat, upon striking the carbon horseshoe, whereas, in the combustion of gas fully nine-tenths thereof is given out in the form of heat and only one-tenth in light, and this is why electric force can be converted into light cheaper than gas can; but for heating purposes gas would be at least ten times better and more economical than electricity.

One of the most frequent opinions expressed since Mr. Edison's discovery is to the effect that it will result in excluding gas from use and entail total loss upon the holders of gas property. There is little danger of this. Before kerosene came into very general use, gas was charged in Chicago at \$4 and \$4.50 per 1,000 feet. The oil cut down prices to \$2.50 and \$3, but there was no complaint on the part of the gas companies of any considerable loss of profits, nor did their stocks materially suffer. Suppose that Edison's discovery should still further force down prices of gas to \$1, or \$1.25, or even 75 cents per 1,000 feet, there would even then be no danger of annihilation of the gas business. The profits on gas hitherto have been so enormous that the stocks and "plants" of companies were long ago paid for and the investment capital returned to the subscribers several times over in nearly all companies in this country and Europe. If hereafter gas should be sold so cheap as only to reimburse material, labor, and repairs, with 8 or 10 per cent thereon for superintendence, the business would go on, and no gas company wind up and abandon the business; and probably this much profit could be made on gas at 60 or 75 cents per 1,000 feet. Gas is available not only for illumination, but for heating. We have already stated that nine-tenths of its product is heat. If the price is forced down by the electric light to one-third own of present prices, the effect will be to create an enormous demand for gas for heating purposes. It will then come into universal use in domestic economy as a heater. The gas companies are already considering this question, and contemplating the enlargement of their works for the manufacture of the vastly increased amount which will be used in stoves, grates, and in various other ways where the electric light can be of no avail. There is no danger that any one will warm himself by lightning, or cook by it. Gas will be cheaper than any other fuel, will cook better, will save on the purchase of coal and wood, will do away with smoke, dust, soot, and dirt, can be lit instantly, and shut off as fast. While, therefore, Mr. Edison's invention may be a great blessing to the world in the way of better and cheaper illumination, there is no reason for holders of gas stocks to get in a panic. Gas has too many and too valuable uses to be shut out even by the lightning.

ELECTRICITY AND GAS.

History Repeating Itself at Menlo Park.

New York Herald

THE NEW INVENTION AND THE OLD.

Dec 30 [illegible] 79

How Gas Had to Fight Its Way—Electric Street Lamps To-Night.

"SCEPTICS DIE HARD."

MENLO PARK, Dec. 29, 1879.

It was quiet out here this morning and through the day as far as visitors were concerned. The machine shops were running full blast, and the laboratory was endued with its mysterious activity to the full. You would get the idea at first that in this place work was only taken up spasmodically, because you might see a man in broad daylight asleep on a bench, but shortly you discover that they only leave off work for short spells. Hence a peculiar Bohemian air about the place and all who are in it that might be a sign of demoralization in any other establishment in the world. Of this more anon.

VISITORS COMING.

The afternoon trains brought some visitors, but in the evening every train set down a couple of score at least. All immediately started for the scene of the laboratory, and a good many of those simple people who hold that Rome was built in a day and those modest people who believe that the hinges of the universe should turn upon the pivot of their desires expressed disappointment that they did not step out of the train upon a scene from fairyland. The moon was obscured by clouds, the way was dark up the little plank road, and the new white lampposts seemed to be stretching up their long fingers to clutch a little light from the heavens since Edison would not give them any of his little horseshoes. In fact, as the inventor said to me to-day, he is only waiting for another electric generator to be finished to light up all those long white fellows in what is out of courtesy called a street. It will, he expects, be ready to-day, and to-night he hopes to have fifteen street lamps and several of the houses lighted up.

[illegible] TOWER.

"It is a mistake to [illegible] Edison, "that a [illegible] Menlo Park is all I [illegible] of my eighty [illegible] and to put every lamp it will [illegible] to have 800 of them [illegible] put a dozen of them over there a mile aw[illegible] turn them on and off from this window. I d[illegible] where I'll put them all, unless along the [illegible] everybody will have plenty of time to se[illegible] It will take weeks to get them all out, the[illegible] are working night and day."

THE ELECTRIC REGISTER.

The stream of visitors passed through the shops, [illegible] wondered at the steady electric lights [illegible] by all sorts of laudatory epithets. [illegible] a well informed visitor would catch [illegible] or Mr. Upton and ply him [illegible] upon candle power, gas-jet [illegible] kindred intricate matters that are "caviare to the general." A particular object of interest was the register for regulating the strength of the current. Young Francis Jehl stood by it with all the solemnity of a patriarch, and explained it lucidly to all who desired. A current passing through a galvanometer deflects a small mirror at the back of which is a tiny magnet. Opposite this mirror, at a couple of feet distance, is a board along which, horizontally laid, is a scale. Through a slit in this board a ray of light passes from a lamp. The ray falls upon the small mirror, which, as the current is stronger or weaker, casts the reflection to the right or left upon the scale opposite. As more lights are put on more electricity is needed, and Francis turns an indicator, near which is an electric light, just as they do in a gas house when more or less pressure is called for by the consumption.

"It may be done automatically," said Mr. Batchelor, in answer to a gentleman's inquiry; "but it hasn't been thought out yet."

AN AGED SCEPTIC.

The visitors seemed never tired of lighting the lamps upon the main table, by simply laying one between the two long wires. Most were content to ejaculate "Wonderful!" But no amount of explanation would persuade one old gentleman that it was not an iron wire that was inside the glass globe. It could not be the carbon filament of a piece of paper, for, said he, "I have seen red hot, white hot iron wire, only it was not quite so bright, but it looked just like that. That's no fillyment."

"This is a bad time for sceptics," I said to Edison.

"There are some left," he said, "they die harder than a cat or a snake."

I turned away reflecting how snakes will bite in dying, and thought the inventor had described the persistent scientific doubter of demonstrated facts pretty accurately.

THE STRUGGLE OF GAS.

It reminded me of the sceptics at the time coal gas was first applied to illuminating purposes. There is, of course, a great change in the attitude of the masses to inventions nowadays. So much has modern science accomplished that people in general are rather inclined to be credulous than sceptical in matters of invention. At the beginning of this century it was very different. The alchemists—the searchers for the philosopher's stone that was to transmute brass to gold—were regarded as having been vain dreamers or impostors, and those searching amid the products of nature for fresh knowledge were looked on as their direct successors. It is close to two hundred years since the Rev. Dr. John Clayton, Dean of Kildare, wrote to his friend, Edward Boyle, a letter which was not published, however, until 1739, giving an account of his strange discovery. He was an experimenter, and he tells how on distilling coal in a retort on an open fire "at first there came over only phlegm, afterward a black oil and then likewise a spirit arose which I could no ways condense; but it forced my lute or broke my glasses. Once when it had forced my lute, coming close thereto, in order to try to repair it, I observed that the spirit which issued from it caught fire at the flame of the candle, and continued burning with violence as it issued out in a stream, which I blew out and lighted again alternately for several times." Then he filled bladders "void of air" with this "spirit." He endeavored to condense it several ways, but in vain. "And when I had a mind to divert strangers or friends I have frequently taken one of these bladders and, pricking a hole therein with a pin, and compressing gently the bladder near the flame of a candle till it once took fire, and it would then continue flaming till all the spirit was compressed out of the bladder, which, he naively adds, was more surprising because no one could discern any difference in the appearance between these bladders and those which are filled with common air."

MURDOCH'S ILLUMINATION.

Yet close to a century elapsed from the Dean of Kildare's writing and over fifty years from the publication of his experiments before any practical steps were taken in using coal gas for illumination. In 1792 Mr. Murdoch, a Scotchman, first tried it in Cornwall and afterward in 1798 established an apparatus on a more extended scale in a Birmingham foundry, the Soho Works. There were then no swarms of hungry professors and "practical" men going about trying to steal other men's brains in applied science, and Murdoch worked on without attracting great attention. But an opportunity at last presented itself for a public exhibition of gas illumination. On the conclusion of the peace of Amiens the people of England were rejoiced indeed. The Jingoism of the British nation had cooled for the moment, and when it was known that the treaty of peace was all but signed preparations were made all over the kingdom for "lighting up." The illuminations were general, and we read how a mob of the Jingoes of the period assembled before the French Minister's house, and not finding the blazing device quite to their taste made him change it. The word "Concord," it appears, offended them, as that was the way the majority of them spelled "conquered," so the obliging Ambassador changed it to "amity." Then, seeing the letters "G. R." without a crown, they thought it was a republican slur upon His Majesty King George III. of insane memory, so the French Minister, ever willing to oblige *ses amis l'ennemi*, got out a blazing crown. But all these illuminations were in oil and candles save in one place, and that was the exterior of the Soho Works in Birmingham.

1802-1879.

When we see the people walking about at Menlo Park admiring the electric light of Edison we may well recall in 1879 the scene at Birmingham on the night of the 28th of January, 1802. Says Matthews, describing it:—"The illumination was one of extraordinary splendor. The whole front of that extensive range of buildings was ornamented with a great variety of devices that admirably displayed many of the varied forms of which gaslight is susceptible. This luminous spectacle was novel as it was astonishing, and Birmingham poured forth its numerous population to gaze at and admire this wonderful display of the combined effects of science and art. The writer was one among those who had the gratification of witnessing this first splendid public exhibition of gas illumination and retains a vivid recollection of the admiration it produced."

A BATTLE WITH IGNORANCE.

Still gas had not then won its decisive victory, although the demonstration was perfect. We trace it along through the succeeding years struggling with ignorant prejudice, perverted humor and cheap satire. In 1803 it was introduced into a cotton mill at Manchester. Nearly one thousand burners of different forms were employed; and we are informed by Mr. Murdoch that "the peculiar softness and clearness of the light, with its almost unvarying intensity, brought it into great favor with the workpeople, and its being free from the inconvenience of sparks and the frequent necessity of snuffing are circumstances of material importance, as tending to diminish the hazard from fire, to which cotton mills are so much exposed."

But although it reached London speedily, and found in Mr. Winsor an enthusiastic promoter, it had to fight its way at every step. The explosive nature of gas mixed with common air became known and frightened many. Then the great train oil interest that supplied street lamps—just look at Hogarth's

pictures for an illustration, the great candle-making interest, the great candlestick interest, the great wick making interest, the great snuffer-making interest, all combined to denounce gas illumination as "wild, absurd and extravagant in its conception and fraught with the greatest danger in its execution." The popular writers in the papers made light of the "preposterous innovation," as "Winsor's gaseous proposals for enlightening the inhabitants of London," his "smoke lights" and his "fire of wind" to their hearts' content. Oddly enough nowadays it is from so-called scientists that the loudest opposition comes to the equally demonstrable incandescent electric light. But Winsor fought seventy odd years ago with a wonderful enthusiasm. He attracted the attention, however, of some discerning men of wealth anxious to promote science—and make a little more money. On the 28th January, 1807, the first public street lighting took place in Pall Mall, London, near Mr. Winsor's laboratory, which stood on the present site of the Carlton Club. Subsequently, in 1813, old Westminster Bridge was lighted with gas. Yet it was adopted generally by very slow degrees.

SLOW SPREAD OF THE GAS MAINS.

In 1821 a Thames fisherman, arrested for using an illegal net, complained that the discharge of gas water into the Thames from the works near the Temple destroyed the fish, and the Lord Mayor sympathized with the poor man and made his fine merely nominal. Still that gas was far from being in general use may be judged by the strenuous way with which we find the advantages of gas over oil and candles insisted on in the London Encyclopædia of 1821. "Many persons," it says, "object to introduce the gas directly into their apartments; and it has accordingly been proposed to bring the gas to the window, to allow it to burn on the outside, and thus to illuminate the room without any of the annoyances which arise both from the smell of the gas and from the heat generated during its combustion." Then it gives directions how such a light should be [illegible]: "The light might be rendered uniform by means of an ornamental blind of the finest muslin (varnished or not as may be found most advantageous), and if the blind has a landscape upon it the most luminous portion, or that nearest the gas flame, might be made to have the appearance of the sun in the heavens."

THE COMING BATTLE.

All this comes back with renewed force to us when another revolution in domestic illumination is impending. If it is a better, purer, more manageable, cleanlier, and, above all, a cheaper light than gas, then gas is doomed. Of course no revolution like this can take place in a day or a year, but as the gas men crowded the oil men and candle men into a little corner, giving them only the refuse of the lighting of the streets and houses, as coal oil pushed the poor candle men still closer to the wall, so the electric light begins to push all three of them. That is inevitable, though the uses of gas for purposes in which it is now but sparingly used will be studied out with persistence and ingenuity. When we think of the enormous amount of capital invested in gasmaking we can easily guess how mighty the struggle will be.

EDISON'S BRAIN MOTOR.

Up there at the laboratory there is no particle of doubt in any one's mind that the electric light is a success and a permanent one. I spoke yesterday of the enthusiasm of a young glassblower; but it is a curious instance of Edison's brain force that this enthusiasm is common to all about the place. It is not unusual in such establishments for the inquirer to find here and there a captious understrapper who with very little encouragement will proceed to belittle their master. I have found nothing of the kind here. Edison animates the men and boys—there is scarcely a grey head in the establishment—with his own indomitable, persistent spirit. It is not merely in talking to a stranger, but in working, that this is seen. Edison's chief assistant, Mr. Batchelor, will glow like a carbon lamp when he is asked a question. Secretary Griffin, who sits up in the office, generates enthusiasm with eighty horse power if you hint at a desire for information, and it is all done with bonhomie and has nothing of "shop talk" about it. Mr. Upton is genial and answers questions with text-book exactitude, although the object or process may be only a week old. The truth is Edison attracts the right kind of people for his work, and his "no" keeps them going. It is not mere day's work that he exacts from them or himself.

"I want people to do as I tell them just when it suits me," said he. "I don't want any man that's afraid to burn his fingers."

This rather took me aback, so I asked "[illegible] burn his fingers?"

"We had a young gentleman come here from college, with a first rate diploma and all that. He was a chemist. He could answer any questions; but, somehow, he seldom could get anything out. I believe he was afraid to burn his fingers. You mustn't be afraid of your work. I said to him one day, 'I want two ounces of iridium.' He worked and worked, but somehow he didn't get it. We were working here one evening and I wanted it badly next morning, so I said to Batchelor, 'Batch, do you know anything about iridium?' 'Not much,' said Batch. 'Well,' said I, 'go and look it up. I want two ounces in the morning.' Now, Batch is not a chemist, but he went to work all night and in the morning he had four ounces for me. That's the way I want [illegible] I'll tell you more about it some other time."

SALE OF ELECTRIC LIGHT PA[illegible]

CLEVELAND, Ohio, Dec [illegible] 1879.

Charles F. Brush, of Cleveland, has just sold his English patents for electric lighting apparatus to a large incorporated company in London [illegible] £30,000.

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67

SCIENTIFIC VIEW OF IT.

Plumber & Sanitary Engineer Jan 1 1880

[From the New York Times of Dec. 28th.]

Prof. Henry Morton, the President of the Stevens Institute of Technology, who is well known for his researches in physics, and whose experiments were a source of unfeigned pleasure and astonishment to Prof. Tyndall, recently sent a communication to the SANITARY ENGINEER protesting against the trumpeting of the result of Edison's experiments in electric lighting as a "wonderful success," when "every one acquainted with the subject" will recognize it as a "conspicuous failure." To this was added the statement that Edison "has done and is doing too much really good work to have his record defaced and his name discredited in the interests of any stock company or individual financiers." Edison, to whose attention this letter was called, was reported in a newspaper yesterday morning as inviting Prof. Morton or any other electrician to visit the Menlo Park laboratory and see the light in practical operation. In conversation with a Times reporter yesterday, Prof. Morton said that, for several reasons, he did not think he would accept Mr. Edison's kind invitation. "What is needed to be learned," said the Professor, "is the durability of these new lamps of Mr. Edison's, and the actual economy in the conversion of power into light by his arrangement. For example, according to the statement in the *Sun*, Mr. Edison places his present lamps and machines as yielding him what is equivalent to 10 gas-burners for every horse-power. Now, my own experience with the best dynamo-electric machines—such as those of Siemens, Weston, Brush and Maxim—using the ordinary carbon poles, show that we may obtain a light of from 1,200 to 1,600 candles per horse power. Assuming a gas-burner to be equal to from 12 to 16 candles, this would be about 100 burners per horse power. As compared, therefore, with the electric light obtained between carbon poles, Mr. Edison gets only 10 per cent., showing, therefore, precisely that enormous loss in the division of the light which has been alluded to before as one of the standing difficulties in the way of the practical application of such a system as Mr. Edison is working upon. This is taking simply his apparently rough estimate. For any definite and certain conclusions, prolonged and careful experiments, entirely under the control of the investigator, are absolutely necessary."

As regards the durability of Prof. Edison's new lamps, Prof. Morton was not at all sanguine. "Lamps," said he, "in all essential respects identical with these described by Mr. Edison, have been in constant experimental use for several years past, with one invariable result, namely, that, while the carbon would operate successfully for periods varying from a few hours to several days, it has been found utterly impossible to render them reliably permanent. It is, therefore, in my estimation, here also necessary that experiments of some length, likewise under the entire control of the investigator, should be made in order that a decisive conclusion may be reached. With reference to the confident assertions of success which reach me from various quarters, I must fall back upon my experience of a little over a year ago. Every one remembers how, at that time, Mr. Edison read some remarks of mine by the light of his then brilliantly-glowing electric light, and pointed to it as a shining refutation. In turning over some old letters a few days since, I came across one from a friend of mine, who is a scientific man of high standing, and was at that time on very intimate terms with Mr. Edison. This letter is dated October, 1878, and in it I am assured that Mr. Edison's lamp is a perfect success, capable of replacing a gas-burner, and that when I see it I shall, no doubt, be charmed with its simplicity and efficiency. When I reflect that this previous complete success has been since abandoned by Mr. Edison, I feel that a little caution is needed in accepting the enthusiastic conclusions of his friends, even when they are illuminated by the shining electric lamps which occasion them."

"Can you tell me, Professor," asked the reporter, "what are some of the chief difficulties in the way of the success of Mr. Edison's light?"

"Well," Prof. Morton replied, "the first difficulty of all is the production of a lamp which shall be thoroughly reliable, and neither complicated or expensive. All attempts up to the present lamp in this direction are acknowledged to be failures, and, as I have pointed out, there does not seem to be any novelty such as would authorize us to hope for a better success in the present one. The next difficulty is in the economical production of small lights by electricity. This is what is commonly meant by the phrase, 'dividing the electric light.' Up to the present time, and including Mr. Edison's latest experiments, it appears that this involves an immense loss of efficiency. Next comes the difficulty of distributing on any large scale the immense electric currents which would be needed, and to provide for their equal action at different points under varying conditions of the number of lights used. In reference to this, as far as I judge from the reports, Mr. Edison has been running not over 50 lights in all, while his 80 horse-power engine ought to supply 800 lights. The small number actually in use does not, therefore, develop this problem in any practical way."

"The question of measuring the current," added the Professor as the reporter turned to leave, "the loss involved from the necessity of running the machinery without a moment's intermission during the entire time that any light is needed—in other words, the absence of any storing capacity in electricity—and various other matters of detail, while less important than the three principal difficulties which I have given you, are, nevertheless, very serious difficulties in the direction of a successful practical application of electricity for general illumination."

EDISON'S ELECTRIC LIGHT.

THE REPORT OF AN EXHIBITION AT MENLO PARK UNTRUE.

For some time a rumor has been circulated that Edison, the famous inventor, intended to illuminate the village of Menlo Park, N. J., with his electric light on Christmas Eve. A director of the Electric Light Company that is supplying Mr. Edison with money to prosecute his undertaking said to a TRIBUNE reporter yesterday:

"The report is untrue; we have made no preparations to illuminate Menlo Park to-night. We never have set a day for making a trial of Mr. Edison's inventions for using the electric light—that idea was the creation of some visionary reporter's brain. The apparatus is not yet perfected, nor has some of it been tried: nor has Mr. Edison, I think, yet obtained his patents for some of it. Many experiments will be made before the directors of the company will feel like inviting the public to an exhibition. The company has already been subjected to a great deal of ridicule in consequence of the publication in the newspapers of exaggerated reports of the results of Mr. Edison's labors, and is not inclined to invite any more by a display of the electrical machines while they are yet imperfect and not thoroughly tested. We do not yet know positively the cost of manufacturing and distributing the electricity. Laboratory experiments cannot be entirely trusted. I doubt if we will know the cost of the electric light supplied by our company compared with the light supplied by the gas companies till the new system can be tested in some large city. Mr. Edison has had poles erected in Menlo Park to hold his electric lamps, and has also put lamps in several houses in the village. The village of Menlo Park is an imaginary one, however, consisting merely of Edison's laboratory, house and two or three other buildings—so that the experiment, when it is made, will not be a very extensive one. None of the directors of the Electric Light Company have been invited to come there to-night to witness any experiments, and I am positive none will be made."

"Was the description, recently given of Mr. Edison's machines and lamps a faithful one?"

"Yes," said the director, "it was faithful as far as it went; but no mention was made of several important inventions inseparably connected with the other parts of the new system of light. I suppose Mr. Edison did not care to mention them, from a belief that others in the inventive world would instantly rush in and say, 'Oh, that's old; we invented that years ago.' But the gas companies evidently have some faith in Edison, for gas stock fell in price in London and Montreal on the publication of the report that Mr. Edison had finally succeeded. The owners of gas stock, I think, are mistaken in assuming that their property will be severely damaged by the introduction of the electric light. The gas companies ought to control the new business, it seems to me, as they have the old. They have the right of way through the streets, the names of customers, in fact the entire business of lighting the cities is in their hands. They can adopt the new method of lighting and still hold the business."

Date?
Dec 26, 79

NDAY, DECEMBER 28, 1879.

EDISON'S ELECTRIC LIGHT

CONFLICTING STATEMENTS AS TO ITS UTILITY.

THE INVENTOR SAYS HE HAS SUCCEEDED IN GETTING A CHEAP SUBSTITUTE FOR GAS LIGHT—A PUBLIC EXHIBITION PROMISED—PROF. MORTON'S CRITICISM.

There was no lack of enthusiasm or of confidence about Mr. Edison as he greeted the TIMES reporter who entered his laboratory at Menlo Park, N. J., yesterday. The inventor, a short, thick-set man, with grimy hands, led the way through his workshop and willingly explained the distinctive features of what he and many others look upon as an apparatus which will soon cause gaslight to be a thing of the past. The lamp which Mr. Edison regards as a crowning triumph is a model of simplicity and economy. In the lamp the light is emitted by a horseshoe of carbonized paper about two and a half inches long and the width of a thread. This horseshoe is in a glass globe, from which the air has been as thoroughly exhausted as science is able to do. So good a vacuum is produced that it is estimated that at the utmost no more than a one-millionth part of the air remains. The operation of pumping lasts one hour and a quarter. At the ends of the carbon horseshoe are two platinum clamps, from which platinum wires run outwardly through a small glass tube contained within a larger one leading out of the glass globe. The small tube contains air. Within it the platinum wires are met by two copper wires connecting with the conductors of the electricity. The air is left in the small tube, because otherwise the copper wires would be fused by the electric current. The carbonized paper is capable of being made incandescent by a current of electricity, and while it allows the current to pass over it, its resistance to the heat is strong enough to prevent it from fusing.

The first place visited was the room in which the furnace for carbonizing the paper is situated. The furnace is of the ordinary pattern, and on the coals rested a horseshoe mold, in which the bristol board to be charred was placed. Over each horseshoe a piece of tissue paper was placed, and the whole was washed until all the material of the card-board, except the carbon, was taken away. When the filaments were taken from the mold they resembled pieces of black thread. The particles hung tenaciously together, however, and the black horse-shoe was easily placed in the platinum clamps of the globe of the lamp. The exhausting of the air takes place after the carbon is put in position, and when this is done the lamp is complete. "As there is no oxygen to burn," said Mr. Edison, "you can readily see that this piece of carbon will last an ordinary life-time. It has the property of resisting the heat of the current of electricity, while at the same time it becomes incandescent, and gives out one of the most brilliant lights which the world has ever seen. The cost of preparing one of these little horse-shoes of carbon is about 1 cent, and the entire lamp will cost not more than 25 cents." Here the inventor gave a practical illustration of his invention. He was standing just under an ordinary gas chandelier in which two of his lamps were burning. He took one of the lamps out, and it appeared simply as a glass globe. He placed it back in the burner, and immediately a brilliant horse-shoe of golden light illuminated the globe. Mr. Edison then, by turning a screw in the lamp, brought the light down to a spark, turned it off completely, as gas can be turned off, and then turned it on again to a brilliant incandescence by a twist of his fingers. He certainly demonstrated that in his own laboratory at Menlo Park, the electric light is as obedient to his will as the gas light is to the general public. The light from each lamp is of about the power of an ordinary gas-jet, but Mr. Edison claims that by increasing the electricity, he can raise the power to 15 gas-jets.

"Eighty-four lights are burning night and day in the laboratory, and they are all supplied with electricity by an 80-horse-power engine, which is stationed in the laboratory. This engine, in addition to lighting these lamps, furnishes the motive power for all the machines in the laboratory, and at night feeds the electric lights which have already been erected in Menlo Park in anticipation of the proposed grand illumination. The wires which are to convey the electricity to the lamps for the grand display are to be above ground, so that all spectators can see and investigate them. They will lead directly from the lamps to the generator in the laboratory, and any person can trace them from point to point."

From the furnace-room Mr. Edison conducted the reporter to the room in which his lamps are made, and where the air is exhausted from them. In this room, also, is Mr. Edison's machine for regulating the pressure of the electricity as it passes to the different lamps throughout his laboratory. This machine consists of a series of coils of copper, over which the electric current is continually passing, and each coil is connected with a series of lamps. If the pressure is too great on any series of lamps it is at once shown by the coil representing that series, and can be regulated in an instant. In this room, also, the carbonized paper is placed in the globes, and the lamp is completed. It is Edison's pet room, and here he spends most of his time when not engaged in studying out new inventions.

It has been asserted by some persons who are supposed to be conversant with the subject of electricity that in order to furnish lights for houses in this City a copper coil as large as an ordinary barrel would be required as a conductor from the central station to the different houses in two or three blocks. Regarding this, Mr. Edison said: "The size and amount of conductors for carrying electricity for lighting purposes depends, of course, upon the distance to which the electricity is to be carried. If I have to carry it 10 miles my conductor must be larger than it must be if I have to carry it 10 feet. My idea is to have central stations to cover, say, a square of three or four blocks. The pipes containing the wires on a street, if this idea is carried out, will not exceed in size the circumference of your arm. They will be laid underground, and stations just at the edge of the sidewalks, as gas-pipes are now laid."

"What will be the cost of these conductors," asked the reporter.

"The cost, compared to gas-pipes, will be very small, and there is very little chance of their getting out of order. The wire itself, which will convey the electricity, will be an ordinary No. 9 telegraph wire, the same wire that you see in use every day by the Western Union Company. That is as near the size of a lead as I intend to get."

"How will the light be distributed?"

"Precisely as gas is now distributed. You see that I can turn that burner off entirely if I wish to; I can lower it or I can raise it, just as you can lower or raise a gas jet. Our electricity will go from our central stations just as gas flows from the meter. Whether the company will charge for the light according to the amount of electricity which each consumer uses, or whether so much a month will be charged to each consumer I cannot say. That is a question which the company will determine when the electric light is introduced."

"Do you intend to illuminate Menlo Park on New Year's Eve?"

"Not for the public as soon as that. Menlo Park is now illuminated every night to a certain extent. All the lamps that we have on hand are lighted nightly, but we cannot give the grand display that I intend to give until we have more lamps. You can say this, however, that the electric light is perfected, and that all the problems which have been puzzling me for the last 18 months have been solved. I expect to have every house here lighted, and a number of street-lamps going within 10 days. When I once get the light started, I shall keep them burning night and day for at least two weeks, in order to make a time test of my carbon. I believe that it is practically infusible, and I have confirmed my belief by experiments here in my laboratory for several weeks, but I want the public to believe it from their own knowledge, and the only way to make the public believe it is to show it to them. I think that my carbonized paper is the only substance which is capable of becoming thoroughly incandescent, and at the same time of offering to the current of electricity sufficient resistance to prevent it from melting away. The vacuum in the globe, of course, offers no oxygen of any consequence to burn; but the intense heat generated by the electricity would destroy any other substance than this carbonized paper. There is absolutely nothing there to fuse. It is strong, pure, and simple, and no machine known to this age can generate enough electricity to destroy it."

"Have any electricians responded to your invitation to see you and investigate your method of lighting by electricity?"

"No electricians have been here yet, nor are there likely to be any here. Electricians are a very scarce article in this country, although there are many persons here who call themselves electricians. They don't come here, because they know that if they do they will be convinced that my light is at last a perfect one. I am glad they don't come. Practical men, with experience, and what I call 'horse sense,' are the best judges of this light, and they are the men whom I like to welcome to my laboratory."

BUSINESS ASPECT OF THE MATTER.

CONFIDENCE OF THE COMPANY WHICH FURNISHES MR. EDISON WITH MEANS.

Mr. Edison's inventions and discoveries, in the way of electric illumination, whatever they may be, are the property of the Edison Electric Light Company, a corporation which supplies him with the money for conducting his experiments. Mr. Calvin Goddard, the Secretary of the company, told a TIMES reporter yesterday, that the company had no doubt of Mr. Edison's having perfected his light to such an extent that it can be supplied equal to gas, as easily managed as gas, and to be furnished at a cost not greater than that of gas. The company, he said, was not yet quite ready, mechanically, to show the public the full and complete machinery and the manner of preparing the light, and the statement that a day had already been set apart to exhibit the completed light was incorrect. The first perfect demonstration of the success of the invention will be made at Menlo Park, but just when this will be done cannot yet be told. Time is needed to complete certain necessary fixtures. Among others a large number of lamps are still to be made. The company does not wish to invite the public to inspect the light until everything can be shown, and it is intended to exhibit the full capacity of the 80-horse-power engine to supply electricity to about 700 lamps. The objection which has been raised to the effect that one great difficulty in the way of the success of the light was in the large amount of copper necessary to carry the electricity, had been entirely avoided by Edison, according to Mr. Goddard. The objection was raised in France, he said, in the experiments with the Jablochkoff candle, where the cost of the copper was very great. But this difficulty had been overcome, and the company had no fears on that score. When the light is introduced it is intended to generate the electricity by engines of comparatively small horse-power distributed over the City. Each engine will supply the lights for an area of a quarter to a half mile around it, the distance of the engines from each other depending upon the number of lights each has to supply. This arrangement will be made both for the sake of convenience and economy. To be ready for any emergency, as an accident to the generator, duplicate engines will be placed at each of the stations. It is understood that the Electric Light Company does not intend to take charge of the placing of the light, but will simply license others to do so.

A SCIENTIFIC VIEW OF IT.

PROF. HENRY MORTON NOT SANGUINE ABOUT EDISON'S SUCCESS.

Prof. Henry Morton, the President of the Stevens Institute of Technology, who is well known for his researches in physics, and whose experiments were a source of unfeigned pleasure and astonishment to Prof. Tyndall, recently sent a communication to the *Sanitary Engineer* protesting against the trumpeting of the result of Edison's experiments in electric lighting as "a wonderful success," when "every one acquainted with the subject" will recognize it as a "conspicuous failure." To this was added the statement that Edison "has done and is doing too much really good work to have his record defaced and his name discredited in the interests of any stock company or individual financiers." Edison, to whose attention this letter was called, was reported in a newspaper yesterday morning as inviting Prof. Morton or any other electrician to visit the Menlo Park laboratory and see the light in practical operation. In conversation with a TIMES reporter yesterday, Prof. Morton said that, "for several reasons, he did not think he would accept Mr. Edison's kind invitation. "What is needed to be learned," said the Professor, "is the durability of these new lamps of Mr. Edison's, and the actual economy in the conversion of power into light by his arrangement. For example, according to the statement in the *Sun*, Mr. Edison places his present lamps and machines as yielding him what is equivalent to 10 gas-burners for every horse-power. Now, my own experiments with the best dynamo-electric machines—such as those of Siemens, Weston, Brush, and Maxim—using the ordinary carbon poles, show that we may obtain a light of from 1,200 to 1,600 candles per horse-power. Assuming a gas-burner to be equal to from 12 to 16 candles, this would be about 100 burners per horse-power. As compared, therefore, with the electric light obtained between carbon poles, Mr. Edison gets only 10 per cent., showing, therefore, precisely that enormous loss in the division of the light which has been alluded to before as one of the standing difficulties in the way of the practical application of such a system as Mr. Edison is working upon. This is taking simply his apparently rough estimate. For any definite and certain conclusions, prolonged and careful experiments, entirely under the control of the investigator, are absolutely necessary."

As regards the durability of Prof. Edison's new lamps, Prof. Morton was not at all sanguine. "Lamps," said he, "in all essential respects identical with those described by Mr. Edison have been in constant experimental use for several years past, with one invariable result, namely, that, while the carbon would operate successfully for periods of varying from a few hours to several days, it has been found utterly impossible to render them reliably permanent. It is, therefore, in my estimation, here also necessary that experiments of some length, likewise under the entire control of the investigator, should be made in order that a decisive conclusion may be reached. With reference to the confident assertions of success which reach me from various quarters, I must fall back upon my experience of a little over a year ago. Every one remembers how, at that time, Mr. Edison read some remarks of mine by the light of his then brilliantly-glowing electric light, and pointed to it as a shining refutation. In turning over some old letters a few days since, I came across one from a friend of mine, who is a scientific man of high standing, and was at that time on very intimate terms with Mr. Edison. This letter is dated October, 1878, and in it I am assured that Mr. Edison's lamp is a perfect success, capable of replacing a gas-burner with perfect ease, and that when I see it I shall, no doubt, be charmed with its simplicity and efficiency. When I reflect that this previous complete success has been since abandoned by Mr. Edison, I feel that a little caution is needed in accepting the enthusiastic conclusions of his friends, even when they are illuminated by the shining electric lamps which occasion them."

"Can you tell me, Professor," asked the reporter, "what are some of the chief difficulties in the way of the success of Mr. Edison's light?"

"Well," Prof. Morton replied, "the first difficulty of all is the production of a lamp which shall be thoroughly reliable, and neither complicated nor expensive. All attempts up to the present lamp in this direction are acknowledged to be failures, and, as I have pointed out, there does not seem to be any novelty such as would authorize us to hope for a better success in the present one. The next difficulty is in the economical production of small lights by electricity. This is what is commonly meant by the phrase, 'dividing the electric light.' Up to the present time, and including Mr. Edison's latest experiments, it appears that this involves an immense loss of efficiency. Next comes the difficulty of distributing on any large scale the immense electric currents which would be needed, and to provide for their equal action at different points under varying conditions of the number of lights used. In reference to this, as far as I judge from the reports, Mr. Edison has been running not over 50 lights in all, while his 80 horse-power engine ought to supply 800 lights. The small number actually in use does not, therefore, develop this problem in any practical way."

"The question of measuring the current," added the Professor, as the reporter turned to leave, "the loss involved from the necessity of running the machinery without a moment's intermission during the entire time that any light is needed—in other words, the absence of any storing capacity for electricity—and various other matters of detail, while less important than the three principal difficulties which I have given you, are, nevertheless, very serious difficulties in the direction of a successful practical application of electricity for general illumination."

BIRDSALL HOLLY.

He Spends a Few Days in Burlington and is Interviewed.

His Opinion of Our Water Works--Edison's Electric Light.

Mr. Birdsall Holly, the inventor of the famous Holly system of water words, arrived in the city from Milwaukee on Saturday, and spent the Sabbath with his nephew, Mr. Ira Holly, the chief engineer and superintendent of the Burlington water works. During his stay in Burlington Mr. Holly was interviewed by THE HAWKEYE, and although he manifested a disposition not to talk when he discovered us making use of a memorandum pencil, we gleaned some points in our conversation that will be as interesting to our readers as they were to us and will be no violation of confidence. Mr. Holly is public property, in one sense, as he has acquired a national reputation as an engineer, mechanic and inventor. He is a prolific inventor, and has had a large number of patents issued to him. He is of tall, robust stature; a man of fine presence, and wears a head upon his shoulders that does not decieve the observer as to the brain power it holds. He is a fine specimen of the American inventor—a fair counterpart, in the world of mechanics, of Edison in the realm of electricity. He is a great admirer of Edison, both personally and as an inventor, and visited him at Menlo Park only two weeks ago. Edison's name started a new theme in the conversation:

Hawkeye—How is Edison's electric light getting along?

Holly—Edison says it is practically complete. There is but little yet to be done before the public exhibition. He asked me to prepare designs for a 250 horse power engine to run his electric generators.

Have you got up some special designs?

Yes; here are drawings of two designs. This is a combined high and low pressure. It is arranged upon a new principle so that the high pressure engine can run at a high rate of speed, and the low pressure or condensing engine at a low speed. Edison thought he would like an engine like the one at Burlington, but probably my new design will be better for his purpose.

How many engines does he intend to use in New York City?

I believe they intend to divide the city up into districts, with four engines of 250 horse power each, or a total of one thousand horse power at each station. There will be a dozen or more stations.

Why couldn't the electric light be introduced into Burlington, if it works well in New York, and use the water works engine for power for the electric generator?

I think that might be done. I believe that is a good idea. The difficulty is that Edison's generator requires a steady power, or, if it varies, it must be in compliance with the necessities of the generator and circuits, or according to the number of lamps in or out of circuit. The water works engine varies in speed, and is governed by the pressure in the mains. But I thing a governor could be devised—as, for instance, two cone pulleys—which would regulate the power for the generator to suit its own requirements. It might require delicate mechanism, but I think it could be done. This would get the power almost without expense, as the same engineers, boilers, engine, building, etc., would answer both purposes.

What do you think of the Burlington water works?

I am very much pleased with them. They are run with remarkable economy. I do not think any works in the west can make a better showing. And your works here will do still better when you get more consumers.

You think, then, the true policy for our city is to increase the number of water consumers as rapidly as possible?

Certainly. It is much cheaper in proportion to pump a large amount of water than a small amount. You can double and treble the amount now pumped with no increase in expense for wages, etc., the only added expense being the increased consumption of fuel, and that would be light.

How is your steam heating project getting along?

We are making good progress in the cities where it is now in use, and I think it is destined to come into general use.

Do you think it would pay in Burlington?

I do not know of any place more favorably situated for the system than Burlington. The business portion of your city is concentrated. The principal investment for steam heating is the pipes. It would take but little pipe to reach all the principal business blocks, hotels, and quite a number of factories, printing offices and other places where steam would be wanted for heating, cooking and power purposes. It would not take a great deal of capital to get a company well started here. Two miles of six-inch and four-inch street mains would reach a great many consumers, and make it pay from the start. The mistake made in some cities has been putting in too much pipe to begin with. By laying only enough pipe at first to reach the best patronage but little capital will be required and it will pay.

How many boilers would be needed?

Three or four to start with, and increase as the consumption increases. By putting in furnaces like those at Milwaukee, you can burn soft coal screenings, and run it with very little expense. The Milwaukee furnaces burn the coal without smoke; the smoke is all consumed.

For what purposes could the steam be used?

It would furnish power for engines up to, say, ten horse power; it will cook and bake, and do everything that a stove or range will do; it will heat houses, melt snow in the streets and on the sidewalks, and it is better than water, in many instances, for putting out fires, as you can thrust the nozzle into a room and the steam will penetrate every nook and corner when cold water would only deluge the floor. The day will come when steam will be used the same as water now is for putting out fires, and in cities where steam fire engines are used we will furnish the steam for the engine, thus greatly lessening the weight of the latter by dispensing with the boiler. The light engine, on wheels, will be run to the hydrants and there be supplied with both water and steam. There are a great many other uses to which steam will be put, and it will be supplied to every house the same as water and gas are now supplied.

We learn that quite a number of [illegible] citizens have the matter under advisement and we have no doubt a company could be organized to put in the steam heating works in Burlington if some one could lead off in the enterprise. It would undoubtedly be another good boom for our manufacturing industries, and we hope the movement will be undertaken.

WISE WORDS.

A NEW STANDARD OF LIGHT[1]

Nature Dec 18 1879

IN the pamphlet before us we have a proposal for a new form of standard light, and the author has shown some considerable skill in drawing out his method of producing it. We cannot do better than quote his opening paragraph as showing the requisites of a standard that the author deems necessary. He says:—

"No exact measurement of any quantity, even with the most accurate and sensitive test measures available, can reasonably be expected unless the standard by which the unknown quantity is to be gauged is perfectly constant in itself; or if nature does not permit of such a desirable state of things, the causes to which the variation of the standard are due should be known, and in addition also, their quantitative effect on the standard, in order to be able to introduce a correction whenever accuracy of measurement should permit, and circumstances necessitate it."

The want of a standard of light has long been felt in physical researches, and the British Association has acknowledged the impossibility of obtaining scientific measures with the ordinary standards, and has appointed a committee to consider the question of fixing such a standard of white light, that a unit of light may be capable of accurate definition. It must not be forgotten that up to quite recent times the principal necessity for a standard at all has arisen through the introduction of gas into our dwellings and streets, and it has only been necessary to adopt one which should give the comparative illuminating powers of any variable qualities of gas. In fixing such a standard the points to be looked at were (1) that the standard should be capable of easy and exact reproduction; (2) that the colour of the light should be approximately the same; and (3) that in varying states of barometric pressure and temperature, proper corrections in the results of the comparisons should be feasible. It will be seen further on that a fourth desideratum should be introduced for scientific work. Perhaps on no subject has more attention been paid to small details than in the production of a standard candle, and as a result, when burnt under proper conditions, it gives fairly correct values of the illuminating power of gases.

In the record of Mr. Schwendler's experiments with the standard candle as against his new standard of light, we have some startling variations in the light of a standard candle, but we feel sure that, had the proper conditions been observed, there would never have occurred such a tremendous difference as 72 per cent. We are more convinced that ordinary precautions could not have been rigidly observed when we find that some of the comparisons were made after the candle had been freshly lighted. In gas photometry it is well known that the standard candle should burn at least a quarter of an hour before it can be considered to have settled down to a steady light. The standard candle, however, is not a nice unit of light; and two years ago Mr. Vernon Harcourt introduced to the notice of the British Association a gas standard which seems to meet every requirement. By making a mixture in a small gas-holder of one part of the most volatile spirit from American petroleum which distilled at 50° C. with 600 of air, or seven of the vapour with twenty of air, he produced a gas which, whilst almost insoluble in water, was permanent at all ordinary temperatures and pressures, and which was of a known composition and easy of manufacture. A jet of such a gas could be compared with the ordinary coal-gas, and any variations affecting the one would equally affect the other. The colours of the standard and coal-gas lights are also approximately the same. It seems that a standard of such a character meets the requirements for comparing the illuminating value of different coal-gases. Mr. Schwendler proposes to use the light radiated from platinum foil, when raised to incandescence by an electric current, as a new standard, and we agree that a solid instead of a gaseous body as the source of illumination is a step in the right direction. The standards made, however, appear to have been used for determining the illuminating value of the light produced by dynamo-electric machines under varying conditions of speed of armature and resistance in circuit, and it is in reference to this that we will first judge of its probable effectiveness, since for gas measurements the standards already existent suffice. Some dynamo-electric machines are advertised as generating the light of 50,000 candles, and we will suppose for the moment we are comparing such a light with Mr. Schwendler's standard.

Now it may be safely said that a standard candle, farther away than twenty feet from the photometer, would give too small a light to be practically of use as a standard, whilst if approaching the photometer within one foot the magnitude of the illuminating source would seriously affect any accurate results. In the first case the electric light would have to be about 4,500 feet away from the photometer and in the last about 220 feet. For ordinary photometric work even the least of these distances would be objectionable. The platinum standard employed by Mr. Schwendler is only about ·7 of a standard candle, and these distances would have to be increased nearly 20 per cent.

For practical measurements of this description a candle-power of fifty candles is a far preferable value, which it would be difficult to attain by the method proposed. In this case we have the distances reduced, and if the electric lamp is fixed at a distance of 100 feet, we have the movable standard ranging between twenty feet and three to four feet, and the readings become easy and are not subject to be seriously affected by the magnitude of the illuminating source; in fact, the errors of observation then become of larger magnitude than any error arising from this cause. Another point which we have to note is that as far as the colour of the light from the platinum standard is concerned, it possesses very little advantage over the ordinary gas or candle flame, and it would be impossible, or at all events incorrect, to give the illuminating value of a light such as of that produced by the electric arc in terms of the new standard; some recent experiments have demonstrated that the red light emitted by one square mile of the hollow crater in the positive carbon is equal to about the red light radiated by 40,000 standard candles, whilst the mean green light of the former is equal to the mean green light of about 135,000 of the latter, and until such a time as the relative physiological values of green and red light are accurately known it will be impossible to give any true estimate of the illuminating power of the electric light by ordinary photometric comparisons. Both in magnitude and colour, then, the proposed platinum standard of light seems to fail for measuring light produced by high temperatures.

We now turn to the details of the lamp itself. We have, firstly, a U-shaped piece of thin platinum foil cut out about 20 mm. in total length, each limb of the U being about 3 mm. in breadth, the tops of which are clipped in thick metal clips. The usual arrangements are made for passing a current through this foil, the amount being registered by a galvanometer in circuit. A glass shade is also employed for steadying the light, by keeping off convection currents. There seems to be an objection to this form of lamp for accurate scientific work, where it may be necessary to use an *image* of the source of illumination. For instance, in certain spectroscopic comparisons of different lights only a small portion of the image of the incandescent platinum would fall upon the slit. Now the great difficulty that would be met with would be as to the part of the platinum that would emit a standard light. Near the contacts the heat would be conducted away so rapidly that the colour of the light would be of a different tint.

Again, presumably near the middle of the limbs of the U-shaped foil the temperature would be slightly higher than at the outsides; in fact, no two portions of the foil would be exactly at the same temperature.

For work, then, of this class, the standard seems to fail in an important particular.

The writer of this notice made many experiments on this point some years ago, and it was this objection that led him to abandon the idea of a platinum standard light of a form somewhat similar to that of Mr. Schwendler.

For a standard perfectly suited to scientific work, perhaps the following definition will be found tolerably exact:—It should be a body (solid or liquid), some known area of the surface of which can be kept at a high constant temperature. It seems probable that a combination of a body of good with one of a bad conductivity will eventually be found to offer suitable materials for a really trustworthy standard.

It would be unjust to conclude this notice without paying a testimony to the great value of the experiments which have been carried out by Mr. Schwendler in this research. It is quite possible that a modification of his platinum standard may be constructed which will eliminate the defects which are to be found in it. It is certainly a step in advance of the gas or candle standard for everything beyond merely technical work, but it is not of the same accuracy as other scientific units. W. A.

[1] On a New Standard of Light. By Louis Schwendler. From the *Journal* of the Society of Bengal, vol. xlviii. Part ii., 1879.

Edison's Eureka—The Electric Light at Last.

N. Y. Herald

Herald. Dec. 21 1879

In to-day's HERALD we lay before the public in all its details and completeness what seems to be an absolute solution of one of the most important problems that has fixed the attention of scientific men and inventors in our time—the perfection of the electric light. How shall cities, their streets, public places, churches, theatres and public halls be lighted effectively, agreeably, safely and cheaply? That is an inquiry of dominant importance in municipal administration the world over. And how houses shall be lighted; how the people in their homes shall weather the difficult point of gas, astral oil, gasoline and similar commodities, is one of the grave issues of domestic economy. For a time—for many months together—the people had their hopes excited on this point, and were led to contemplate the practical application of the electric light to ordinary needs as a boon almost within reach, as a conquest of science not merely possible but so nearly made that it might almost be counted as in the number of the wonderful additions that the progress of discovery has made to the physical comforts of life. And then there was a silence about the wonderful invention, and the chronicle bid fair to end like the history of a shooting star.

Everybody was disappointed. Everybody who watches with interest that material progress in the unessential advantages of life upon which depends a great part of what we call civilization, counted the lapse and temporary disappearance of the electric light as an actual loss. It had promised the greatest single advance ever made in the contrivance of artificial methods of illumination, and the failure of the promise left us with a grievous disappointment. In virtue of the glimpses shown in electrical experiments of how near we might be to having in every house these little white stars of the "ethereal essence increate," "heaven's first born" of the phenomena of nature, we had come to class all lower artificial lights with the tallow dip and to regard them with the disgust appropriate to unsatisfactory agencies that we had been compelled to cast aside. In fact, all the progress ever made in the improvement of artificial lights before the electric light was extremely little, and to merge the yellow and white gaslight with the white and yellow flame of the tallow dip was not an extravagant hyperbole of disappointment. The dip itself was a noble advancement of human invention; but the use of gaslight was taught to man by nature in volcanic countries where, through crevices in the rocky rifts of the earth, the escaping vapors caught fire. Perhaps there were exceptions to the number of those disappointed by the apparent failure of efforts to utilize electricity in illumination. All persons deeply interested in the welfare of gas companies stood this failure with great fortitude. Panic had seized upon them at the first reports, and the shares of gas companies had shown the common opinion of what were likely to be the financial consequences of success with electricity. But now they were able to contemplate what seemed the futile labors of Edison with self-satisfied complacency. His lamp was even classed already as a "philosophical toy." "Philosophical toy" is the name that has been given in turn to a number of great inventions before the element of cost in them was brought to bear a satisfactory relation to their practical value.

But the story told in our columns to-day will reassure the public whose faith in the "Wizard of Menlo Park" had grown feeble; will revive the general confidence in the future of electricity as the common agent of domestic and public illumination, and may possibly provoke anew the concern of gasmakers. By this story it will be seen that Mr. Edison has finally elaborated a lamp for the use of electricity that is simpler than any lamp in common use in the houses of the people; as simple as the gas burner itself and more manageable; a lamp that cannot leak and fill the house with vile odors or combustible vapors, that cannot explode and that does not need to be filled or trimmed. Once more, therefore, the public may reasonably anticipate a time when they will be free from nearly all the annoyances and grievances of ordinary lighting apparatuses and in the full enjoyment, besides, of a light compared to which every other, save daylight itself, is a mere glimmering and gloaming; compared to which, indeed, even the daylight of about one-third the year is a deteriorated and adulterated article. People generally knew the soft glory of the light electricity would make, but they never dreamed of the possibility that it could be applied without an appa-

72

ratus so complicated that it would need a special education to enable them to take care of it.

Perhaps, therefore, this may be regarded as the supreme point of Mr. Edi[illegible] achievement in this field—that h[illegible] vented [illegible] of such unexpected and remarkable simplicity. His lamp may be screwed on at the end of any ordinary gas burner and the wires from the electric battery may be conveyed to it in the tube that served to convey the gas to the same burner. Whether the wires thus connected come from a battery in another part of the house, or from some larger common reservoir of electricity outside the house, is a point as to which householders will be able to choose for themselves, since both sources are contemplated by the inventor. Mr. Edison, it will be seen in the narrative, has contrived a battery for household use which can be adapted to any different number of lamps and to other uses also—can light the house at night and run the sewing machine or rock the cradle all day. For country houses, or for the houses in the city of people who want to keep themselves out of the clutches of corporations that may succeed the gas companies, that will be the chosen source of electricity. But in every city this subtle fluid will be made on a large scale and served to houses at a fixed price as gas is now served, and of course the street lamps must be served from such great public laboratories.

Edison's discovery of a substance [illegible] which electricity could produce the ligh[illegible] incandescence with comparative inexpensiveness and perfect effect is one of those little romances of science with w[illegible] the pathway to every great inven[illegible] is strewed. Platinum was a great obstacle for a while in this hunt; and, not altogether satisfactory in operation while of extremely high value, it seemed at the moment as if it might make the search altogether vain. But the happy discovery of the uses of a bit of cotton thread has turned in a moment the whole current of this story into a fortunate channel, and we are rejoiced to congratulate not merely Edison, but the people of all civilized nations, upon Edison's success.

12. From Grah[illegible]'s experiments it may be inferred that, in [illegible]wing metals also, there is a greater constant, D, for lighter gases.

PROF. GEIKIE ON THE GEOLOGY OF THE FAR WEST.

At the opening lecture to his class of Geology, in Edinburgh University, Prof. Geikie gave an account of his recent exploration of the Western territories of North America. He reminded [illegible] by faults, to what [illegible] they had been twisted, and to what ext[illegible] by atmospheric influences. Getting [illegible] tops of these great mountains, he coul[illegible] that the strata were almost entirely horiz[illegible] for miles, and that the valleys had been trenche[illegible] out of them, not by means of faults at all, but actually by erosion of the surface. He found also that the numerous lakes were true basins of erosion, that they had not been formed by any subterranean movements, but actually gouged out by the ice that once covered those mountains. Striking into one of the valleys, he found beautiful horse-shoe moraines These had gone across the valley and formed a succession of lakes; while the beavers had made a great many more lakes i[illegible] places not reached by the moraines. In most of th[illegible] valleys there were hundreds of acres of bog-land, entirely due to the damming of the water by the beavers. The plains in the neighbourhood of the Uintah Mountains were called "Bad Lands," because they were crumbling down under the action of the weather, and nothing would grow up[illegible] them. A skeleton, found in a hill of that district, was brought to Professor Marsh, and turned out to be the bones of an extinct and undescribed reptile. From the Uintah Mountains Prof. Geikie found his way north into the Yellowstone country, and examined the fading traces of volcanic action. The volcanoes seemed in that region to have confined themselves very much to the valleys. The heights on either hand consisted of crystalline rocks; the bottom of the valley had been literally deluged with sheets of lava. These were examined with considerable care. In the course of the examination, huge mounds of gravel and stones were met with, which at the first glance were evidently moraines. The first was marked by a huge block of rock, an erratic of coarse granite, different from the rocks round about. Such bl[illegible] he found to increase in number as he went [illegible] the valley; and on entering the second can[illegible] or gorge, he found the sides exquisitely glac[illegible]. It was clear, therefore, that not only wa[illegible] this second canyon old; it was older than the [illegible] period: it supplied a channel for the glacie[illegible] ground its way out from those mountains. Endeavouring to estimate the minimum thickness of the ice, he traced striæ up to 1,000ft., and th[illegible] evidently went higher than that. But in going further up the valley, he found that the erratic blocks of granite and gneiss dropped by the glacier as it melted went far above the 1,000ft. limit; he got them on the shoulder of one of the great hills overlooking the valley 1,600 or 1,700 feet above the bottom of the valley; the ice, therefore, must have been 1,600ft. or 1,700ft. thick. It thus appeared that not only did those mountains possess glaciers, but some of these were of such thickness as to deserve the name of ice-sheets, covering the whole surrounding region. As to the volcanic phenomena of the district, he saw evidence of a lo[illegible] series of eruptions, one after another, separ[illegible] by prolonged intervals, during which the river was at work cutting out the older lavas, the newer lavas filling up the hollows eroded by the river. In the grand canyon of the Yellowstone, he saw the most marvellous piece of mineral colour anywhere to be seen in the world. It was cut out of tuffs and lavas, showing sulphur yellow, green, vermilion, crimson, and orange tints, so marvellous that it was impossible to transfer them to paper. Leaving the Yellowstone Valley, he struck south-westward into the famous geyser regions, where a number of geysers had been made known of late years more wonderful than those of Iceland. He tried hard here to get a pool to wash in, but could find nothing below 212°, and the only chance of getting a bath was to get into some hole where the water had had time to cool after flowing out of the hot crater. The whole ground was honeycombed with holes, every one of which was filled with gurgling, boiling water. Some went off with wonderful regularity, others were more capricious; and the chief geyser, which threw up an enormous body of water and steam, was very uncertain in its movements. In one part of the district he came upon a marvellous mud spring, the centre of it boiling like a great porridge pot full of white and very pasty porridge. Steam rose through this, and, after forming great bubbles, burst, the mud thrown out forming a sort of rim round the crater. After describing a meeting with Indians on their way to a great council, the Professor said his road after that lay across what he supposed was one of the most wonderful lava fields in the world—hundreds and thousands of square miles of country—a sort of rough plain—having been absolutely deluged with lava. How this lava was poured out he at present could hardly tell; it seemed to have risen through long fissures, and spread out so as to fill a vast area. Here and there along the margin of it were distinct volcanic mounds, apparently formed during later stages of its [illegible]. Coming at length to the Salt Lake territory, one of the [illegible] that struck him was the evidence [illegible] the former vast [illegible]tension of the Salt Lake [illegible] the mou[illegible] [illegible] tains, about 1,000ft. above the present level, and he succeeded in discovering what was the relation between the extended lake, which must have been a great many times larger than the present one, and 1,000ft. deeper, and the glaciers which at one time covered the Wahsatch and the Yellowstone Mountains. Striking into some of the canyons descending from the Wahsatch into the Salt Lake basin, he found evidence of wonderful glaciation. The rocks were smoothed and polished and striated by the glaciers that had come down from the heights, and these glaciers had carried with them great quantities of moraine matter. Huge mounds of rubbish blocked up the valleys here and there, and these mounds came down to the level of the highest terrace. That was to say, that, when the Salt Lake extended far beyond its present area, and was over 1,000ft. deeper than now, the glaciers from the Wahsatch Mountains came down to its edge and shed their bergs over its waters. On his return journey the Professor resumed the examination of the prairies. Coming out of the Colorado Mountains, he noted, in connection with the gravel formerly observed, great quantities of a peculiar grey clay. This clay was inter-stratified with the gravel, and here and there contained a small lacustrine, or terrestrial shell. It was, therefore, a fresh-water deposit, a deposit swept by the waters coming down from the mountains over the prairie; and marked an interval in the period during which the gravel and sand were being thrown down. He traced the gravel mounds over an extensive tract, and he found the gravel had been deposited irregularly, just as would have been the case from the action of water escaping from the melting ends of the ice. A great current would traverse the plain in one direction; then the ice mass would send water in another, so that the whole prairie must have been flooded with water derived from the melting ends of the vast sheets of ice. It was those excessive floods that brought down the gravel and sand; and during that time there were intervals when nothing but the finest mud was coming down, just as was seen in the valleys of the Rhine and Danube.

EDISON'S RESONANT TUNING FORK.

THE following description of a resonant tuning-fork is given by Mr. T. A. Edison:—For the purpose of rendering audible the sounds produced by tuning-forks they are generally mounted upon resonant boxes containing a column of air, whose vibrating period is the same as that of the fork. I have devised a modification,

in which the box is dispensed with, the resonant chamber being formed by the prongs themselves. To make the fork, a thick bell-metal tube has one end closed, a slit is sawed through the centre of the tube nearly to the closed end. This divides the tube and gives two vibratory prongs. To bring the prongs in unison with the column of air between them the tube is put in a lathe and turned thinner until unison is attained, whereupon the sound is powerfully reinforced.

SOME RECENT ADVANCES IN TELEGRAPHY.—IV.*

NOW, as to that which supports the wire. Wires are suspended along the line from pole to pole at distances of about 80 yards; and at every point where the wire rests against the pole (the pole itself being a conductor), if it were not protected in some way, the electricity passing through the wire would fly to the earth and disappear. I told you that on the first line the insulator that was used was a goose-quill. This was speedily replaced by an ordinary earthenware ring; and from that day to this changes have been going on—from rings to cups of all kinds and forms, made of either earthenware, glass, white porcelain, black ebonite, or any other material that the genius of the inventor or manufacturer could bring forward. In this field we have been taught what to use solely by experience. From 1840 to the present day, everybody who has had anything to do with telegraphy has been devising some dodge by which the power of our insulators can be improved; and the concentration of experience of telegraph engineers all over the world has been to show that

WERDERMANN'S ELECTRO-MAGNETIC ENGINE.

Telegraphic Jour. 1. 15. 79

ALTHOUGH many attempts have been, and are being, made to obtain motive power by means of electricity, but very little success can be said to have been attained. As an economical source of power, electricity cannot by any means be said to have established itself, and there does not yet seem any prospect of its doing so. It is not necessary here to enter into any details concerning the relative costs of motive power, produced by the combustion of coal in a steam engine, or of metals and acids in a battery; the extreme unfavourableness of the comparison, as regards the latter, is too well known to need repetition. It is quite possible that considerable use may be made of waste chemical products for producing electricity to obtain motive power, but such cases must be comparatively few, and but very lightly touch upon the general question.

There is, however, a question in which electricity will assuredly play, ere long, a very prominent part, and that is in the "conveyance of motive power to a distance." Should this problem be satisfactorily solved, the enormous sources of power produced by the operations of nature, in the ebb and flow of the tide for instance, which are useless to a great extent, because these operations take effect at places far removed from localities where the power is most required, would be laid under tribute.

The problem has, to a very great extent, been solved by the very great success which has been attained in the means for producing dynamic electricity in the machines of Siemens, Gramme, &c. Given the motive power, we have here the machines necessary and able to convert it into dynamic electricity; the conveyance of the latter to a distance is only a question of stout insulated metallic wires or rods, and it possesses no points of great difficulty. There only remains then the machine to reconvert the electric stream into motive power, and the question is in a very fair way to be solved.

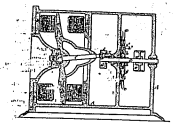
Among the many attempts that have been made in this direction, may be noticed the machine of Mr. Werdermann which possesses several points of novelty worth being pointed out.

In this machine three or more electro-magnets are arranged in a circle with their axes parallel to a main shaft which traverses the centre of an iron plate or disc, on which are fixed the electro-magnets.

In front of the poles of these electro-magnets an oscillating armature, preferably in the form of an obtuse cone, is arranged, provided at the apex with a short shaft and in the centre of its basis with a spherical bearing or universal joint. The shaft fits in a bush of copper or brass, or any other suitable non-magnetic material, fitted to the crank arm which is keyed on the main shaft, while the spherical bearing, made of non-magnetic material, enters a hole cut out at the apex of another disc which is connected with the frame of the apparatus.

On the main shaft is fixed a driving pulley. The shaft also carries a current breaker, which consists of two discs of ebonite or lignum vitæ, or other suitable non-conducting material, a segment of each being replaced by copper or brass, or other suitable conducting material, and connected with a ring of copper. The two discs are insulated from each other and are in contact at the periphery, each with as many springs, rollers, or rubbers as there are electro-magnets. The periphery of each ring is in contact with another spring, roller, or rubber, one of which is connected with the positive and the other with the negative pole of a galvanic battery or other generator of electricity.

The electric current flows through the rings,



segments, rollers, and the coils of the electro-magnets, which in succession, singly, or in series, attract the conical armature, thus forcing the crank pin to move in a circle, or, rather, to develope a cone, through the axis of which passes the main shaft, imparting to it a rotary motion.

The current or contact breaker is adjusted in such a manner that at the moment when one of the electro-magnets is in contact with the cone, the circuit is broken, the contact rollers passing from the copper segment to the insulating surface of the ebonite discs.

In order to obtain the largest possible surface, the polar extensions may be cut obliquely, so that their surface may have the form of an ellipse, or the cone may be provided with as many hemispherical or other projections as there are electro-magnets, the polar extensions of which must be concave or otherwise suitably formed to receive the said projections.

By preference, electro-magnets of a novel construction are employed in the machine; they are composed of an iron cylinder or tube fixed on a bottom plate, coiled with copper wire, or ribbons, or sheets of copper, and placed inside another iron tube, which is also coiled with copper wire, but in an opposite direction, so that the outer tube assumes opposite polarity to that of the inner tube; or, between two concentric tubes of suitable diameter, coiled with copper wire in such a manner that they have both the same polarity, may be inserted a series of cylinders or smaller tubes, coiled with copper wire in such a manner that the cylinders or tubes have all the same polarity, but an opposite polarity to that of the two large tubes, between the peripheries of which they are placed. The two concentric tubes are always magnetised, in fact, they may be permanent magnets, while the smaller magnets are magnetised or demagnetised in succession.

The figure shews a longitudinal section of the engine.

A is a frame of cast iron or other suitable material; a, a^1, are discs or plates forming part of or secured to the frame. The disc a carries one series of electro-magnets b, and the other disc a^1 carries another series of electro-magnets b^1; c is the armature; d is the main shaft of the engines; e is a driving pulley on the shaft.

Two series of three or more electro-magnets b, b^1 are employed, arranged in a circle, with their axes parallel to the main shaft d. Between the poles of these two series of electro-magnets, the oscillating armature c is arranged, which is preferably of the form shewn, and is provided with a central shaft f; one end f^1 of this shaft projects from the centre of the base of the armature c, and is fitted into a bearing g in such a manner as to form therewith a universal joint. This bearing g is formed of non-magnetic material, and is secured in a part of the frame as shewn. The other end f^2 of the shaft f fits in a bush i of copper or brass or other suitable non-magnetic material connected with a crank arm or disc j, which is keyed on the said main shaft d.

The main shaft, besides carrying the driving pulley e, also carries a current breaker k, which consists of a disc k^1 of ebonite or lignum vitæ or other suitable non-conducting material; a segment of this disc is removed, and replaced by copper or brass or other suitable conducting material as shewn at k^2, and connected with a ring k^3 of copper. The communicator k at its periphery is in contact with as many springs, rollers, or rubbers l, as there are electro-magnets in each series. The periphery of each ring k^3 is in contact with another spring, roller, or rubber, one of which is connected with the positive and the other with the negative pole of a galvanic battery or other generator of electricity.

The electric current flows through the said rings, segments, and rollers, and the coils of the electro-magnets, b, b^1, which in succession, singly or in series, attract the conical armature c, thus forcing the end f^2 of the shaft f to move in a circle, or rather to develope a cone, through the axis of which passes the main shaft d, and thereby impart a rotary motion to the said shaft.

The current or contact breaker k is adjusted in such a manner, that at the moment when one of the electro-magnets is in contact with the oscillating armature the circuit is broken, the contact roller passing from the copper segment to the insulating surface of the ebonite disc.

Sci Am Dec 6 1879

[EDISON'S] ELECTRICAL GENERATOR.

To the Editor of the Scientific American:

The letter of Mr. Upton, on page 337, is far from being satisfactory, at least to myself, for it tends to frustrate the realization of the plans I had suggested of relieving Mr. Edison from the appearance of having put forth a preposterous claim for his electric generator. It has almost brought me into the thick of a controversy; I barely escape and reserve my valor for another day. I protest that up to this time I do not know that there is any disagreement between Mr. Edison and myself. Mr. Upton is indeed Mr. Edison's assistant, and his letter purports to be authorized, and yet I cannot find anywhere irrefragable proof that Mr. Edison is the author of the preposterous claim, or that he ever indorsed it. I believe it is best, indeed, as I did in my article on page 305, to assume, until its falsity is proved, that Mr. Edison in the matter of that preposterous claim, or anything else, has not treated with indignity the revered memories of Ohm, Faraday, and the other fathers of electricity. Mr. Edison, like myself, appears to love peace and quietness, and perhaps the guilty author of that preposterous claim will never be discovered and punished. The disagreement which so far is developed is between Mr. Upton and myself only, and it will not long continue if he will take my advice.

The matter in Mr. Upton's letter which is offered as especially pertinent to the preposterous claim is comprised in the two following sentences:

1. "The writer of the article (on page 242) simply stated that the machine was so constructed that when used at its normal capacity the exterior resistance shall be nine times as great as the internal, so that ninety per cent of the power of the current could be used outside."

2. "Yet all that was claimed in the article (page 242) was perfectly true, and has been carefully verified."

I have not been able to satisfy myself as to what are the intent and meaning of sentence 1. I cannot find out what "normal capacity" is. I cannot find out what the thing is which was simply stated; why did not Mr. Upton state it simply? Among various theories of the intent of sentence 1 which I have worked out, the most plausible is, that the sentence is a device like those terrible engines which Knickerbocker, in his history of New York, relates were employed by the ponderous Dutch warriors. This theory derives confirmation from the fact, which appears on page 308, that Mr. Upton found it a fair thing to fire, without warning, at short range, and point blank, hot shot of Calculus (!) right into a gentleman by the name of Weston.

But sentence 2 is direct, explicit, and emphatic. It is so admirable in its way that I quote it again: "Yet *all* that was *claimed* in the article was *perfectly* true, and was *carefully* verified." Now, as nothing was claimed (on 242) but what is covered by the preposterous claim, this latter is signed, sealed, and indorsed; it is represented as having been verified; it is reasserted strenuously. Did Mr. Upton pen that sentence, with the demonstration on page 305 before his eyes?

I reproduce, from page 242, the preposterous claim: "Mr. Edison claims that he realizes ninety per cent of the power applied to this machine in effective external current," and thereupon soon follows the explanation that the great economy is due to the employing of a resistance ratio of 1 : 9. For the demonstration of the fallacy of this I refer to page 305.

I might stop here, for I have said all that is required concerning the matter of the preposterous claim. Mr. Upton introduces several other and extraneous things which are calculated, like that sentence 1, to befog and lead astray the hasty reader, and I shall therefore briefly notice them. The larger part of the letter is devoted to remarks which are aimed more or less directly at myself personally. The general effect of these is substantially that of the trite retort, you're another; but I meet them in detail by pointing out that a part are intended to show that I had overlooked something important, and the rest that I use technical terms ignorantly and recklessly.

1. After a very ingenious prelude, in which I am made to take a rather funny part, the following climax is reached: "It seems never to have occurred to the doctor that it is in the power of the maker of the machine to exert this 'moral suasion' on the wire covering the armature, so that it shall be more effective and redouble its exertion when greater resistance is offered for it to overcome." Mr. Upton is correct; it really never did occur to me. But feeling that such a confession, on account of its brevity, is rather weak, I append the remarks of one whose opinions are worth their weight in diamonds, and are the delight of the world: "If so be ye overhaul yer masheen, tack on [illegible] wire, and make them irons, which ye call magnets, a leetle heftier, why then yer masheen will be bigger; and howbeit ye do these things, why ye'll have a bigger masheen. Bigger, did I say? No! Why? For the bearings of the observation is in the application on it." This is perhaps one of Bunsby's greatest efforts.

2. Mr. Upton neatly gets round to the remark that I deliberately state that current and foot pounds are the same, that energy is directly proportional to the current, etc., and he corrects and instructs me by remarking that "foot pounds are always meas[ured] by the square of the current," etc. Moreover, he says: "Dr. Seeley's distinction of outside from inside current seems to me ridiculous." Mr. Upton, no doubt, made himself quite merry at the discovery of all these blunders of mine. Now I reply: Mr. Upton would not have discovered those blunders unless he had been looking for them; the wish is father to the thought. I do not think anybody else h[as fo]und them, or is likely to find them. When we are obliged to write in the telegraphic style, as we are when limited as to time and space, we spontaneously take up abbreviated expressions which hypercritics might object to. Thus we may use the letter C for current or strength of current or energy of current, and no one but the hypercritics will misunderstand or complain unless some positive ambiguity results. Life is too short to write with a view of satisfying the hypercritics. I might quote many precedents for the expressions I used, but I content myself with a single one, for the reason that it is from an authority which, I am sure, Mr. Upton greatly respects; the authority, please understand, is not Mr. Edison; possibly it is Mr. Upton himself. If Mr. Upton will turn to page 242 he will find there the preposterous claim as originally propo[unde]d and he will observe that the last two words are "o[illegible]." How is it now? Will Mr. Upton ever again say, "the [illegible] action of outside from inside current se[ems] to me ridic[ulous]"?

After finishing my case, Mr. [illegible] "In conclusion, I may state that the method [illegible] employed for testing Mr. Edison's machines was fully described in a paper read by me (in August) at the Saratoga meeting of the American Association. At that time (in August), as now, full results were withheld until Mr. Edison was fully satisfied with the performance of the machine." I find in this pretty plain evidence that Mr. Edison did not—and this I have contended for from the first—put forth the preposterous claim. He had full tests in August as well as on October 11th, and of course he knew that he did not realize that 90 per cent; if he had realized it, he would have been fully satisfied with the performance of his machine, for his machine would be the greatest invention of all time.

Mr. Upton concludes by mentioning that Mr. Edison hopes soon to have a machine with a resistance ratio of 1 : 20. I trust this is not quite true. It would be almost a public calamity if Mr. Edison should employ his great talent on such a puerility. I quote again: "His machine is so made that it would be impossible to use it with the same resistance outside as inside, as it would heat the wire on the armature so as almost to burn it, by carrying a current so much in excess of that for which it was intended." The truth of this must be evident to any one who is a tolerable expert on machines; but I quote it as further evidence that Mr. Edison is not the author of the preposterous claim, and to raise the [illegible] whether we cannot relieve Mr. Upton also from sus-

A few weeks since (suppose) the startling announcement was made in the papers that X, a dear and distinguished friend of mine, had lifted himself over a tall fence by pulling on his boot straps. Many respectable people, influenced mainly by their exalted and often proved faith in the ability of X, accepted the announcement as true; for my friend was an eminent authority and exceedingly expert in the matters relating to the alleged achievement. The hopeful people at once began speculations on the applications of X's discovery to rapid transit and other great projects. The larger part of the community, however, remembering something of the little lessons in natural philosophy of their school days, denied the claims set up for X, and they scoffed at him. At this juncture it seemed to me a proper thing and a duty towards a *friend* and to the public to make an explanation. I said that the feat proclaimed was really an impossibility, that it was a contradiction of the law of action and reaction; that the pulling up on the boot strap would be precisely balanced by the pressing down of the feet in the boots, etc.; that my friend was of too good sense to claim impossible [pe]rformances; that the announcement was an exaggeration, or came from a wicked partner, etc. My explanation w[a]s calculated to pacify the scoffers and to make all lovely again. My friend had no call to say anything, unless to [indo]rse my explanation or to turn the whole affair into mild b[ut] pleasing entertainment by relating how the announcement originated in a little badinage of his, in which he propose[d] to lift himself over the fence, by pulling on [illegible] boot strap[s] [illegible] his carriage after slinging them over a p[illegible] etc. But the affair is going to terminate differently and sadly. For a gentleman by the name of Z, who is an assistant (some say a partner) of X, has written a letter to the public w[hich] purports to be authorized by X, in which the original claim is reasserted and enlarged. Mr. Z says: "Spring, at its normal capacity, is the pleasantest season of the year. X never denied Newton's laws. Yet all that was claimed in the papers was perfectly true, and has been carefully verified. X has positively lifted himself over a fence ten feet high, and it may be mentioned that he hopes to lift himself over a fence 20 feet high. There are doors in the fence, but they [illegible] patent locks on them. (What does this mean?) This [illegible] doctor, and I wouldn't trust him with a sk[illegible] [illegible] with a G, and his name is mentioned [illegible] [conn]ection with a neighbor's hen roost." This letter of [illegible] great [illegible] to us, but I protest and persist that [illegible] innocent [illegible] can foretell what is to come out of all this [illegible].

But all this is supposition. [illegible] isn't apropos of anything. "The bearings of an observation is in the application on it."

CHARLES A. SEELEY.

A Note from Mr. Edison.—The Hughes Microphone and the Blake Transmitter.

To the Editor of the Scientific American:

In reference to the communication from T. D. Lockwood, which appeared in the SCIENTIFIC AMERICAN (No. 21), November 22, 1879, regarding the carbon telephone, I wish to say that his statement that the scientific men of Europe have supported the claim of Hughes that the microphonic action is different from the carbon telephone, is absolutely false, and as a fact just the contrary is the case. Also that the Patent Office has declared that the Blake transmitter filed in the Patent Office in 1879 infringes several of my patents filed in 1877. In fact there is not the slightest difference between the carbon transmitter and the so-called Blake transmitter, except in size of parts and delicacy of adjustment.

T. A. EDISON.

Menlo Park, N. J., November, 1879.

77

HEINRICHS' ELECTRIC LAMP.

Telegraphic Journal

By C. F. HEINRICHS.

Sep 15 1879

THERE have been lately many systems of electric lighting shown to the public, in which the production of small lights for the purpose of superseding gas has been quite successfully effected; but, from a financial point, they have not been quite satisfactory, as the unpracticability of the subdivision of the electric current for lighting purposes without loss has been often proved.

The only field in which electric lighting has already superseded gas, both as regards its being superior in illuminating power, and also its being actually cheaper than gas, has been where large lights (1,000 to 6,000 candle power) have been employed, and in which the consumption of the carbon pencils has been regulated by clockwork.

The only drawback in this line has been the inefficiency of the regulating mechanism; thus the light becomes extinguished frequently, and in some lamps it takes from 4 to 10 seconds before they are relit, and a disagreeable flicker is the result.

In almost all regulators, where the consumption of the carbon is regulated by clockwork, in conjunction with an electro-magnet, the current which produces the light has to pass through this magnet, and the increase or decrease of the current increases or decreases the attracting power on the armature of the same, which stops or releases the clockwork. I have found always that when the armature releases the clockwork and the carbon feed, the increase of the current does not take effect at once, not in proportion to the feed, and not until the arc covers again sufficiently and equally the new advanced mass of the positive carbon, and this sometimes takes from 2 to 10 seconds of time. Now in this time the clockwork is free, and the carbons keep feeding, and, therefore, are liable to come too close together, which produces the disagreeable hissing noise so often observed; or else, by the carbons coming quite together, the great increase in the current flowing in the circuit causes the generator to become heated, and its insulation thereby to be impaired.

That the increase of the current does not take effect at once when the carbons feed, will be explained by the fact that the heated carbon is a better conductor than the cold, therefore the current cannot rise to its maximum power until the new advanced mass of carbon is equally heated, and not until then does the arc equally cover the positive carbon; when again the arc becomes most conductive, and the current most powerful, then by its acting upon the armature of the magnet, it prevents the carbon from further feeding.

It will, therefore, be evident that regulators should be so constructed that when they are extinguished by accident they shall re-light instantaneously; and, secondly, that the carbon points shall never come actually in contact while burning.

The last point has been already effected by the candles of Jablochkoff, Wilde, &c., in which the arc is kept always of the same length. But these candles burn only with alternate currents, and the continuous currents have always proved their superiority in light power against alternate currents; also as

are used, all four points will become nearly pointed. Fig. 5 shows the candle arranged on a lamp post, the carbon points, in this case, being set upwards. These candles may be constructed for any size of light, and will burn from 10 to 24 hours without change of carbon; in fact, an advantage is gained by their being made in that shape. It is very difficult to make long carbons accurately straight, and unless they are so the points will not preserve their proper position relative to one another when set in the lamp. The circular carbons being made in the form of a ring, and then cut into two parts, accurately keep their annular form, and always, therefore, will burn with their points in the same relative position.

An important point attained by the use of the circular carbons is economy of space and portability; when straight carbons are used, it is evident that the length of the space occupied by the lamp cannot be less than that of the two carbons, whereas with the circular carbons the length occupied is reduced to less than one-third, thus rendering the lamp very compact. Practically, also, it must be evident that long carbons could be used without inconvenience, and thus the lamp could be kept burning for a very long time without renewals. The manufacture of the circular carbons presents no difficulty whatever.

The whole system is most economical for lighting public halls and large open places, as the lamps can be fixed at an unusual height, with a reflector and glass globe, so that rain, wind and dust would have no effect, whilst they will cast their light to a long distance.

PRODUCTS OF THE VOLTAIC ARC.

SHORTLY before his death, the late Professor T. Wills, of Greenwich Naval College, made the important discovery that nitric oxide is formed in the voltaic arc. More recently Professor James Dewar, of the Royal Institution, has determined the curious fact that hydrocyanic, or prussic acid, that deadly poison, usually distilled from laurel leaves or bitter almonds, is formed in small quantities in the voltaic arc.

A series of experiments favouring the conclusion that the so-called carbon lines are invariably associated with the formation of acetylene (as suggested by Plucker, Angstrom, and Thalén) induced Professor Dewar to make some experiments to ascertain whether this substance can be extracted from the electric arc, which invariably shows this peculiar spectrum at the positive pole, when it is powerful and occasionally intermittent. For this purpose the carbons were used in the form of tubes, so that a current of air could be drawn by means of an aspirator through either pole, and the products thus extracted from the arc, collected in water, alkalies, and other absorbents. Gases may be led through one of the poles, and suction induced through the other, in order to examine their effect on the arc. The experiments were made by means of the Siemens' and De Méritens' magneto machines. Hydrogen led in by the positive pole, and the gases extracted, gave the well-known acetylene compound with ammoniacal sub-chloride of copper; while, at the same time, a wash-bottle containing water gave distinct evidences of the presence of hydrocyanic acid. Air drawn through the negative carbon gave considerable quantities of hydrocyanic acid, which was greatly increased by extracting the gases through the positive carbon. Carbons purified in chlorine and hydrogen gave with De Méritens' nothing; with Siemens', and a draught of air through the negative pole, a small quantity of hydrocyanic acid, but a larger yield when positive was used. The gases extracted after the absorption of the hydrocyanic acid contained acetylene. If the carbons are not purified, sulphuretted hydrogen is always found along with other gases. The inference to be drawn from these experiments is that the high temperature of the positive pole is required to produce the reaction, which is in all probability the result of acetylene reacting with free nitrogen, as when induction sparks are passed through the mixed gases, viz.: $C_2H_2 + N_2 = 2HCN$, and that the hydrogen is obtained from the decomposition of aqueous vapour and the combined hydrogen in the carbons. It is possible traces of alkaline salts in the carbon poles may favour the formation of hydrocyanic acid, but, as all attempts to purify the poles so as to stop the reaction failed, I am inclined to believe it is a direct synthesis. The acetylene reaction is one of the many remarkable syntheses discovered by Professor Berthelot, of Paris. The presence of sulphuretted hydrogen is doubtless due to the reduction of the sulphates, invariably present in the ash of the carbon. A more complete examination of the various reactions to be brought about by means of the Siemens' arc, and with poles of varied composition, and in presence of different gases, will be communicated to the society in a subsequent paper.

The hard diamond-like deposit of carbon, which after a short time is found to obscure the interior of the globe of an incandescent carbon electric lamp, like the Sawyer-Mann, has also been made the subject of analysis by Mr. B. S. Proctor. The lamp examined was made by Mr. J. W. Sivan, and exhibited to the Newcastle Chemical Society in December last year. It consisted of a glass flask, which after being filled with nitrogen was exhausted by a Sprengel, and an incandescent pencil of carbon. It was, therefore, supposed to contain nothing which could carry carbon from the glowing pencil to the cooler surface of the glass around it. Platinum contacts were employed to connect the current with the carbon.

Under the microscope the smoky deposit on the glass showed numerous bright globules, no doubt of platinum, and more minute particles of dark matter, nebulous, under a $\frac{1}{4}$-inch objective. On exposing the glass to an oxidising heat, the deposit partially disappeared, still leaving the glass partially darkened however.

The platinum support was coated with dark sublimate. The deposit on the glass was not entirely dissolved by *aqua-regia*, and analysis showed that the soot contained platinum, carbon, and iron. The platinum globules might result from the disruptive discharge which took place at the moment the lamp failed.

80

CHRONIQUE DE LA LUMIÈRE ÉLECTRIQUE

La Correspondance Scientifique 2 Dec 79

Des expériences comparatives vont avoir lieu cette semaine, croyons-nous, à l'Opéra et dans une des salles de la gare Saint-Lazare, d'une part, entre la bougie Jablochkoff et la lampe Werderman, et, d'autre part, entre cette même bougie — qui est devenue aujourd'hui un véritable point de comparaison — et les lampes Loutin et Seimens.

Ces expériences, dont il est facile de prévoir le résultat, permettront de fixer le public sur la valeur des systèmes employés.

Nous disons à dessein le *public*, car, depuis longtemps, les électriciens ont une opinion faite sur ces lampes à mécanisme compliqué et à fonctionnement irrégulier que l'on nous a présentées ces temps derniers, avec une exagération intolérable de réclames.

A ce propos, nous ne pouvons nous empêcher de regretter la façon dont M. Siemens ou plutôt son représentant a cru devoir, au palais de l'Industrie, attirer l'attention publique. Le bout de l'oreille passait de telle sorte qu'il était impossible de s'y tromper : on voulait prouver que la lampe Seimens pouvait et devait avantageusement remplacer la bougie Jablochkoff.

Ainsi que nous le disions haut, c'était la bougie Jabloc'.koff que l'on désignait comme mesure de comparaison, en montrant au public quelques luminaires d'une lumière pâle et vacillante.

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Le monde savant est assez étonné de voir décerner un diplôme d'honneur à la compagnie Loutin, alors surtout que le jury de la classe de l'électricité était généralement composé d'hommes compétents, très au courant des choses relatives à la lumière électrique. Nous croyons être bien renseignés en disant que le jury n'est pour rien dans la haute distinction accordée à M. Loutin et que celui-ci aurait tort de se prévaloir outre mesure de ce diplôme d'honneur. Il nous paraît inutile, quant présent, d'insister sur ce sujet; nous y reviendrons s'il le faut, nous y reviendrons avec d'autant plus de connaissance de cause, que M. Ch. Varey, notre rédacteur en chef, faisait partie de ce jury.

***

Cela dit, nous ajouterons que toutes les expériences que l'on pourra faire ne nous déplaisent en aucune façon, elles sont même utiles dans certains cas, ne serait-ce que pour provoquer le silence de certains inventeurs turbulents ou de sociétés financières auxquelles les succès des autres portait envie.

En attendant que nous puissions consacrer une étude sérieuse aux expériences qui vont se produire dans d'excellentes conditions aussi bien au point de vue pratique qu'au point de vue économique, nous sommes heureux d'annoncer à nos lecteurs que la bougie Jablochkoff fait à Londres des progrès considérables. Elle vient d'entrer, et d'entrer par la grande porte, dans l'éclairage privé. Ce n'est plus seulement la voie publique qui est éclairée à Londres par cette splendide lumière, mais de nombreux établissements particuliers. Et remarquez que le succès n'est venu qu'après la réussite des expériences entreprises sur les quais de la Tamise. Les Anglais ne s'enthousiasment pas facilement — et ils ont raison. Lorsqu'ils adoptent une invention, c'est que la démonstation de la valeur est positivement sérieusement faite. En lisant cette semaine, dans les journaux scientifiques anglais, la marche progressive de l'emploi de la bougie Jablochkoff, je me suis rappelé les lignes écrites par M. le comte du Moncel dans son livre si intéressant, l'*Eclairage électrique*, lignes qu'il nous paraît opportun de rappeler, en ces temps de singulières revendications :

« C'est grâce à elles et à la puissante Compagnie qui s'est organisée pour exploiter cette invention — écrivait l'éminent électricien, en parlant de la bougie Jablochkoff — qu'on a pu entreprendre ces belles expériences et ces éclairages splendides de l'avenue de l'Opéra, de l'Arc-de-Triomphe de l'Étoile, de la Chambre des députés, des magasins du Louvre, du théâtre du Châtelet, etc., qui ont émerveillé tous les étrangers qui sont venus à Paris lors de l'Exposition de 1878, et ont démontré que l'éclairage électrique n'était pas une chimère comme avaient voulu le prétendre les intéressés des compagnies du gaz. Enfin ce sont elles qui ont provoqué cet engouement général de tous les pays pour l'éclairage électrique, qui amènera fatalement d'ici à peu de temps la substitution au moins partielle de l'éclairage électrique à l'éclairage au gaz. »

A. de Rupembert.

81

EXPOSITION DES SCIENCES
APPLIQUÉES A L'INDUSTRIE

La Science pour tous Nov 29 1879

Exposition Loutin

La production du fluide électrique à bas prix n'est pas le seul problème que doive poursuivre l'ingénieur électricien; il faut en outre qu'il songe à utiliser ce fluide de la manière la plus avantageuse et la plus complète.

La transformation du fluide en lumière a lieu soit par la combustion de baguettes de charbon, sous l'influence des courants électriques, soit par l'incandescence du platine porté au blanc éblouissant, suite de son échauffement sous l'action de ces mêmes courants.

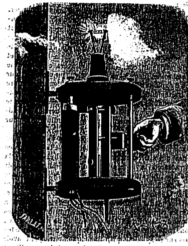

Fig. 158. — Régulateur automatique pour lampe à incandescence de fil de platine.

Dans le premier cas, les appareils employés sont basés sur le même principe que les autres lampes électriques déjà décrites de Jablochkoff, Werdermann, Reynier, etc. Ils consistent en baguettes de charbon poussées automatiquement l'une contre l'autre, entre les extrémités desquelles jaillit l'étincelle lumineuse. En réunissant, comme le montre la figure 160, quatre systèmes de baguettes de charbon rayonnant vers un centre unique, sans se toucher, on obtient ce que M. Loutin appelle un soleil électrique. Quatre courants sont envoyés dans ces quatre charbons, de manière à donner naissance à quatre étincelles ou plutôt à quatre arcs voltaïques qui se confondent pour former un seul point lumineux d'une intensité prodigieuse.

Un phénomène curieux se produit si l'on vient à écarter les charbons les uns des autres : des flammes jaillissent, non pas avec amoindrissement de lumière, comme cela se

présente dans les cas ordinaires, mais avec accroissement notable. Ces flammes peuvent atteindre quinze centimètres de longueur, et affectent la forme fourchue. On ignore, paraît-il, la vraie cause de ce phénomène, qui est le contraire de ce que l'on connaît de l'arc voltaïque lumineux, quand il se présente dans les autres lampes électriques.

On peut également, avons-nous dit, produire la lumière électrique en élevant la température du platine jusqu'au blanc éblouissant. Dans ce cas, le fil dont on doit élever la température n'est pas rectiligne, mais il est contourné en spirale; les deux extrémités de cette spirale sont fixées dans les trous de deux bornes de cuivre où les serrent fortement des vis à tête aplatie.

Ce mode d'utilisation de la lumière électrique est moins favorable et plus coûteux que la combustion des charbons, mais il présente des avantages dans certaines circonstances.

Mais quand on fait passer un courant électrique sur un fil fin de platine, la température de ce fil peut s'élever à un point tel que le métal peut se rompre, brûler, ou se volatiliser. C'est là le plus grand obstacle à l'utilisation de l'incandescence du métal comme foyer lumineux. Le physicien Edison, aujourd'hui illustre, a essayé de corriger cet inconvénient, mais il n'a pu y réussir. On comprend en effet que si, pour une cause ou pour une autre, la quantité de fluide ou sa tension augmente, la chaleur du platine s'élèvera à un point exagéré, et un accident pourra se produire. M. Lontin a obvié à cet inconvénient au moyen d'un régulateur à jeu automatique de type spécial (fig. 158).

Cet appareil est disposé de telle sorte, que si l'intensité du courant s'accroît outre mesure, le jeu d'un électro-aimant attire un petit bouton de fer, qui ouvre au courant une voie de dégagement et interrompt son passage dans le fil de platine.

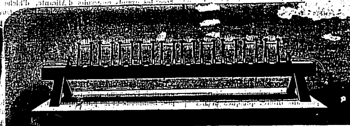

Fig. 159. — Rampe de dix lampes à spirales incandescentes.

Ce fil se refroidit, le régulateur cesse alors d'interrompre le passage du fluide, la spirale redevient lumineuse et éclairante. La même manœuvre se reproduit toutes les fois que l'électro-aimant est influencé par le courant, ce qui a lieu lorsque la force de ce courant atteint un certain degré, le degré nécessaire pour mettre en jeu l'électro-aimant du régulateur.

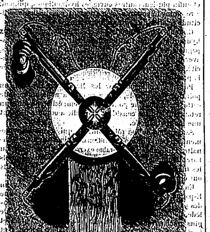

Fig. 160. — Soleil électrique de M. Lontin.

Un seul régulateur peut servir à modérer le courant, non pas d'une seule lampe, mais de plusieurs, de dix par exemple, comme pour cette rampe de dix lampes à spirales de platine représentée par la figure 150.

Ces dix lampes sont dix spirales de fil tendues entre dix paires de bornes de cuivre; elles sont alimentées par une machine à lumière de force moyenne.

Le fil de platine formant ces spirales a un diamètre de un millimètre, et chaque lampe est constituée par une longueur de vingt-cinq centimètres de fil, ce qui donne deux mètres, cinquante centimètres pour la longueur totale de fil employé. Chaque fragment de fil est enroulé en spirale à tours ou spires très-rapprochés les uns des autres, se touchant presque. Avec cette lampe, et au moyen du régulateur qui empêche la rupture ou la volatilisation du métal, on peut obtenir des effets lumineux des plus remarquables. Chaque spire peut en effet donner une lumière dont l'intensité variera de la simple veilleuse à l'éclat de plusieurs becs Carcel.

Nous devons constater que l'exposition de M. Lontin est vraiment l'une des plus remarquables, si même elle n'est pas la plus curieuse, de l'Exposition des Sciences appliquées à l'Industrie; il ne nous reste plus qu'à nous rendre compte des avantages que ces appareils producteurs

83

L'ÉCLAIRAGE ÉLECTRIQUE

PAR LA PILE TOMMASI.

Le Nature Dec 13 1879

Toute invention nouvelle qui se présente au public, appelle son attention à plusieurs points de vue très différents et souvent contradictoires.

C'est le cas de la pile Tommasi qui fait beaucoup parler d'elle depuis quelque temps et dont le côté *affaires* fait trop négliger, par ses promoteurs, le côté *scientifique* et surtout le côté *pratique*. Aussi est-ce au point de vue scientifique et pratique seulement que nous allons examiner les procédés d'éclairage électrique domestique et public de M. Tommasi, laissant de côté le point de vue *affaires* qui n'est ni de notre ressort, ni de notre compétence.

M. Tommasi emploie comme producteur d'électricité la pile Bunsen à laquelle il apporte quelques modifications de détail plus ou moins heureuses.

Prenons pour type, une batterie composée de 16 éléments Tommasi devant faire fonctionner une lampe à incandescence de charbon de 15 becs de gaz brûlant chacun 140 litres à l'heure, chiffres donnés dans la notice qui nous a été remise par la Société lorsque nous sommes allé voir les expériences et sur lesquels il y a lieu de faire quelques réserves.

Chaque élément de la pile Tommasi se compose d'un vase en terre renfermant un cylindre de zinc creux qui lui est soudé par un enduit, pour préserver la surface extérieure du zinc de l'attaque de l'eau acidulée dans laquelle il plonge.

Les vases poreux placés au milieu du vase extérieur sont *hermétiquement fermés;* émaillés dans leur partie inférieure qui contient de l'acide azotique en quantité suffisante pour durer *dix* jours, ils sont poreux dans la partie supérieure qui se trouve en regard du zinc. Les charbons demi-cylindriques sont placés dans le vase poreux à la même hauteur que les zincs dans le vase extérieur. Lorsque la pile est au repos, les charbons ne sont pas plongés dans l'acide nitrique. Pour mettre la pile en activité, on fait descendre dans la partie inférieure des vases poreux, des demi-cylindres de porcelaine dont le volume égale celui du charbon, ils font alors remonter le niveau de l'acide azotique qui vient baigner les charbons.

L'eau acidulée $\frac{1}{11}$ des vases extérieurs, a une circulation continue à l'aide de syphons convenablement disposés qui les fait communiquer entre eux.

L'invention de M. Tommasi dans cette disposition nouvelle de la pile Bunsen, se réduit donc à préserver la surface extérieure du zinc, idée qui n'est pas neuve, et à boucher hermétiquement le vase poreux pour empêcher le dégagement des vapeurs nitreuses si désagréables et si dangereuses.

Ici la critique est par trop facile au point de vue scientifique. La pile Bunsen *doit* dégager des vapeurs nitreuses pour fonctionner, puisque l'acide nitrique qui joue le rôle de dépolarisant, se transforme en acide hypoazotique pour effectuer cette dépolarisation.

Il faut donc, ou bien que l'acide nitrique soit inerte dans la pile et alors sa présence est inutile, ou bien que l'acide hypoazotique produit se dégage par les pores des vases, et c'est en effet ce qui arrive lorsque l'acide azotique a absorbé tout ce qu'il peut d'acide hypoazotique. Dans la pile Bunsen ordinaire, on laisse échapper l'acide hypoazotique dans l'atmosphère, dans la pile Tommasi il doit traverser les vases poreux; c'est mettre un obstacle à son dégagement, mais non un arrêt, obstacle qui nuit à la production de la pile sans lui enlever ses inconvénients.

Nous ne dirons presque rien de la lampe électrique de M. Tommasi, connue des lecteurs de *La Nature* par les appareils analogues dont elle est une copie. Une tige de charbon de 1 millimètre à 2 de diamètre est appuyée contre un disque supérieur en graphite contre lequel elle est poussée par un ressort comme les bougies de voitures. On n'a qu'à se reporter aux appareils de M. Émile Reynier, Werdermann, Ducretet, Trouvé, etc., précédemment décrits. Nous avons remarqué cependant un système ingénieux qui permet de faire passer le courant d'un charbon à l'autre lorsque le premier est usé, dispositif qui constitue la *Lampe-revolver*. Grâce à la circulation de l'acide sulfurique et au renouvellement partiel de l'acide azotique on peut faire marcher pendant dix jours, à raison de quatre heures par jour, une lampe à incandescence dont la lumière, d'après le rapport de M. l'abbé Moigno, égale celle de 15 becs de gaz.

Après ces 40 heures de fonctionnement, il faut démonter la pile pour renouveler l'acide nitrique, nettoyer les zincs, les ré[illegible] la pile et ainsi de suite chaque fois [illegible] heures. Au point de vue pratique, cette [illegible] nous paraît impossible, et en admettant même les chiffres extrêmes de la notice, nous croyons peu au succès de la pile Tommasi en dehors de quelques applications dans les laboratoires où les manipulations d'acides sont choses fort secondaires.

Nous nous permettrons donc de différer d'avis avec M. l'abbé Moigno lorsqu'il affirme que la lampe Tommasi *brûle sans oxygène et jusque dans le vide* et de différer d'avis avec M. Paul Giffard, — qu'il ne faut pas confondre avec M. Henry Giffard, l'éminent ingénieur universellement connu, — lorsqu'il affirme que la pile Tommasi, donne la solution tant cherchée de *l'éclairage domestique dans toutes les applications possibles.*

Malgré ces affirmations, nous le répétons, la pile économique pratique et domestique reste encore à trouver. Personne plus que M. Émile Reynier n'était intéressé à la solution d'une question qui aurait ouvert à ses lampes un si grand débouché. M. Émile Reynier a essayé toutes les piles connues dont l'application pouvait donner quelques résultats et voici la conclusion de ses expériences :

« Une pile aussi énergique que la pile Bunsen, aussi économique que la pile Thomson et aussi commode qu'une pile rotative bien agencée, serait encore loin de pouvoir convenir à l'éclairage courant. »

« *Ce n'est donc pas parmi les piles hydro-électriques aujourd'hui connues que se trouve la solution d'un électro-moteur domestique applicable aux lampes électriques actuelles.* »

La pile perpétuelle de M. Tommasi n'a rien changé à ce jugement : le champ reste donc ouvert aux inventeurs.

E. HOSPITALIER,

Ingénieur des Arts et Manufactures

84

from works Nos. 1 and 3. Whether this arises from the withdrawal of the tar at the end of the hydraulic main, or from other causes, I am not prepared to say, but I may state that a general impression prevails at the works that the illuminating power of the gas has been greater since the adoption of the new plan.

With regard to the remaining figures in the table, the only facts worthy of note appear to be that samples of tar were met with containing as high an amount as 13 per cent. of light naphtha, and that as much as 7·5 per cent. was found in ordinary condenser tar. As these figures were obtained from the analyses of samples taken in comparatively warm weather, it is probable that they represent minimum quantities, and that during the winter months the percentages of light hydrocarbons would be found considerably higher.

In my next article I shall endeavour to show what is the absolute light-giving value of the light hydrocarbons to the gas manufacturer when retained in the gas, the estimate being based on the percentage of naphtha found in the stock tars.

ON THE USE OF THE RADIOMETER AS A PHOTOMETER.

35

By Mr. ALEXANDER PEDLER, F.C.S. (London and Berlin), F.I.C., Professor of Chemistry, Presidency College, Calcutta.

In a paper "On the Mechanical Action of Light," by Mr. Crookes,* written about four years ago, and which gave a sort of summary of the results obtained with the radiometer, a few photometrical experiments with the instrument are given, and from them it is concluded that the radiometer is a perfect photometer. The author says: "By this means photometry becomes much simplified; flames the most diverse may readily be compared between themselves, or with other sources of light. A standard candle can now be defined as one which, at x inches off, causes the radiometer to perform y revolutions per minute (the values of x and y having previously been determined by comparison with some ascertained standard); and the statement that a gas-flame is equal to so many candles may, with more accuracy, be replaced by saying that it produces so many revolutions." This conclusion being of great practical importance, and as the experiments on which it was based were very few in number, it appeared to be advisable that they should be, if possible, confirmed by a more extended series of observations.

It being part of my regular work to test the illuminating power of the Calcutta gas, I made a series of observations with the radiometer, comparing it with a standard gas-flame, whilst I was at the same time determining the illuminating power by the ordinary photometric method, as prescribed by the London Gas Referees. My first results were embodied in a note read before the Asiatic Society of Bengal, and published in their Proceedings for August, 1876. The conclusions at which I arrived were not very favourable to the use of the radiometer as a photometer, and one great cause of the discrepancies of my results was apparently to be found in the friction of the instrument. In the paper referred to I say: "It will be seen that these results agree very closely with those calculated according to the law of inverse squares; that is to say, the number of revolutions of the radiometer will be inversely proportional to the square of the distance from the source of light. But it will also be noticed that there is one marked exception to the rule, and that is at a distance of 10 inches from the gas-flame, where the rapidity of revolution is great. Here the actual number of quarter revolutions amounted to 59·36 per minute, whilst theoretically they should have been 90. Evidently when the radiometer is rotating rapidly there must be an immense increase in the friction, so as to reduce the rotation by one-third of the whole amount. There are also indications that when the radiometer is rotating very slowly, there is a considerable disturbance from the theoretical rate of revolution, probably showing that friction has much influence both when the rotation is slow and rapid." My general conclusions on Mr. Crookes's proposal to use the radiometer as a photometer were summed up in the following paragraph in the same paper:—"It is, I think, evident, from these experiments, that it would be impossible to say that because a radiometer rotated 16 times as rapidly with one flame as it did with another, the former flame possessed 16 times the illuminating power of the latter; for it must be seen that in working with either a very high or a very low rate of revolution, there appears to be considerable disturbance due to the friction of the instrument. It is, I believe, possible and even probable that much better results will be obtained by working the radiometer always to a fixed number of revolutions (say about 30 or 40 quarter revolutions per minute), and by altering the distance of the flame until such rapidity is obtained; in this way the friction of the instrument would be reduced to a constant quantity, and the comparative luminosities would be judged by the squares of the distances."

In the hope of proving the feasibility of this method of procedure, I have carried on a series of experiments with the Calcutta gas for more than two years, testing the illuminating power simultaneously by the ordinary photometric method and by the radiometer. The method of procedure was very simple. The instrument used was an ordinary radiometer with four aluminium vanes blackened on one side. The vanes rotate on a steel point, which is supported in the usual glass cup. The glass globe of the radiometer is about 6 centimètres in diameter, and it stands about 18 centimètres from the table. The radiometer was placed on a table which was graduated in centimètres, the zero point of the scale being made the centre of the radiometer. A standard Argand burner was so arranged that the centre of the flame was as nearly as possible at the same height as the vanes of the radiometer, and by means of a test meter exactly 5 cubic feet of gas per hour were burned in the jet. The burner was then moved towards or away from the radiometer until the vanes made exactly 15 whole revolutions or 60 quarter revolutions per minute. This number was selected as being most convenient, for by having a clock in the room audibly beating seconds, it was easy to see whether the rapidity of rotation was correct or not. The radiometer having then attained a constant speed of 60 quarter revolutions per minute, the distance of the centre of the flame from the central pivot of the radiometer was noted. No extraneous light was allowed to reach the radiometer, for all other flames which were burning in the room at the time of determination were either enclosed in the photometer or their light was screened off in some similar way. At the same time, and from the same supply-pipe, the illuminating power of the gas was determined by the photometrical process adopted by the London Gas Referees. In this process the illuminating power, as is well known, is corrected both for the temperature and pressure of the gas at the time of the experiment, the standard of 60° Fahr. and 30 inches pressure being adopted. In this way a large number of values were obtained for this particular radiometer, the experiment for each day showing that a certain distance of the standard flame from the instrument was equal to an illuminating power of so many candles.

To compare each day's experiment with others, I calculated from the numbers obtained what should have been the distance of the standard light from the radiometer if the gas had possessed an illuminating power of 12 candles. The calculation is, of course, a simple one, the distances being directly proportional to the square roots of the illuminating powers. Very considerable variations were, however, found in the numbers thus calculated; but I still persevered with the experiments until I had obtained between 250 and 300 results, which I thought would be sufficient to show the causes of these variations. I did not, of course, expect to obtain a perfectly exact agreement of the results of the photometer with the radiometer, for there is no doubt that the photometric method, though much improved, still does not give absolutely reliable results. This is inherent in the method itself, and it can scarcely be said to be capable of giving results nearer than *plus* or *minus* half a candle. In the second place, the colour of a gas-flame is known to vary somewhat, being sometimes comparatively white, but generally degenerating into a very decided yellow, and Mr. Crookes* has pointed out that different coloured rays have different actions on the radiometer. At first I was inclined to ascribe the differences I obtained to the above two causes; but as my experiments multiplied, and especially as the seasons here changed from the so-called cold weather to the hot weather and rains, it appeared that another and more serious cause affected the results. It appears clearly from my experiments that at the comparatively high temperatures which obtain here during the hot-weather months, the radiometer which I have used is very much less sensitive than at lower temperatures.

In all the experiments which I have made, I have recorded the atmospheric temperature and pressure; but, so far as I can see, it is practically impossible that the slight differences of atmospheric pressure which obtain here can have any effect on the rotation of a radiometer. No attempt has, therefore, been made to connect the changes in the sensitiveness of the radiometer with changes of atmospheric pressure. The readings of temperature are, however, important, for it is clear that, with every change of temperature, there will be an alteration in the tension of the residual gas in the radiometer. It is unfortunate that, working in a comparatively small room, as I have had to do, with sometimes three or four gas-jets burning, as well as the standard candles, it has been practically impossible to keep the atmospheric temperature constant. I have usually read the thermometer immediately on making the determination with the radiometer; but as the temperature was constantly though gradually rising, the exact temperature of the experiment is a little doubtful, for the temperature of the air and of the radiometer during the actual experiments may have varied by a degree or more from the observed temperature. It is clear also that the action of the light on the radiometer will be to raise its temperature, and this will be another disturbing cause which it is impossible to overcome. To eliminate any such slight doubt as the actual temperature at which the experiments have been made in the table below, I have grouped the experiments for every five degrees (Fahrenheit) of temperature. Starting with the lowest temperature which we have here of about 66°, the first group will be from 66° to 70°, the second from 71° to 75°, the third from 76° to 80°, and so on:—

Temperature of Air at Time of Experiment. — Deg. Fahr.	Number of Observations made between these Temperatures.	Calculated Distance of Standard Flame of 12-candle Power from the Radiometer in order to produce 60 Quarter Revolutions per Minute.	Differences.
66 to 70	8	54·5 centimètres.	—
71 „ 75	29	51·7 „ „	2·8 centimètres.
76 „ 80	25	49·5 „ „	2·2 „ „
81 „ 85	51	47·8 „ „	1·7 „ „
86 „ 90	94	43·6 „ „	4·2 „ „
91 „ 95	56	40·1 „ „	3·5 „ „
96 „ 100	8	36·8 „ „	3·3 „ „

It will, I think, be clearly seen from these numbers that the radiometer used in these experiments is much more sensitive at low than at high temperatures. At temperatures of 71° to 75° Fahr., with 12 candle power gas, to obtain 15 rotations of the radiometer per minute, the gas-flame is placed at 51·7 centimètres distance; but with the same amount of light to obtain the same velocity of rotation at a temperature of from 96° to 100° Fahr., it is necessary to

* *Quarterly Journal of Science*, July, 1875.

* Proc. Roy. Soc., xxiv., p. 279.

85

Aug 31 1880

Aug 31 1880

The communication "On the Use of the Radiometer as a Photometer," by Professor Pedler, F.C.S., of Calcutta—[w]hich the kindness of Dr. Frankland enables us to publish in [a]nother part of the present number of the JOURNAL—is the [b]est exposition which has yet appeared of the exact relations [o]f Professor Crookes's discovery to the modern practice of [p]hotometry. We need not repeat in detail the great expec[t]ations which were formed at one time, with much apparent [r]eason, respecting the possible value, as a means of measuring [li]ght, of an instrument which was supposed to be moved by [t]he action of light itself, and whose rate of motion seemed [t]o depend directly and solely on the intensity of the light to [w]hich it was exposed. In this discovery of a motive power [i]n light the germ of the most perfect of all possible photo[m]eters seemed to lie, only waiting the slight additions neces[sa]ry to embody the principle in a workable form. But it is [n]ow evident, from Professor Pedler's account of his experi[m]ents in this direction, that there are causes of disturbance and [er]ror in the radiometer itself and in the conditions under which [it] must be used as a working implement, which render its [in]dications too irregular to be trusted as a measurer of light. [T]he effect of temperature on the extremely rare medium [w]hich fills the radiometer-bulb is shown by Professor Pedler [to] be almost as abnormal as the functions of the instrument [it]self, and it would be impossible to rely, however tentatively, [u]pon the indications of any particular radiometer until the [co]nstants due to its own structural peculiarities had been [de]termined, with some accuracy, by long and difficult experi[m]ent. The net result of Professor Pedler's labours, which [w]ere most carefully directed to the avoidance of all prejudice [an]d preventible error, seems to be that when the peculiar [re]quirements of a radiometer-photometer are most scrupu[lo]usly observed, its records are at best only to be taken as [a]pproximately correct, when compared with the candle-photo[m]eter. Such a conclusion must be held as entirely con[de]mnatory of the apparatus in question. We know that the [or]dinary photometrical method gives results only approxi[m]ately true, and what is wanted in its place is not another [m]ethod of similarly incomplete character, but one which shall [b]e positive, and free from the risk of error which must always [b]e present when the personality of the observer plays such an [im]portant part in the determination of the result, as it does [in] the present system. The radiometer appeared to offer a [po]ssibility of immunity from this personal element, and if [th]is could have been secured without counterbalancing [da]ngers a great advance would have been made in the exact [m]easurement of the power of light. But we must now cease [to] expect that this desirable end will be attained by the [ag]ency of the radiometer, for although it is perfectly [m]echanical in its action, it has been shown to possess a mul[ti]plicity of defects, apparently inherent and insurmountable, [w]hich render its use as a photometer chimerical.

Scientific American Suppl. Nov. 18, 1880

THE FOURTH STATE OF MATTER—A REFUTATION.

IT may interest the readers of *Science* to know the opinion held in Germany respecting those phenomena which led Mr. W. Crookes to believe he had discovered a fourth state of matter. For this purpose we have translated and abridged an article by Dr. J. Puluj, the well known scientist of Vienna, published in the *Chemiker Zeitung!*

According to Mr. Puluj, the beautiful experiments of W. Hittorf, published in 1869, under the title "Electrical Conductibility of Gases," have received too little attention from our scientists, it may be, on account of the modest title. The scientific labors of Goldstein, and some interesting researches of Reitinger and Urbanitzky have met with the same fate. W. Crookes, the renowned English chemist, to whom the writings of the above-named gentlemen were evidently unknown, made similar experiments, the results of which did not differ essentially from those of Mr. Hittorf. His conclusions were, however, entirely new; he declared that his experiments proved a fourth state of matter.

English Mechanic Sept 24 1880

THE ELECTRIC DISCHARGE IN RAREFIED GASES.

SEVERAL Continental *savants* are engaged just now in controverting the claim of Mr. Crookes to the discovery of a fourth state of matter, and otherwise prosecuting the same line of research. The well-known electrician, Dr. Gintl, of Prague, one of the original inventors of the duplex system of transmission, has arrived at the conclusion that the light seen at the negative poles in Crookes's rarefied tubes is due to molecules of the metallic electrode torn off by the discharge, an opinion which is sustained by Dr. Puluíz, of Vienna. Articles interposed in the molecular stream have been found to acquire a coating of the atoms, and if this coating does not take place in the case of an aluminium pole (as has been pointed out by a supporter of Mr. Crookes), it may be due to the fact, elicited by some experiments of Herr E. Wiedemann, that aluminium poles are least liable to disaggregation under the electric discharge. Dr. Puluíz, we learn from our contemporary *l'Electricité*, has contrived a pretty electric light from the negative discharge in a vacuum tube from a Ruhmkorff coil capable of giving a spark of ten centimetres in length. In this device the metallic dust wrenched from the metal pole is concentrated upon a positive pole of carbon which reaches a red heat, but suffers no loss of matter.

The latest published researches on this interesting subject are those of M. Righi, recently communicated to the French Academy of Sciences. His results are as follows:—

1. If, while we produce by means of a Ruhmkorff coil the illumination of a Crookes vacuum tube (for example, one of those in which the negative electrode is cylindrical or spherical), we approach to the glass a conductor connected to the negative electrode, and if at the same time, by means of a magnet, we cause the discharge to bend itself towards the same side of the tube, we shall observe a dark spot produce itself in the midst of the green fluorescence at the part where the glass is negatively charged. It would appear, therefore, that the glass becomes luminous at the point where it acts like a positive electrode.

This results equally from the two following experiments:—

2. Let us insulate one of these tubes by means of long silk threads and approach to the wall a ball communicating with the positive conductor of a Holtz machine. The electrodes of the tube emit positive electricity into the air, and negative is emitted by a point applied to the conductor. The green fluorescence appears upon the electrified wall of the tube, which acts as the positive electrode in the interior discharge.

3. M. Righi has approached the same ball, or a metallic point to the wall, or a little cylindrical Geissler tube containing sulphate of calcium, or phosphorescent strontium. The powder becomes strongly luminous, opposite the ball, if it is negative, and very feebly luminous if it is positive. If the ball, being negative, is placed near the extremity of the tube in such a way that one of the electrodes is between the ball and powder, we distinctly observe the shadow of the electrode project itself upon the powder. We thus obtain with an ordinary Geissler tube one of the striæ phenomena described by Mr. Crookes.

4. The pale light, azure or violet, that is seen to fill the tubes of Crookes is strongly influenced by the hand or by conductors brought near the tube. M. Righi has connected the electrodes of the tube with the conductors of the Holtz machine (without condensers), and has approached insulated balls connected with the two electrodes. Under these circumstances he always finds that the light due to the discharge is attracted by the positive ball, and repelled by the negative one, that is to say, the discharge acts like a body negatively electrified. He has observed this phenomenon, although with less evidence, in Geissler tubes, and particularly in the little tubes containing nitrogen or carbonic acid. Ordinarily the hand repels the discharge, perhaps, because it charges itself under the influence of the tube. See the next experiment.

5. Mr. Crookes has shown that all insulated conductors introduced into one of the tubes charge themselves positively. The following experiment of M. Righi explains this phenomenon.

If, while the current from a Holtz machine is made to pass in a long Crookes tube, we approach to it perpendicularly by one of its electrodes, a small Geissler tube, the other electrode of which is held in the hand, we see in the latter tube a discharge directed from the long tube to the hand. If the potential of the positive conductor is reduced to zero, the little tube becomes dark; but if, on the contrary, we touch the negative conductor, the little tube is traversed by the discharge. It seems, then, that the long tube almost throughout has a potential little different from that of the positive electrode, and that near the negative electrode there occurs a very great fall of potential. It is, therefore, probable that during the discharge the negative electrode becomes heated much more than the positive electrode.

6. This is demonstrated by M. Righi by the following experiment:—The discharge from an induction coil is sent through the electric radiometer; holding the latter in such a position that the mill cannot turn. The discharge is then interrupted, and the apparatus brought back to its normal position, taking care to avoid turning the mill by shocks in the ordinary way or even giving it a negative rotation. Very soon the mill will begin to turn almost with the same swiftness and in the same direction as if the apparatus was still traversed by the discharge. The cause which makes the mill turn is apparently the heat developed when the vanes act as negative electrodes.

According to this experiment, the cause of the mechanical actions proper to the negative electrode are the same as in the radiometer. The electric force of the negative electrode upon the molecules which rush from it charged with negative electricity ought to tend to direct them normally to the surface of the same electrode. When these molecules collide with the glass they discharge themselves upon it, and the glass becoming luminous (see experiment No. 1). In fact, it is often noticeable that discharges pass from the positive electrode to the fluorescent portions of the glass.—*Electrician.*

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LECTRIC MA- PARATUS.

(No. 5157.)

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being kept touching each other; also of the special use of carbon as a convenient resistance for electric light circuits."

The various details of the invention are particularly described with reference to the drawings annexed to the specification.

TRIPLICATE MARSEILLES AND ALGIERS CABLE.

The ss. "Dacia," Capt. Hayward, belonging to the India Rubber, Gutta Percha, and Telegraph Works Company, left Greenhithe on Sunday, the 13th instant, for the Mediterranean to lay a third cable for the French Government between Marseilles and Algiers. The expedition is under the charge of Mr. R. K. Gray, engineer to the India Rubber Company. We have already given particulars of the cable as regards length and type (see *Electrician*, July 31). The insulation resistance is about 700 megohms at 75° Fahrenheit. The ship carries two electric lights, the current being supplied by two Gramme machines worked by two separate engines. These lights light the deck for paying out, picking up and sounding. The lamps have an ingenious hand adjustment. Regnier lamps are carried for lighting the tanks. A sounding wire apparatus, with improved self-adjusting break, is fixed permanently at the taffrail, on the starboard side, the cable stern sheave being on the port side. The machine is driven by a small engine fixed close to it, and connected by driving wheels with vulcanised india rubber tires. The ship carries a buoy containing tanks filled with gas and carrying a well-designed lamp. Electric signals are fitted from bow, stern, and bridge to the engine room and helm. These have been in use in the ship for several years, and answer very well indeed. A system of electric bells between all the cabins, chart rooms, deck-houses and saloon, to the stewards' pantry, is fitted; and altogether the arrangements show that all appliances are being tried that will facilitate the work and thus reduce its cost. Mr. R. K. Gray is, as we have stated, engineer in charge; Mr. E. M. Webb is chief electrician; and there is an excellent staff of assistants, including Mr. Page, who has charge of the electric lighting apparatus, Mr. J. Gray, Mr. C. Gray, Mr. Jones, and Mr. Bosse. Several gentlemen more or less connected with the company or with telegraphy have, through the courtesy of the directors, received passages as vistors, including Mr. Tyler (the secretary to the company), Mr. Foster (son of the late Mr. *Le Neve Foster*, formerly the much repected secretary to the Society of Arts), Mr. Robinson (secretary to the West Coast of America Telegraph Company), Mr. Alfred Niaudet (the well-known French electrician), Mr. Jackson, and Mr. H. L. Webb. It is expected that the work will be completed and the "Dacia" back at Silvertown in about six weeks, and she will soon afterwards start with the "International," to lay the new Mexican cable. The steamer "Newfield" will start in about a fortnight from Silvertown to lay the several cables for the Canadian Government which are being made at Silvertown. Mr. King, formerly engineer to the Western and Brazilian Telegraph Company, has charge of this work.

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1. If, while we produce by means of a Ruhmkorff coil the

Scientific Am. Dec. 8 7

An important improvement in the Sprengel air pump was described by Prof. O. N. Rood, of Columbia College. After cutting off certain sources of leakage into the apparatus by means of mercury traps, he obtained a vacuum of one-sixty millionth of air atmosphere. Still finer results were obtained after the adoption of devices for withdrawing the moisture contained in the mercury used. In conclusion, Prof. Rood said that he had obtained vacua as high as the ninety-four-millionth of an atmosphere in some of his experiments, and in one had gone as high as one one-hundred-and-ten-millionth. There was no reason why higher results even than these should not be obtained, as it was merely a question of making the pump perfectly tight and excluding moisture. Prof. Crookes, of London, who has experimented in this direction, has reported his highest result as one-twenty-millionth of an atmosphere, and in France a distinguished experimentalist had recorded a vacuum of one-seventeen-millionth.

A METHOD FOR PRODUCING THE LIGHT-PHENOMENON OF GEISSLERS' TUBES.—L. Weber.—A U-tube whose limbs are about 770 millimetres in length is filled with mercury, inverted and placed with its limbs in two capsules filled with mercury and connected with the ends of an induction-coil.—*Wiedem*...

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The English Mechanic

AND

WORLD OF SCIENCE AND ART.

FRIDAY, APRIL 7, 1882.

ELECTRIC INCANDESCENT LAMPS.

JUDGING from the numbers of incandescent lamps which are now made every week, it is evident there must either be a very great demand for them or they must be very short-lived, for, if rumour is to be credited, one factory alone is turning them out at the rate of several thousands a week. There are at present five competing patterns, which differ from one another only in details, though some of them are very important, while others are mere matters of choice. From time to time we have given particulars of the various patents which have been taken out in connection with the "bridges" or threads of carbon which form the incandescent medium, and the method of preparing which seems to be the only real point of novelty in connection with the lamps. The early experimenters speedily discovered that even with a so-called perfect vacuum the carbon filament rapidly gave out, owing to the gases occluded in the pores of the carbon, and whilst some sought for special fibres, others endeavoured to so prepare the better-known materials as to overcome this difficulty. Hence, while Edison has, according to rumour, scoured the world and settled upon bamboo fibre, others have contented themselves with more easily-obtained materials, and have endeavoured to prepare what is needed by treating ordinary substances in such a manner as to render them practically homogeneous. Without attempting to give the dimensions of the outer shells of the lamps, which are really of no particular moment, it will suffice to say that they all consist of oval or globular glass envelopes, with more or less elongated stems, and a tubulure at the other end which is left for connecting with the vacuum-pump. The carbon thread, mounted with its wires in the stem-block, is passed into the shell and hermetically sealed by melting the glass around it, and the "lamp" is then placed in the vacuum-pump and submitted to the special treatment which the rival inventors or patentees favour. In Edison's case the thread is raised by degrees to a high state of incandescence while in the "pump," cooling being allowed after each passage of the current. By this means the occluded gases are believed to be eliminated, and certainly the fibres are submitted to a greater trial than they will experience in their future life as lamps. Of course, many of them fail, but the process secures the survival of the fittest, for it is only those which stand the test that are finally sealed up as practically perfect. Other inventors prefer to submit their carbon threads to a high heat in the presence of hydrocarbons, by which means they fill up the pores of the fibre with carbonaceous matter, and make the threads nearly or, it may be, perfectly homogeneous. In any case the final exhaustion is carried as far as possible before the lamp is sealed and passed as ready for use. At the Crystal Palace five different patterns are shown: the Swan (the earliest), Edison's, Maxim's, Lane-Fox's, and the British, and in appearance there is little to choose between them. The real test of superiority is, of course, durability, and of that we have no particulars, save that while at first the life of the lamps was reckoned only in hundreds of hours, it is now reckoned by thousands. Just as in the arc lights, the positive carbon wastes more rapidly than the negative, so in the incandescent threads it is found that there is a transference of carbon from one end of the bridge to the other, and although in the newer devices this defect has been partially remedied by making the thread thicker at the negative end than at the positive, it is obvious that it practically determines the life of the thread, which sooner or later must give out. We hear of threads lasting 4,000 hours, and even longer, which, for practical purposes, means a year of lighting without requiring new lamps; but we imagine that in making an estimate it would be preferable to reckon the life of a lamp at 2,000 hours, which will probably cover contingencies. Besides the carbon thread itself, an important point is the means of connecting it with the wires, and here we find the chief divergence between the different systems; for while Edison prefers, or, at any rate, uses platinum junctions coated with copper, Lane-Fox coats the ends of his filaments with platinum, and dips them into globules of mercury. Maxim's, Swan's, and the British, all use platinum connections slightly varied. For the filament itself, Lane-Fox uses the fibre familiar to housekeepers as bass-broom, the British Company use cocoanut fibre, Maxim and Swan prefer paper, cardboard, or cotton, and Edison, as mentioned above, bamboo. The latter, in fact, professes to have tried all sorts of substances, and to have found in certain species of bamboo just the kind of fibre he requires, both for uniformity of substance and for the facility with which it lends itself to the necessary manipulations. On page 462, Vol. XXXIV., we illustrated and described Edison's latest method of making and arranging incandescent lamps, and it will be sufficient to say here that the bamboo canes are first cut into lengths, then split through the centre, and each half further divided into three. The hard flinty shell is then removed, and the pieces planed down to uniform thickness, when they are placed between metal blocks and subjected to forcible compression, leaving the press as fine threads of bamboo with thick ends. They are then ready for the most important stage in their preparation. This consists in bending them to the required shape by forcing them into grooves in a nickel plate, which is then covered by another plate of the same metal, and the two being clamped tightly together, are raised to a red heat in a furnace. The filaments are thus carbonised, and are attached to the platinum wires in the glass foot or stopper of the lamp (see p. 462, Vol. XXXIV.) by a copper film deposited by electrolysis. The foot being blown into the lamp, the latter is put in the pump, and while the exhaustion is being carried on a current is sent through the bridge of bamboo fibre, which is allowed to cool down several times, while it is raised by degrees to the highest state of incandescence. It is believed that by this means the occluded gases are completely eliminated, but other researches have shown that it is extremely doubtful whether any natural fibre or other form of carbon can be altogether freed from hydrogen, and Mr. Edison acknowledges that, in the present state of the art, it is impossible to construct a lamp which shall have an indefinite duration so far as the carbon thread is concerned. The vacuum in the lamps is produced with ease by means of a modification of Sprengel's pump, a tube being left projecting from the top of the shell, which is connected to the pump-tube. The required vacuum having been produced, the tube is sealed near the joint with the pump, and the lamp being thus separated, the final closure of the shell is made in the form of a bulb fused on the end of the tube, which in the finished state is little more than a projection from the surface of the shell. The lamps hitherto shown by Edison are pear-shaped, but other forms have been made, that most liked by the inventor being a cylinder with rounded ends. In all, however, the finishing or connecting terminal is a screwed piece in which the platinum wires are secured respectively to a screw and a cone in thin brass (the latest are of thin copper), which are insulated from each other by plaster of Paris. The socket, which has the "lead" and return similarly connected to a cone and a female screw, thus makes perfect metallic contact with the lamp as soon as the latter is screwed home. The details of this arrangement have been modified in some specimens, but in principle they are the same. The large-sized lamps have a resistance when hot, of 130 or 140 ohms; the smaller or 8-candle half-lamps, as they are termed, have a resistance of about 80 ohms.

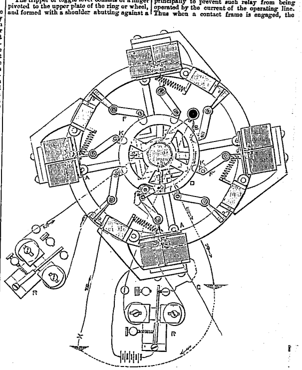
The description above given of the manufacture of the carbon filaments applies with some alteration of detail to all the lamps mentioned; but all the inventors have not been so successful in devising an easy means of securing perfect connection with the main lead and return. Edison uses a filament with a plain bend, Maxim bends it twice on itself so that it represents the letter M, and Swan, as we have previously shown, uses either plain loops or coils. The Maxim lamp is fitted into a socket containing two insulated springs as terminals to the conducting wires, so that perfect contact is maintained by their pressure. These details, which are really of considerable importance, will no doubt be improved; but at present the plan adopted by Mr. Edison is by a long way the most simple as well as efficient. The arrangements for turning out a lamp are practically the same in principle and can be readily understood. The tap, which resembles nothing so much as a gas-tap, in one position is in contact with the lead, lamp, and return, and in the other with only the lead and return, so that no current passes through the lamp when the tap is turned sufficiently to break the circuit with the lamp. Edison uses a split cone, which is, by means of a quick screw-thread on the tap, drawn into connection with two metal blocks, to which the wires are secured. In these simpler arrangements it will be understood that the light given by the lamp depends on the machine generating the current; there is no means of reducing it by turning the tap, which, as before explained, either makes or breaks circuit; but amongst Mr. Edison's devices there is one by means of which the amount of light can be regulated within certain limits. That he accomplishes by means of a rheostat composed of a number of vertical rods of carbon, resembling an elongated lantern-pinion. By turning the base of the box the resistance offered to the passage of the current can be increased or diminished, and within those limits the intensity of the incandescence of the carbon filament can be regulated. The display of incandescent lamps at the Crystal Palace, the steadiness which is their peculiar property, as compared with the arc lights, and the facility with which they lend themselves to all purposes of domestic lighting, have made them the popular favourites; and, we understand, that one factory is selling them at the rate of several thousands a week. The duration of any of these lamps is determined practically by the durability of the carbon filament, though occasionally the glass envelope fractures; but the problem to be solved is the possibility of so preparing the threads and so shaping them that they may have an indefinite life, for it is

clear that if any serious expense is incurred in replacing broken or worn-out lamps, the incandescent system, already more expensive, from the photometric point of view, than the arc lights, will be severely handicapped. That many inventors are turning their attention to the production of superior carbons, our columns testify, and probably in some such direction as that taken by Mr. Crookes (see p. 247, Vol. XXXIV.), the greatest measure of success will be attained.

TELEPHONE EXCHANGE APPARATUS.

THE Telephone Exchanges have scarcely done more than elaborate, and make fairly complete, the systems of switching for use in central stations, before an ingenious inventor comes forward and provides an arrrangement by which any subscriber can connect his telephone with that of any other member of the exchange by means of an automatic instrument in the central office, thus dispensing with the services of an attendant. This apparatus has been patented by Mr. T. A. Connolly, of Washington, and has been recently patented in this country as well as elsewhere. To give a full idea of the various ways in which the invention can be worked would occupy more space than we can spare, but with the assistance of the annexed engraving we shall probably be enabled to render the principal features clear. The apparatus at the central station is of an upright cylindrical form carried on a base with the binding posts to which the various line wires are attached. The engraving is a horizontal section, showing, as if they were on one plane, the electro-magnets, the pivoted armatures of which are connected to escapements or ratchet and pawl devices, for converting the motions of the armatures into the rotary motion of a ratchet wheel. The magnets are really in separate planes or tiers as we may say; they receive current from the central battery, and normally the circuits are open. The closing of these circuits is effected by means of relays R in the normal circuits of the subscribers' or members' lines; these relays are responsive to the impulses transmitted from the subscribers' stations, hence each pulsation of an armature A is in keeping or correspondence with that of its relay. These relays are polarised, and preferably of the form known as "Siemens'," and are adapted to close the circuit of the magnets when the current which energises the said relay is passing in one direction. The current in the reverse direction may be utilised for signalling purposes without effecting any operation of the central machine. The magnets and their ratchet appliances are employed to effect the rotation of the rings or wheels D, one of which is allotted to each line. In addition to a ring each line possesses a "contact bar" or frame F; these frames are pivoted either inside or outside the ring, or outside of the wheel; they are arranged at regular intervals around the rings, and are parallel with the axis thereof. Each bar traverses the whole series of rings, so that all the rings have a similar relation to each and every frame. A connection of any two lines is effected through the ring of the operating or calling line and the contact bar or frame of the called line; for this purpose each ring is furnished with a coupling or connecting device, which in the arrangement under consideration consists of a "tripper" or toggle lever; this lever, as a ring D rotates, comes in contact with the several frames, and rotates the same on their shafts or bearings; at the same time the tripper or toggle, which is normally tangential or inclined with reference to the periphery of the ring, assumes a different position, that is to say, it straightens out, and if then the movement of the ring is discontinued, the tripper and frame remain in their conjointly assumed positions. The object of moving the frame is to isolate it, so that when engaged by a line no other line can obtain connection with it; for this purpose the conditions are such that in its normal position the outer end or head of the tripper does not project sufficiently far beyond the ring or wheel to touch the frame or contact bar when moved or turned by an engaged tripper or toggle.

A line when not in use, or when employed in effecting connection with another, completes its circuit to earth, or to a common ground or return through its tripper or toggle. When engagement is made with a line, this ground or earth connection is broken by the movement of the tripper under the toggle action of a frame or contact bar, and the circuit is completed through the line in which the frame is located. Speaking more specifically, each ring or wheel consists of two plates or rings of metal separated by an insulating filling; the lower plate is in constant contact with the frame of the central machine which communicates with earth, or return, either through supporting rollers if a hollow ring is used, or through a central shaft if a wheel with spokes is employed.



The tripper or toggle lever consists of a finger pivoted to the upper plate of the ring or wheel, and formed with a shoulder abutting against a stop, which limits its movement in one direction, and against which the tripper is held in impingement when not engaging with a contact frame by an easily yielding spring. A spring tail piece or continuation of the tripper or toggle impinges against a bent metal pin, stud, or block extending upward from the lower plate of the wheel or ring, and travels thereon during a portion of the movement of the tripper on its pivot. Thus the operating line which leads into the upper plate and thence to the tripper or toggle makes ground through the said pin, stud, or block, until in engaging with a contact frame such ground connection or contact is broken by the tail-piece leaving the same, when the circuit is diverted into the contact frame to be thence led to the line thereof. As above stated, the tripper or toggle lies normally in an oblique or tangential position, as shown; its outer end is formed with a slight concavity or recess, by which a contact frame in its path is caught and held in effecting and maintaining engagement therewith. As the tripper passes each unoccupied contact frame, momentary engagement and conjoint movement ensue, and the diversion of the circuit from central ground to the line of the engaged frame follows. The circuit or contact is made with the ring from the line thereof by means of a brush or rubber B in the path of the same line insulated from the main frame. A wire leading from the said brush connects with a binding post or cup to which is led a return wire from the relay of the same line. The main line wire G from a station leads to connections in the central machine, thence to the relay, and from the relay by the return wire to the binding post. This circuitous path is provided in order that the relay of a called or passive line may be cut out, so as to reduce resistance, but principally to prevent such relay from being operated by the current of the operating line. Thus when a contact frame is engaged, the circuit with its line is made directly from the outer segment to the line without passing through the relay, the latter being in the branch circuit connected permanently with the inner or shorter segment. It has been explained that when a contact frame is swung out to its limit and engaged by a toggle or tripper, the toggle or tripper of another line will pass by without coming into contact therewith, thus preventing disturbance of the communication through the frame of the called line. Engagement, however, with the frame of an operating line is not thus provided against, but such provision is necessary to prevent the operating line from being broken. For this purpose each contact frame is furnished with an arm K supporting an anti-friction roller, which rides on the periphery of the insulated filling of the ring of the same line. A cam recess in the said filling adjacent to the tripper receives the said roller when the ring is home, but as the latter begins to move the roller is pressed outward to the periphery of the insulated filling. By this

English Mechanic Oct 5 1880

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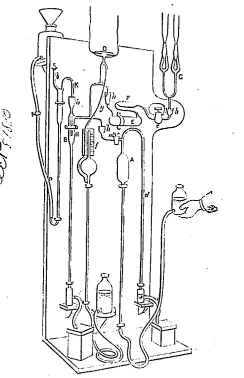
Nov 25

Nov 25th "

No. 48

...R-ZEITUNG.

[39703.]—**Air-Pumps.**—On looking over some back numbers of this paper, I came across query 39703; and although Mr. Wiesendanger has given a sketch of a Sprengel pump, I thought it would be of interest to "C. O. S." to see the combination that Edison uses. I send a sketch, with a slight



explan... n. If "C. O. S.," or anyone else of "our... should desire a further explanation, I shall be happy to give it. A. Geissler's pump; B. Sprengel's pump; C. Macleod's gauge; D. Geissler tube; E. Bulb containing phosphoric anhydride; F. Bulb containing gold leaf; G. Electric lamps; a. Mercury supply-tube; b. Air-trap; c and e. Mercury stop-cocks; d. Discharge-tube; f. Scale; g. Connecting-tube; h. Mercury sealed joints.—J. A. VANDERBILT, New York, Sept. 21st.

...chlagsventil für Wasserstrahlluftpumpen.

...Von Prof. R. Otto.[4])

...Druckschwankungen in der Wasserleitung oder ... Wasserzuflusses, ein Zurücksaugen

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...ion has for its object the production ... means of iron rendered incandescent ... The ends of two conductors are ... with two iron wires, terminating in ... and supported by two insulated and ... supports placed upon a table. The ... soon become red-hot, and afterwards ... at a white heat, but do not melt.

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The Electrician, July 16th 1881.

4755. IMPROVEMENTS IN ELECTRIC LAMPS AND APPARATUS CONNECTED THEREWITH, *J. A. Berly and J. D. Hulett.*—18th November, 1880. 6d.

This invention relates to an apparatus for suspending electric lamps so as to enable the said lamps to be pulled down, detached, &c., to be regulated or attended to, and pushed back into their former position whilst alight. Fig. 1 is an elevation, and Fig. 2 a longitudinal section of the apparatus. In whatever position the sliding portion of the apparatus may be, the currents

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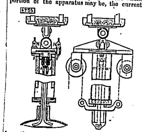


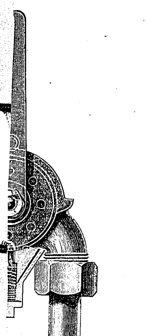
from the circuit wires attached to the terminals N will be conveyed to the strips of metal J and collected by the friction pieces G, from which, through bolts, F, to which they are electrically connected, the second currents will be conveyed to the lamps by means of the conducting wires attached to the heads of the bolts F. The whole apparatus being enclosed, is free from dust and not liable to be damaged, which ensures regularity of working.

Industrial News, Aug. 1881.

THE SUN ELECTRIC LAMP.

La lampe soleil, as it is termed, is a new French electric lamp of considerable promise and some novelty. The light is formed by boring two converging holes into a small block or brick of marble, and inserting into these two carbon rods. The rods are separated at their points by a partition of the marble, and they nearly penetrate through the block. Their upper ends are connected to the dynamo-electric machine, and the current in traversing the wall of marble between their points makes it white hot. The carbons are slowly consumed, the gas escaping from the bore-holes, which are wider than the rods, and they are fed to the arc by their own gravity. The light is admitted by the bottom of the brick, which becomes calcined, and is of a mellow lustre like the sunshine. The cost is said to be only a sou per hour, the carbons consuming at the rate of a centimetre in that time. Already *la lampe soleil* has been introduced into several places in Paris, including the mayor's residence, and it will form a feature of the forthcoming exhibition. It is the invention of MM. Clerac and Bureau; but it reminds us of the electro-calcic lamp patented by Mr. Wentworth L. Scott in 1878, wherein a block of lime or other earth is interposed between the electrodes of the arc. Mr. Scott did not arrange his apparatus like the sun lamp; but his intention was, we understand, to heat a piece of lime white hot by the current, just as it is heated by the mingling gases in the Drummond limelight.—*Engineering.*

1in. by 3-16ths. As to filing them, I am afraid that with the very limited experience I have had with reeds, I should utterly spoil them by attempt-

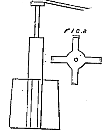


enabled to say whether he knows it or not; I fancy, however, that it is new, although in looking through the back volumes of "ours" for articles on reeds I came across the description of a similar instrument in principle, under the heading of "Automatic Reed Organ," and the "Melophon" is decidedly a modification of the same thing. I would ask "Saul" if he thinks accordion reeds would do for this instrument? I have never seen any myself, so cannot tell. Having written over 350ft. of music from "Les Huguenots," "Faust," "Tannhauser," and other operas, I should much like to put in better reeds. At present I have in the original ones, but the tone is anything but satisfactory. The execution of the music by the machine is all that could be desired, although, of course, there is no expression.—MELOS.

[11135.]—**Medical Coil.**—The form of Fuller cell I employed for my small coil, in which a circular porous pot was used, was modified by using a zinc of cruciform section. To show this more clearly, I inclose sketch, showing elevation and plan of zinc element. The original form was a circular zinc of conical shape only, and, for good reasons, could not be as large as the star-shaped zinc. I found

FIG. 1

FIG. 2



this an improvement, and always use such in a battery of circular form. As you are doubtless aware, the porous pot also contains a quantity of mercury. This rises readily enough for a given distance; after that it cannot be depended on; therefore the stem connecting the arms with the copper wire was Brunswick-blacked or covered with pitch. The copper wire stem is cast in. When using the plate-form of zinc element, I prefer to protect the upper portion also in the same way. There is one thing I would mention with respect to the Fuller cell, and which, in the hands of amateurs, proves a frequent cause of failure. It is the connection on the carbon. After a short time of use, the fluid is apt to creep up and destroy the connection with the binding screws. When these are cast on in lead, it also aggravates matters. My plan is to soak the top of the carbon in paraffin wax; then drive the paraffin down the plate, say, ¼in., and then electrotype the top. To this you may solder any-shaped binder you like, and the fluid never is able to destroy the connection. The makers for the patentee use a lead cap protected with paraffin; but I greatly prefer a copper connection, as mentioned.—SUNLIGHT.

[11138.]—**Midland Railway.**—I am much obliged to "Cambridge" for his reply to my query. Will he kindly say whether the distances to Manchester and Liverpool are *via* Trent Station? Will he also give the shortest distance to Liverpool ...

Nov 25

CHEMIKER-ZEITUNG. Nov 25th " No. 48

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Ein einfaches Rückschlagsventil für Wasserstrahlluftpumpen.
(Von Prof. R. Otto.[4])

Um bei Druckschwankungen in der Wasserleitung oder plötzlichem Abstellen des Wasserzuflusses ein Zurücksaugen des abfliessenden Wassers in den evacuirten Raum zu verhindern, schaltet man entweder zwischen Pumpe und Kolben eine Sicherheitsflasche ein, oder man bringt an den Pumpen besondere Ventile an, welche einen Rückschlag des Wassers überhaupt nicht gestatten.

Als äusserst zweckmässig empfiehlt Verfasser das von seinem Assistenten Dr. Pauly construirte. Diese einfache Vorrichtung besteht aus einer Glasröhre b (siehe beistehende Zeichnung), welche zwischen die Pumpe a und das zu evacuirende mit dem ⊤-Rohre cd zu verbindende Gefäss eingeschaltet wird. cd ist mittelst eines Kautschukstopfens luftdicht in b angebracht und endigt in einem bei g abgeschnürten Endchen Kautschukschlauch, welches mit einem durch ein recht scharfes Messer herzustellenden, penetrirenden Längsschnitt cf versehen ist und in seinem Innern einen soliden Glaskörper — ein Stückchen eines Glasstabes — beherbergt, der nicht völlig die Höhlung des Schlauches ausfüllt.

Chemiker Zeitung Nov 25 1880

Der Einschnitt versieht die Stelle des Sicherheitsventils, indem es der in der Richtung von c nach a sich bewegenden Luft den Durchtritt gewährt, sich aber schliesst, sobald aus irgend welchem Grunde in b von a Wasser gesogen wird.

Dies Ventil hat sich durchaus bewährt, ebenso die in der Zeichnung dargestellte, von Geissler ganz aus Glas construirte Pumpe.

The Electrician, July 2, 1881.

5033. IMPROVEMENTS IN ELECTRIC LAMPS. *J. H. Johnson.—3rd December*, 1880.—(*A communication from A. de Meritens.*)—(*Not proceeded with.*) 2*d.*

This invention has for its object the production of light by means of iron rendered incandescent by electricity. The ends of two conductors are connected with two iron wires, terminating in small balls, and supported by two insulated and adjustable supports placed upon a table. The iron balls soon become red-hot, and afterwards incandescent at a white heat, but do not melt.

The Electrician, July 16th 1881.

4755. IMPROVEMENTS IN ELECTRIC LAMPS AND APPARATUS CONNECTED THEREWITH, J. A. *Berly and J. D. Hulett.—18th November*, 1880. 6*d.*

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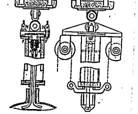

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AN IMPROVED METHOD OF OPERATING THE SPRENGEL AIR-PUMP.*

By Professor Ogden N. Rood.

Professor Rood's paper gave an account of his experiments with the pump for the purpose of obtaining the highest possible vacua. He first experimented with an arrangement similar to the ordinary form of the Sprengel pump, and reduced the pressure to one three-millionth. The exhaustion went on very rapidly at first and then very slowly—slower than the increased rarefaction seemed to call for. This indicated a leakage, and it was found that this leakage amounted in one minute to one-eighty-seven-millionth of an atmosphere. The form of the pump was modified to correct the leakage, and a vacuum was obtained with a pressure of one-sixty-millionth. It was impossible to get beyond that point, and it occurred to Professor Rood that the potash he used might have given out moisture. He therefore substituted sodium, and the pressure rose only to one-four-millionth. Anhydrous phosphoric acid was substituted for the sodium, and the pressure fell to one-millionth. It finally struck the experimenter that the trouble was in the gauge, and when a correction was applied to the gauge, vacua were obtained with pressures of one ninety-four-millionth and one-hundred-and-ten-millionth. Higher vacua even can be obtained.

It had recently been stated in *Nature*, said Professor Rood, that his arrangement was exhibited four years ago at the Kensington Garden, and he would not, therefore, call it new. But the best result obtained in England was one-twenty-millionth, and the best result reached by an eminent French chemist was one-seventeen-millionth. He, therefore, thought there must be at least something new in his method of using the Sprengel air-pump.

* Read before the National Academy of Sciences, N. Y., 1880.

REPORT OF THE COMMISSIONER OF EDUCATION, FOR 1878.

(*Extracts.*)

TEXT-BOOKS AND COURSES OF STUDY.

The lack of uniformity in the conditions of public education in the different States is illustrated in the report on text-books and courses of study.

Returns from 31 States present the following information:

The State board is empowered to decide these matters in California, Connecticut, Delaware, Louisiana, Nevada, and Oregon. In Kansas, Nebraska, New York, and Rhode Island, the State superintendent or commissioner has authority to recommend the text-books to be used, but their adoption and the course of study are finally decided by the school committee or district boards. In Iowa and South Carolina these matters have been decided by a commission appointed for the purpose. In Maine, authority in these matters is delegated to the town supervisor or school committee; in Maryland, to the county commissioners; in Massachusetts, to the school committee; in New Jersey, to school trustees of districts acting with the county superintendents; and in Pennsylvania, to the directors and controllers of each school district, acting with the teachers. District or local boards either solely or acting in concert with superintendents and teachers decide these matters in Michigan, Mississippi, Missouri, Ohio, and Wisconsin.

In the following States—Minnesota, New Hampshire, Tennessee, Texas, Virginia, and West Virginia—the course of study is prescribed by law, but in the application discretion is given to superintendents, local boards, teachers, &c.

In Indiana, North Carolina, and Vermont no definite provision with reference to these matters has been made.

UNIVERSITIES AND COLLEGES.

The total number of universities and colleges reported is 358, with 3,885 instructors and 57,687 pupils. In the preparatory departments of these institutions were 682 instructors and 26,266 students; in the collegiate departments, 3,203 instructors and 30,368 students; unclassified, 1,353. They had 2,187,932 volumes in their libraries, and the value of their buildings, grounds, and apparatus was $36,871,213; their productive funds, $37,071,958; income from these funds, $2,548,324; receipts from tuition, $1,555,484; receipts from State appropriations, $622,577; aggregate amount of scholarship funds, $1,719,426.

Of the students in the preparatory departments, 18,481 are males and 6779 females; 6,576 are preparing for a classical course and 5,621 for a scientific course. In the collegiate departments, 15,803 (14,152 males and 1,651 females) are in classical course, and 3,893 (2,724 males and 1,169 females) are in scientific course.

The summary of college entrance examinations gives the following facts: Total number of candidates, 5,297; admitted without conditions, 2,553; conditioned in Latin, 822; in Greek, 577; in mathematics, 1,068; in history and geography, 585; rejected for deficiency in Latin, 84; in Greek, 70; in mathematics, 66; in history and geography, 22; in two or more subjects of examination, 424.

There are also statements of the numbers preparing for college, classical, and scientific courses, as follows: number preparing for classical course in academies, 6,206; in preparatory schools, 4,195; in universities and colleges, 6,576; preparing for scientific course: in academies, 2,167; in preparatory schools, 1,107; in universities and colleges, 5,621; in preparatory departments of scientific schools, 1,550; total, 27,422.

Students in institutions for superior instruction are distributed thus, viz.: in colleges, 30,368; in schools of science, 11,603; in schools for the superior instruction of women, 18,115; in all 60,086.

The Commissioner presents a brief outline of the movement in colleges to satisfy the demand that the study of science and sociology be advanced to an equality with the classics and mathematics. Without sacrificing anything of the former curriculum, temporary provision for the new studies has been made in most instances by a system of electives. The action is traced through the record of Harvard and Yale Colleges, and the views of Dr. McCosh, president of Princeton College, Dr. Peabody, of Harvard University, and Prof. B. L. Gildersleeve, of Johns Hopkins University, with reference to the most important conditions of the change, are cited.

Some have feared that in this readjustment of college courses the classics would be sacrificed, but the present tendency is toward greater thoroughness and a more extended range in classical studies; nor under the elective system is the number of students who take the modern in place of the classical course sufficiently large to create any apprehension as to the future influence of classical study.

The prevalent views on this subject are well represented in letters from Professor Hæckel of Jena and Professor Zarncke of Leipzig, which are given in full in the report.

SCHOOLS OF SCIENCE.

Of this class 76 schools, including the United States Naval and Military Academies, were reported to the Bureau. They numbered 809 instructors and 13,153 students. The comparative table for the years from 1870 to 1878, inclusive, shows this to be an increase in all particulars over the figures reported for any previous year. The increase above 1877 was in number of schools, 2; instructors, 28; students, 4,594. The number of students in preparatory departments was 1,436, viz.: 1,153 males and 283 females; the number in scientific departments was in regular course, 4,806; in partial course, 772; number of graduate students, 97. The number of volumes in general libraries was 119,164, an increase in the last school year of 3,543; the number in society libraries was 7,737. The value of grounds, buildings, and apparatus reported, was $7,587,421; productive funds, $5,020,446; income from the same, $319,503; receipts from tuition fees, $68,660; from State appropriations, $484,742.

With reference to schools of science the Commissioner observes:

"By the act of 1862 donating public lands to the several States and Territories which should provide colleges for the benefit of agriculture and the mechanic arts, the movement

ous wings and were probably aquatic in early life. The last statement is simply inferred from the fact that all the modern types most nearly allied to them are now aquatic.

"Some of the Devonian Insects are plainly precursors of existing forms, while others seem to have left no trace. The best examples of the former are Platephemera, an aberrant form of an existing family; and Homothetus which, while totally different in the combination of its characters from anything known among living or fossil insects, is the only Palæozoic insect possessing that peculiar arrangement of veins found at the base of the wings in Odonata typified by the arculus, a structure previously known only as early as the Jurassic. Examples of the latter are Gerephemera, which has a multiplicity of simple parallel veins next the costal margin of the wing, such as no other insect ancient or modern is known to possess; and Xenoneura, were the relationship of the internomedian branches to each other and to the rest of the wing is altogether abnormal.

"If, too, the concentric ridges, formerly interpreted by me as possibly representing a stridulating organ, should eventually be proved an actual part of the wing, we should have here a structure which has never since been repeated even in any modified form.

"They show a remarkable variety of structure, indicating an abundance of insect life at that epoch.

"The Devonian Insects also differ remarkably from all other known types, ancient or modern; and some of them appear to be even more complicated than their nearest living allies.

"We appear, therefore, to be no nearer the beginning of things in the Devonian epoch than in the Carboniferous, so far as either greater unity or simplicity of structure is concerned; and these earlier forms cannot be used to any better advantage than the Carboniferous types in support of any special theory of the origin of insects.

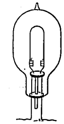
"Finally, while there are some forms which, to some degree, bear out expectations based on the general derivative hypothesis of structural development, there are quite as many which are altogether unexpected, and cannot be explained by that theory without involving suppositions for which no facts can at present be adduced."

The Electrician, July 16. 1881.

239,153. Electric Lamp, *Thomas A. Edison, Menlo Park, N.J.—Filed August* 27th, 1880.

Claim.—(1). The combination with the glass enclosing globe and incandescing conductor of an electric lamp, of a support hermitically sealed to the globe, and supporting the carbons at a distance above the point of sealing, substantially as

239153



set forth. (2). The combination, with the conductors of an incandescent electric lamp, of a glass support, to which the conductors are sealed at two or more points, one near the clamps and one where the conductors enter the enclosing globr, so that the latter point is removed a little distance from the former, substantially as set forth.

The Tradesman Oct. 15, 1881.

The London Athenæum says that M. Jamin has made a considerable advance in the arrangement of his electricht candle. He incloses his carbon loop in a carefully closed vessel containing air. The electric action at first produces the combination of the oxygen and nitrogen of the atmosphere, and the usual colored vapors are seen; these are soon destroyed by the oxygen combining with the carbon, nitrogen and carbonic oxide alone remaining in the glass globe. The phosphorescent arc then becomes quite fixed, giving light of a greenish blue tint. Each candle, by this arrangement, lasts 100 hours.

A NEW AUTOMATIC ELECTRIC LAMP.

We illustrate on this page a new automatic electric lamp made on what is known as the Heinrich system, and which we find described in a recent number of a British scientific journal. One of the distinctive features of Mr. Heinrich's idea is the employment of curved carbon rods, which abut upon each other slightly at their points of intersection. The planes of the two circles are perpendicular to one another, as shown in Figure 14. The upper pair are both positive, being connected to the positive pole of the dynamo-electric generator, and the lower pair are negative, being in electrical connection with the other terminal of the machine. The feed of the carbons requires no mechanical apparatus such as clockwork or gearing, but is determined solely by the mechanical wasting away through the consumption of the carbon rods at their point of contact, the rods falling together by their own weight, as the carbon at their point of contact is dissipated by the action of the current.

While the feed of the carbons is determined by their consumption, the regulation of the length of the arc is effected by electrical means, the strength of the current flowing at any one time determining, by the simple contrivances shown in the sectional view, the degree of approach or separation of the carbon rings. On referring to Fig. 15 it will be seen that the upper or positive pair of carbon holders a^1 and a^2 are so pivoted at s^1 and s^2 that their swing is made equal and symmetrical on both sides. A similar method is adopted with the arms of the negative carbons. This motion is obtained from the crank lever *l*, which in turn is operated by a current from an electro magnet *M*. To prevent a sudden jerk in this lighting which might upset the adjustment of other lamps in the circuit, an ingenious checking apparatus, consisting of a small rack forming a part of the rod *f*, which gears into a small pinion p^4, is provided.

In order to prevent other lamps in the same circuit from being disturbed by a break in the current through the carbons, a coil of German silver wire, of about equal resistance to the arc, is provided, and in case of such break the current is at once automatically shifted to and passes over the wire and the other lamps are not affected by the interruption. This device also enables one of the lamps to be extinguished without disturbing the others. The carbon rings are made by compression between dies, and are then cut in halves varying from 10 to 14 inches. The diameters generally used burn from 20 to 30 hours.

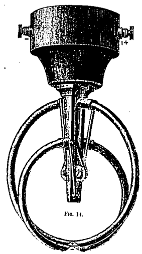


FIG. 14.

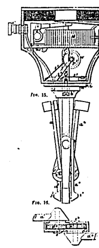


FIG. 15.

FIG. 16.

HEINRICH'S AUTOMATIC ELECTRIC LAMP.

L'INGÉNIEUR

1er Juillet 1881

LAMPE ÉLECTRIQUE DE JOEL

Ce nouveau système d'éclairage, qui semble avoir de l'avenir, a été installé dans les bureaux de la « Prudential Assurance Company » Holborn-Bars, par MM. Rowatt et Fife, Electric Light Company. La moitié de l'étage qui est immense est éclairée au moyen de neuf lampes Joel de cent-cinquante bougies chacune et qui remplacent quarante-cinq becs de gaz; l'autre moitié de l'étage est encore éclairée au gaz. Le contraste qui existe entre ces deux éclairages est frappant sous tous les rapports. La lumière électrique permet de voir les diverses cartes d'assurances de la Compagnie, avec leurs couleurs naturelles, chose fort commode pour le personnel; l'atmosphère peut être maintenue beaucoup plus fraîche qu'avec l'ancien système d'éclairage au gaz.

La lampe Joel est un perfectionnement de la lampe Werdermann, qui a été installée à l'Opéra de Paris ; elle convient fort bien à l'éclairage des bureaux.

Le brûleur est composé d'un crayon de charbon reposant sur un bouton de cuivre. — Le courant positif, en passant du charbon dans le cuivre, chauffe le crayon jusqu'à l'incandescence. Mais il y a en outre un petit arc en forme de perle au point de jonction du charbon et du cuivre lequel augmente sensiblement l'intensité de la lumière sans cependant diminuer sa stabilité. C'est donc un intermédiaire entre l'arc électrique proprement dit et la lumière purement incandescente d'Edison, Swan, Maxim et autres.

Cette lampe n'est peut-être pas aussi petite ni aussi portative que les autres lampes; mais sa plus grande puissance est un sensible avantage dans bien des cas.

Les neuf lampes du « Prudential Assurance Office » sont alimentées par une machine B. de Gramme, de faible tension, mise en action par une locomobile de la force de vingt chevaux installée dans le local même. La force absorbée est estimée à trois chevaux et demi. D'après le rapport du professeur W. G. Adams, le système Joel peut fournir une lumière de sept-cent-quinze bougies par cheval-vapeur.

96 Ironmonger Jan. 24. 1880. (London)

EDISON'S ELECTRIC LAMP.

(FROM OUR SPECIAL CORRESPONDENT.)

NEW YORK: January 7.

HAVING promised in my last letter to give your readers some account of Mr. Edison's new electric light, and of the public test of its qualities made on New Year's Eve at the famous Menlo Park laboratory of this remarkable genius, I shall endeavour to keep my promise within the least space that will permit a description of the apparatus and its working. The Edison lamp, like most useful inventions intended for the general public, is very cheap, simple, and durable. It is not generally known that Edison has for the time abandoned the idea of using platinum, and that his light is obtained from incandescent carbon. But the carbon is not of the kind used in previous lamps, nor is it used in the same way as hitherto. The carbons of the Edison lamp are made from paper in the shape of a horseshoe. After being cut to the proper shape by a die, they are subjected to a heat sufficient to drive off all volatile matter contained in the fibre. This is done by packing them in tightly-sealed boxes and heating in a muffle. These carbon loops are clamped at either end between the jaws of platinum vices of almost microscopic size, which are supported by small platinum wires blown in the glass base of the lamp and forming the electrodes. The whole is then enclosed in a glass globe, about the size and almost the shape of a Duchess pear, from which the air is exhausted by a Sprengle pump until only one-millionth of its original volume remains. This is as near a perfect vacuum as it is necessary to get. The light is secured by passing the current from one electrode to the other through the loop of carbon, which offers a resistance equal to 100 ohms, and such a lamp as I have described will give a light ranging from one to ten four-foot gas-burners as desired. The carbon lamp is very tough, and is not liable to injury from accidental jars. It is also proof against injury from the sudden turning on and off of the current. In use the lamps are connected in multiple arc, and as Mr. Edison has arranged them it makes no difference in the volume or steadiness of the light from one lamp whether one is used or fifty—though of course it makes a difference in the power consumed in the generator. The regulation of the current is effected by the simple expedient of varying the intensity of the magnetic field in which the armature of the generator revolves. The entire apparatus consists of a few wires and the lamps. There are no regulators, no switches, no resistance coils, to compensate for the disuse of a part of the total number of lamps when all are not needed. In fact, the lamp is practically as simple as a candle, and may be moved as far as the slack of its connecting-wires may permit without interruption of the current. Attached to the electrodes are two strips of copper, which are bent upwards towards the glass, and touch two springs at opposite sides of the socket. One of these springs is connected with one of the electric conductors; the other merely touches the copper strip nearest to it, and does not form part of the conductor until the turning of a thumb-screw brings it into connection with the second conducting-wire. Turning this thumb-screw in or out causes the light or stops it. As an impartial reporter of events happening on this side of the Atlantic, I am compelled to say that, so far as my observation goes, Mr. Edison's light is as satisfactory in operation as it is simple in construction. The exhibition at the Menlo Park laboratory on New Year's Eve was, it seems to me, calculated to convince the most sceptical, unless the genuineness of the demonstration is doubted, and it is not questioned here. The laboratory was illuminated by twenty-five electric lamps; there were eight more in the office, and twenty others were distributed about the neighbourhood, lighting the streets and adjacent houses. Attempts were made by visitors, who are believed to have been connected with the gas interest, to tamper with the apparatus, but no accidents occurred, and every experiment made was entirely successful. Very few here doubt that Edison has solved the problem of domestic illumination by electricity. The durability of the lamps has been determined experimentally, by turning on and off the current very rapidly as many times as it would probably be turned on and off in thirty years of actual use in the household. In fact, everything has been done which sceptical scientists have suggested as calculated to satisfy them. The current is obtained from a magneto-electric engine, which may be run by steam, heat, or water power. Mr. Edison will use in connection with his light an electric motor, which, when illumination is not needed, can be employed for any of the ordinary purposes for which power may be needed in the household—raising water, running a sewing-machine, &c. He is confident that the cost of power by day and abundant illumination by night will be found less in practice than that of using gas at night. On this subject I shall probably be able to give you fuller information at some future time. At present I can only say of my own knowledge that his lamp is all that could be desired; that the light is steady, uniform, and agreeable, and that with one which might be carried without inconvenience in a coat-pocket, your readers would have but little trouble in reading the correspondence columns of THE IRONMONGER at a distance of from 80 to 100 feet. The gas companies are badly frightened—more so than at any time since the electric light began to be a matter of public interest. In the face of actual demonstration they derive but little consolation from the assurances of their trusted scientific advisers that the electric light is impracticable for domestic use. Behind Mr. Edison stands a very strong company of enterprising capitalists, who are only waiting the completion of necessary arrangements to push the introduction of the new system. Edison certainly deserves great credit for the originality of his investigations and experiments. He has but small opinion of the large class of conceited scientists who, with much theoretical, and but little practical, knowledge, are so ready to affirm what can and what can not be done. He has still less faith in the dogmatic utterances of book-makers. He says that the so-called information gained from books has almost always led him astray, and that his only real successes have been attained by determining for himself the properties of substances, and their relations to each other. This is unquestionably true, since in his experimentation he has made many important incidental discoveries which are important contributions to the world's knowledge in physical science. He is, without doubt, the greatest mechanical genius of this century.

[Since the above was written we learn that Mr. Edison has discovered that defective vacuums have developed in a considerable percentage of the lamps, but this difficulty Mr. Edison, according to his friends, will easily overcome. Meanwhile, the manufacture of additional lamps has been delayed.—ED. IRONMONGER.]

THE IRONMONGER.

May 10, 1879.]

EDISON'S ELECTRIC CANDLES.

ANOTHER step in the development of the application of electricity to lighting purposes has to be recorded, Mr. Edison's second invention patented in this country having been published at the Great Seal Patent Office. It is entitled "Improvements in Lighting by Electricity." The letters patent bear date November 7, 1878, and the final specification was filed on the 7th inst., by Edward Griffith Brewer, agent, Chancery Lane, on behalf of Thomas Alva Edison, of Menlo Park, State of New Jersey, U.S. As set forth by the patentee in the specification, the special feature of the invention relates to the candle for the diffusion of the electric light. Mr. Edison's candle is in the form of a slightly tapering hollow cylinder, divided vertically except at the upper end. By this arrangement he claims that uniformity and complete incandescence are secured as the electric current passed up one side and down the other. At the base of the cylinder, which is enlarged for the purpose, the electric conductors are connected. A thermal circuit regulator, which has been described in an earlier patent recently published, is attached at the bottom of the candle, and is so arranged that if the current becomes excessive, the regulator becomes heated, and consequently expands so as to bring a movable spring into contact with the adjusting screw of the illuminating apparatus, and thereby diverts the current and lessens its action in the light. Mr. Edison specifies the materials of composition and method of manufacturing the light-giving substance, the essential condition of which is necessarily its power to resist fusion by the heat developed in the passage of the current. He says:—"Metals or oxides of metals are made use of which produce in a comparatively large candle sufficient resistance to render the whole incandescent. Finely divided metal or particles of metal having a high melting point are caused to adhere by earthy materials, such as magnesium or zircon oxides or magnetic oxide of iron, or other substances that are with difficulty fused. The oxides of metals may be obtained by chemical precipitation or otherwise, and the candle is moulded either in a dry or moist condition by pressure. The fine particles of metal may be platinum, iridium, ruthinum, or other metal." The patentee then details the mode of manufacture—"In cases where these oxides or earthy materials are mixed with the fine metallic particles such particles are thoroughly and uniformly mixed into a mass before it is moulded, and hence such particles are kept separate by the earthy material, and cannot fuse or run together, and the metallic oxides themselves are electric conductors to a greater or less extent, and hence may in some instances be used without the particles of metal. In all cases the substances are moulded and pressed into shape under powerful pressure, and if the particles do not adhere together sufficiently, sugar, tar, silica, or similar substances may be used in moulding the candle into shape, and these substances may be volatilised by the heat. The metallic particles are rendered highly incandescent, and the earthy substances and oxides are also rendered luminous by the passage of the electric current." Finally, the patentee declares that his invention "is not limited to any particular form in which the candle may be moulded or otherwise shaped; but it relates to the materials employed in such candles, whereby the mass is adapted to the passage of the electric current, and it is rendered highly luminous or incandescent by such current." In the statement of claims appended to the specification Mr. Edison sets forth as follows:—"What is claimed as the invention secured by these letters patent is that a candle or light-giving body for electric lights, in which particles of metal, or metallic oxides, are moulded into a mass, is adapted to the passage of the electric current, and made luminous by the same, substantially as set forth." Drawings, illustrating the form of construction and use of the apparatus, accompany the specification.

N.Y. El. Review. 3-6-86.

97

The Electric Arc.

Editors Electrical Review:

With the view of demonstrating that the vaporization of the positive electrode was essential to the production of the electric arc, the writer tried an experiment some time since which may interest others.

A disk of sheet copper, about 5¾ inches diameter, was placed in a lathe, and rotated at a speed of about three thousand revolutions per minute, the lathe being connected to the positive pole of a dynamo and the negative wire placed against the periphery of the disk, water being also applied to the disk by means of a moist sponge held against it.

It was observed that at times there would be a failure to obtain an arc by removing the negative wire; but this may have been due to an interposed failure of water, for without the water an arc was apparently formed, although the conditions under which the experiment was performed rendered it impossible to be certain that it was not merely a rapid succession of contacts, producing sparks.

It is suggested to those having facilities for the experiment that two large disks, rolling against each other at a high speed, would be preferable, as the rubbing contact, which causes considerable heat at a high speed, would be thus avoided.

Owing to its higher specific heat, iron might be preferable to copper.

WM. B. COOPER.

PHILA., Feb. 26th, 1886.

N.Y. Elect. World. 3-6-86.

The Invention of the Incandescent Lamp.

To the Editor of The Electrical World:

SIR: In your last issue Mr. Richard N. Dyer, one of the Edison company's patent attorneys, puts forth a manifesto intended probably to assist your readers to accept the statement made by the Edison Company in their new advertisement to the effect that "the Incandescent Electric Lamp is the universally acknowledged invention of Thomas Alva Edison." These be brave words, but it is reported that the Edison stockholders have been recently assessed for the purpose of defending suits brought against their company for the unauthorized use of the incandescent lamp! The acknowledgment is scarcely *universal*.

Mr. Dyer travels over the well-worn track of the Edison supporters. The three elements are there again—the receiver entirely of glass, from which the air is exhausted, platinum wires sealed into the glass, and an incandescing carbon "filament" (there is some magic spell for an Edison man in the word "filament") within the globe, such filament being of "high" resistance. Mr. Dyer does not tell us what is "high" or "low;" the previous experimentalists, he says, failed because their carbons were of too low resistance. How "high" may a carbon be without infringing the "fundamental" patents of the Edison Company?

It would have been well if Mr. Dyer had stated whether he supported the claims of the Edison Company from the standpoint that Edison was the inventor of the incandescent lamp scientifically speaking, or within the meaning and for the purpose of the U. S. patent laws. He must surely mean the latter, but then unfortunately the Patent Office after a fight of five years has decided against him, and, not being able to revoke the "fundamental" patent already issued to Mr. Dyer's client, has issued a "fundamental" patent for the same invention to the representatives of Sawyer & Man. Of course Mr. Dyer may say that decision is all wrong (the defeated party generally does say that), but it is the only one that exists on the point at issue at the present time. If, as Mr. Dyer says, the Sawyer-Man lamp was not such "a practical and commercial success" as Edison's, possibly Messrs. Drexel, Morgan & Co. and the capitalists who put money into the one but not into the other project are to some extent to be credited with that. Perhaps they should be considered as joint inventors. A. T. Stewart made "a practical and commercial success," but he did not claim to be the "universally acknowledged" inventor of calico. There are plenty of valuable inventions that are not "a practical and commercial" success simply because they and capital have not been brought together.

A point to be remembered is that the decision of the Patent Office in the case referred to only related to the question of priority as between the parties. With reference to the three elements of the claims of the Edison Company, Mr. Dyer will probably not dispute the fact that they were all old and well known; but he will say, the combination of them all "substantially as and for the purposes described" involved invention, and was new. He has referred to experimentalists. If he will refer to *Philosophical Transactions* for 1876, Vol. 166, p. 351, he will see that an experimentalist used a receiver from which the air was exhausted and which was entirely of glass; this receiver had platinum wires passing through the glass to which they were directly sealed by fusion, and these wires conveyed current to an incandescing filament of platinum. If he will refer to *La Nature* for the 7th of December, 1878, he will find that M. Niaudet, in an article on the divisibility of the electric light, says that one of the principal inconveniences of metallic wires is that if the current is not regulated, melting of the wire occurs, and that the idea of employing carbon in place of metals appears to belong to King, and to date from 1845. Probably you do not care to try the validity of the Edison patents in your columns, but the two references given above seem remarkably pertinent, and they were not given by the Patent Office on Mr. Edison's applying for his "fundamental" patents. In fact, the office appears to have scarcely looked at the state of the art at all, for some reason or other. Mr. Dyer can, no doubt, give some explanation of the points briefly referred to in this imperfect communication, which I shall be glad to see supplemented by others of greater weight.

If the Edison Company or Mr. Dyer desire to discuss this question it will be interesting, if not profitable; but there is an impression abroad that the Edison Company will be wise to confine their claims to the many valuable improvements which do belong to them, and not lose what they have by trying to claim the whole earth.

WOBURN, Mass., Feb. 27. LUX.

N. Y. El. World. 3-13-86.

A Miner's Electric Lamp.

At the recent conference of the Miners' Union, in England, Mr. Burt, M. P., the president, observed that two things were very desirable in the way of lessening the number of explosions. One was the provision of a good, useful light, and the other the abolition of blasting by gunpowder in fiery mines. We read in the London *Times* that the first of these conditions appears to be met by an apparatus which is self-contained and consists of a chloride of silver battery composed of three cells, each 6 in. high by 3 in. wide and 1 in. deep. The current produced supplies a small glow lamp, of German manufacture, which is placed in front of the metallic case containing the battery after the fashion of the bull's-eye of a police lantern. The lamp is well protected, and is provided with a reflector, so that a good light is thrown forwards. The light given by this lamp is stated to be of 3 candle-power, and to be capable of burning for nine hours, but this, as far as candle-power goes, is in excess of the requirement of the miner, so that smaller sizes are made. The cells are hermetically sealed, so that the lamp can be used at any angle without fear of loss of the liquid or extinction of the light as with the ordinary miners' oil lamp, than which the new one is said to cost much less for maintenance. Upon this point, remarks our contemporary, it is to be observed that when the power of the cells is exhausted there is no waste of the elements. The chloride of silver will have become converted into pure silver, and can be revivified by washing in a solution of nitric and hydrochloric acid. The lamp and the battery are both locked against the miner, who cannot interfere with either. The lamp can be hooked up in the ordinary way, or attached to the miner's belt. It has, says the paper, had the approval of one of the leading electricians, and of several mining authorities, subject to being tested.

London Eng. Globe. 8-19-86.

A NEW ELECTRIC LAMP.

An electric lamp for domestic use was yesterday afternoon exhibited by the Regent Primary Battery Company, at 17, Craven-street, Strand. This lamp is of simple construction, and seems to be a step in the right direction inasmuch as it is composed of a simple incandescent lamp, to which the current is supplied by a primary battery to which it is attached. The battery, comprising 24 cells of 2·6 volts each, is contained in a mahogany box rather less than a foot square, on which the lamp is fixed. The inventor states that these lamps will burn for eight hours, giving a light of 15 candles, and exhibiting a nominal resistance of 7·1 ohms. The battery can, we are informed, be renewed daily by any servant, and, when supplied with the necessary fluid, requires no further attention. The cost of this light is about double that of gas, and the lamps will be sold for a small sum.

Boston. Journal of Commerce. 3-13-86.

Something About Making Electric Lamps.

The incandescent electric light remarks a contemporary, has become a familiar object to everyone. The little glass bulbs with their brilliant horseshoe of glowing filament attract no more attention than the flickering gas jet. But the facts about the gas jet are easily and generally understood, while the electric lamp is still a puzzle to many people. Both produce light by incandescence. The molecules of gas are rendered incandescent by the heat generated by the combustion of other molecules. The blue portion of every gas flame is where combustion is taking place, and from that comes the heat which keep the rest in a state of incandescence. With the electric lamp it is the heat produced by the friction of an electric current compelled to go through a fine carbon filament, which raises that filament to a condition of incandescence and produces light.

The three substances which enter into the composition of an electric lamp are glass, platinum wire and bamboo or paper. Glass bulbs are readily prepared by the usual methods of glass-blowing, but the preparation of the bamboo is a delicate piece of work. In the best lamps the little horseshoe is made of bamboo, and this material has proved its superiority to its rival, paper, in several ways. The bamboo comes from Japan in bundles of slips a foot in length. Japanese bamboo is of finer quality than the Chinese. It is first split up into little square strips. Girls round this off by running them through dies until they look like little broom straws. These are put in crucibles with graphite and submitted to a white heat for several hours. This carbonizes them thoroughly. The filaments are not all of exactly the same size when taken out of the crucibles, and if used in that state would present varying resistances to the current and the lamps would not be even and economical in their working. To make them uniform, they are put one by one into a glass jar from which the air can be exhausted and a hydrogen gas—the lighted of the products of petroleum—can be admitted. A current of electricity is run though the horseshoe filament and it absorbs carbon from the gas until the operator sees that its resistance has been reduced to the regulation amount. The standard used in the factory from which this description was obtained is 250 ohms. The moment when the resistance has reached the desired point is told by means of an apparatus familiar to electricians—the Wheatstone bridge.

Now, the lamp is in three parts: The bulb, the carbon filament, and the stopper, containing the two platinum wires which are to connect the horseshoe of carbon with the system of wires that carries the current all over a building to the hundreds of lamps. It only remains to put the stopper in its place at the larger end of the pear-shaped glass bulb, seal it air-tight in the flame of a blow pipe, extract the air from the bulb by a mercury pump and then seal the other end. The bulb is made of the thinnest glass, and before the air is exhausted from it will break easily. After the vacuum is created, however, it can be handled carelessly without injury; and when it does break there is a report like that of a dozen popguns.

The lamps are expected to burn 600 hours. Sometimes, like other articles of human manufacture, they fall short of expectations. The competitive trial recently made at the Franklin Institute of the lamps of various companies furnished several woful examples of this truth. A well-made lamp will last that length of time, however. If by bad workmanship air is allowed to leak in, the carbons burn out quickly. If it is run at too high a tension; that is, if too much current is sent through it, the friction wears out the little horseshoe in a shorter time and it breaks. It is the necessity for a practically absolute vacuum that requires the employment of the platinum connecting wires. Platinum is the only metal which expands and contracts with heat at the same rate as glass. This keeps the joint, where the wires pass through the glass, always tight, so that no air can enter. There is a fortune in store for the inventor who can get up some kind of cement that will prevent the passage of air, and at the same time admit the use of cheap copper instead of costly platinum wires. The problem may be capable of solution, for this whole matter of electric lighting is still in its infancy, though not a most vigorous stage of infancy.

Menlo Park Scrapbook, Cat. 1050

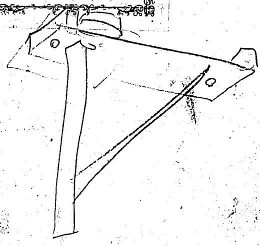
No. 35A. "Radiometer and Vacuum Pump"

This scrapbook covers the years 1874-1880 and contains clippings about radiometers and vacuum pumps. Between pages 110 and 111 is a note that a leaf was removed and placed on exhibit in the Patent Office interference proceedings between Edison and Ludwig Boehm. The spine is labeled "Vacuum Pump--Tube--Radiometer--Elect. Lamp." There are 126 numbered pages.

Radiometer &
Vacuum pumps

1050

35



1

2

(10.) Repeated (5) and again proved the presence of phosphoric acid.

Remarks.—The presence of alumina or aluminum phosphate is seen from (3·*b*) and (8 *a*); of silica from (3 *b*) and (9); of lime from the white *balls*, which might, however, have been MgO. The presence of copper was so evident that it was unnecessary to use phosphoric acid as a detective.

The minuteness of these details (necessary where a process is described for the first time) makes the analysis appear much longer than it is, but the essential character of the mineral appears in operation (3), what follows that is chiefly confirmative.

September 19, 1876.

Oct

NOTE ON THE RADIOMETER.*

By WILLIAM CROOKES, F.R.S., &c.

During the last three months several papers have been read before the French Academy respecting the radiometer. On reading these papers I find that the various experiments performed are in general repetitions of some which I have devised during the four years I have been working at the subject. The descriptions of my experiments and the results I have obtained have been communicated by me from time to time to the Royal Society. Unfortunately, however, these papers do not appear in the *Philosophical Transactions* until twelve or eighteen months after they have been read, and according to custom I could not communicate them to other learned Societies. If these *savants* had seen my papers they would have found that I had not only tried the experiments, but that I had also discussed the evidence both for and against the several theories they have advanced to account for the action of the radiometer. The experiments with radiometers are almost all described in the third and fourth parts of my paper: these were read before the Society on February 10th, 1876, while in parts one and two I have considered the various supposed causes of the phenomena.

In the *Comptes Rendus* for July 3rd, 1876, M. Govi describes an experiment showing the action of dark heat on the instrument. This experiment is described in the paper read before the Royal Society on February 10th, and was also shown at a *Soirée* of the Royal Society on April 5th. The radiometers described by MM. Alvergniat and Gaiffe, in the *Comptes Rendus* of July 24, differ in nothing from those that I had previously caused to be constructed, and which are also described in the paper referred to above, while M. Ducretet's experiment of pouring ether upon the case of the radiometer was demonstrated to my audience on the occasion of my lecture at the Royal Institution, on February 11th, 1876. At the Royal Society *Soirée*, April 5th, I exhibited the turbine-radiometer, and this is also described in the paper read on February 10th. In the *Comptes Rendus* for June 19th a similar instrument is explained by M. de Fonvielle. With regard to the cause of the rotation, M. de Fonvielle adheres to the theory of emission; while M. Fizeau, in the *Comptes Rendus* of May 29th, attributes the action to, first, a slight excess of temperature acquired by the discs as compared with the ambient medium under the influence of light; secondly, to the unequal powers of emission and absorption of two opposite surfaces (black and polished of each disc; thirdly, to the presence, in the apparatus, of a small quantity of elastic fluid. In the No. for June 19th M. Govi refers to Fresnel's experiments, which he will find described in my paper read in December, 1873; and he also says that, if the thermic currents of rarefied gases contained in the receiver do not suffice for explanation of the facts observed, there is another explanation, namely,

* Translated from a Letter to Count du Moncel, published in the *Comptes Rendus*, September 11, 1876.

Examination of the Possible Mechanical Action of Light: Study of the Radiometer of Mr. Crookes.—M. A. Ledieu (continuation).—The author having explained his theory to M. Fizeau, this eminent academician proposed an experiment by polarising a pencil of rays. In this manner, in fact, in accordance with his theory, we ought to obtain a minimum impulsion, or none at all when the plane of polarisation is made to pass along the axis of the radiometer. On the contrary, the maximum impulsion should be obtained at 90° from the first position. This experiment was made with an excellent instrument by M. Alvergniat, but it gave no conclusive result. M. Fizeau then caused an ordinary pencil of rays to fall exclusively upon the blackened discs, and thus obtained a movement more accelerated than when the pencil fell at once upon both kinds of surfaces. He then operated in an analogous manner upon the bright surfaces, taking care to incline the pencil of rays so that no reflection might be thrown from the polished surfaces upon the black ones. The instrument continued to revolve, but with a reduced speed. This latter experiment would lead us to condemn all radiant influence, since this would attract in one case and repel in the other. The author's theory would therefore seem confounded by such a result, as well as every other explanation based upon the doctrine of emission. But on examining more closely, we are led to remark that in all the experiments related there is reflection of light upon the glass of the globe, and that, besides, when these rays are polarised, the plane of polarisation, after reflection, is no longer presented in the same direction as regards the faces of the discs. We must then conclude that further experiments are absolutely required to elucidate the question. The author, then, quoting the opinion of M. Fizeau, given in the present number of the Chemical News, continues—"This opinion, emanating from so distinguished a *savant*, must assuredly be taken into high consideration. Nevertheless, considering the regularity, the definite character, and the certainty of the revolution of the instrument, always in one and the same direction, the explanation of M. Fizeau does not satisfy us entirely, and the debate does not seem to be closed. He then suggests the following experiments:—Illuminate an ordinary radiometer, *i.e.*, with discs alternately polished and blackened in the direction of its axis. The instrument ought to revolve in the same direction as when the pencil of rays illuminates the axis vertically, and the rotation even ought to be accelerated. Second. Construct an apparatus all the discs of which shall be left bright so as to reduce to a minimum the influence of the reflections upon the glass; then to throw a pencil of rays upon the disc situate on one and the same side as relates to the axis of the instrument. If the rotation is really due to the mechanical action of light the instrument will turn as if the discs were repelled by

the luminous rays. M. Ledieu does not hold that the movements of the earth, as a whole, can be effected by the solar radiations. He considers, however, that we have here a very natural explanation of the form of the tails of comets.

Considerable attention was deservedly attracted by the experiments made during the evening by Mr. A. Apps, several of these experiments being among the most striking and beautiful within the vast range of electrical science. Nothing could surpass in richness of colour and softness of tint, his admirable combination of the fluorescent liquid and cascade experiment. An aurora tube 10 ft. long was lit up by an 18 in. induction coil, which, when connected with a large Leyden jar, gave the discharge a peculiarly snapping resonance. The diamagnetic property of copper was also shown, and many were very much amused with the time-honoured "poker" experiment.

Explanation of the Impressionability of the lackened Discs of the Radiometer by the Aid of e Emission Theory, according to J. B. Biot.—I. W. de Fonvielle.—J. B. Biot, in the third volume of is "Traité de Physique," explains how the luminous olecules cannot communicate their *vis viva* to reflecting urfaces. In fact, these latter exert a truly repulsive action pon those molecules which, not touching them, cannot roduce upon them any percussion similar to that impressed by electric forces. The considerations developed y this illustrious physicist not being applicable to blackened discs, we understand that the rotation of the radiometer should be produced in such a direction that they may fly from the ray. Is it not curious to find that the emission theory has permitted us to some extent, as far back as 1816, to foresee the experiment of Mr. Crookes? The explanation of the phenomenon, if we admit M. Biot's starting-point, does not require any new reasoning. The effort lost in the change of direction of the luminous molecules seems at first sight not to produce any effect, a result which does not appear reconcilable with the law of the conservation of the quantity of movement. Nevertheless, we may reply to this objection that according to the theory of emission this quantity of motion is represented by an internal ray performed upon the ray of light; for the direction of the axis of the luminous molecules has been changed since the reflection, for in place of being situated in the direction of the ray these axes have become perpendicular to that direction after the reflection. In this hypothesis the energy destroyed is represented by that which has been employed for the polarisation of the incident ray. The author has studied, along with M. Ruhmkorff, an apparatus known in Germany under the name of *light-mill*—an appellation which seems to him scarcely justifiable, for the rotation of a wheel placed in the centre of a Geissler's tube seems exclusively produced by a dynamic effect peculiar to electricity, and in which light does not intervene in any manner. In fact, the vacuum is so imperfect that a radiometer placed in Geissler's tube cannot turn without the action of a ray of light. Further, the state of the surfaces has no influence upon the direction of rotation in Geissler's "mill," which is entirely bright, whilst the direction of this rotation is changed at will by altering the direction of the current. The preponderance of the negative flame, much more direct than the positive, cannot exert, as the author at first believed, any influence on this inversion, for a very sensitive radiometer, capable of being set in motion by the light from a smouldering match just blown out, was not moved by the light of an induction spark striking sufficiently near to the glass case to perforate it.

New Radiometric Experiments.—M. Collado.—The author has exposed a sensitive radiometer to the light of the full moon, and concentrated the light upon the blackened surfaces of the discs by means of lenses or of concave mirrors, but without perceiving any movement. In like manner, if a radiometer is submitted to the radiation of a single Bunsen burner the speed of the revolution is not altered if the pale blue flame is rendered luminous.

3

dered insensible, though it turned very quickly if a vacuum was made without heating in the ordinary manner. But if the discs, instead of being made of two metals, were made half of metal and half of mica the instrument could not be rendered insensible. The glass case was pierced by an electric discharge, when the radiometer began to turn with great speed, and continued for an hour. The aperture was so small that its diameter could be approximately estimated only by the aid of a powerful microscope. It was found practicable to re-form a vacuum in this instrument up to 100 m.m., even though perforated; rotation then took place in the ordinary manner. Nos. 6, 7, and 8, are radiometers with discs of mica and varnished copper, green, blue, red, and yellow; the colours, in these conditions, have no effect on the radiation.

Cause of the Motion of the Radometer.—M. G. Salet.—According to all the experiments made, the cause of movement in the various apparatus resembling the radiometer of Crookes is a difference in the temperature of the surfaces of the discs. The theory of Tait appears the best. A disc, compound or simple, whose surfaces have actually two different temperatures, and which is plunged into a highly rarefied atmosphere, begins to move, the hottest surface recoiling. Whilst the difference of temperature exists the movement continues. There is no occasion to bring forward the possible action of gases condensed on the surfaces. Wherever two thermometers, isolated in a vacuum, and constructed of two different substances, A and B, would indicate different temperatures, a radiometer disc composed of adjacent laminæ, the one of the substance A and the other of B, will begin to move, and the movement will show the direction and the degree of the difference of temperature. In the circle of lights the discrepancy between the indications of two thermometers, the one with its bulb blackened maintained itself for an indefinite time; it is the same with the movement of the radiometer. Not content with repeating the experiment of Mr. Crookes and M. Fizeau, by placing the radiometer in the centre of a sphere of opal glass so as to equalise the light and avoid currents of air, the author has made an experiment which he considers absolutely demonstrative. He has fixed upon the mill of a radiometer the needle of a compass: the discs were composed of two laminæ of burnt mica, one of them blackened. Under the influence of an adjacent flame the needle deviated to a certain angle, and variations in the lustre or in the distance of the flame were shown very distinctly by a corresponding change in the deviation. The source of light having remained constant for four days the needle kept its position invariable for the whole of the time. The action of condensed gases cannot be invoked here.

4

Photometric Researches on Coloured Flames.—M. Gouy.—Not suitable for abstraction.

Note on the Radiometer.—M. A. Gaiffe.—The author has made a modification, which he considers proves that the actinic and thermic rays act upon this instrument. It is a radiometer of the ordinary form, the discs being coloured a dead blue on one surface and a dead red on the other. It may be made to revolve in either direction by using alternately suitable sources of heat and light. If, *e.g.*, we expose this instrument to the sunlight, the blue surfaces acquire a predominant action, and after some moments hesitation the mill begins to turn from the left to the right. If it is exposed to the flame of a common gas-jet, or of a Bunsen burner, or to the radiations of a plate of hot iron the rotation takes place in an inverse direction.

Radiometers composed of Laminæ of Different Materials.—MM. Alvergniat Freres.—The following observations have been made with radiometers with discs of different materials. No. 1 is a radiometer with discs of silver and transparent mica. In the light the radiometer turns with the mica in front and the silver repelled; in obscure heat, with the radiometer plunged in water at 30° or 40°, the rotation is in the opposite direction. In ice it turns as if exposed to light. No. 2 is composed of aluminium and blackened mica. In the light this radiometer turns with the metal first, and the blackened surface repelled. Obscure heat and light, however intense, do not modify the direction of the rotation. If plunged in ice it turns in the opposite direction. No 3 is formed of aluminium and mica not blackened. In light this radiometer turns with the mica first. In ice the rotation is in the same direction as in light. Dark heat makes it turn in the opposite direction, with the metal first. With this radiometer M. Jamin made the following experiment:—He directed a small light upon one point of the radiometer while in motion, so as to heat only a single point of the globe. This threw the discs into such a state of equilibrium, that instead of rotation there ensued oscillations like those of a pendulum. The two surfaces of the discs, the metal and the mica, are both repelled: if the distance of the flame is varied one of the two laminæ is repelled more or less. No. 5 is a radiometer with discs of silver and aluminium. This radiometer has been heated to 440°, distilling sulphur, and continuing to make a vacuum with the aid of the mercurial pump. The instrument was ren-

Foreign Sources. {Chemical News, July 7, 1876.

Radiometer of Mr. Crookes.—M. W. de Fonvielle.—The experiments executed by M. Darlu de Roissy and myself in the photometric laboratory of the gas works at Vilette appear to us to confirm the opinions put forward by Mr. Crookes. The procedure which enabled us to change at will the direct movement to the right into an inverse movement to the left seems to agree with the arguments of this eminent chemist before the Royal Society of London. We obtained the normal rotation under the action of radiant heat, but after having left the radiometer exposed for five minutes to a temperature of 45° C. we plunged it rapidly into a bath of cold water at 15° C. The rotation to the right ceased, the instrument stopped for a moment, and then began to revolve to the left with a rapidly increasing speed, which reached a revolution and a half per second. This inverse movement ceased almost as quickly as it had begun. At the end of half a minute the movement to the right re-commenced under the action of the solar rays which fell upon the absorbent surfaces of the radiometer in the midst of the liquid mass, and without the possibility of heating by conduction.

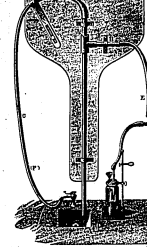
M. Fizeau, with reference to this communication, remarked that the conclusions of the author in favour of the existence of an impulsive force in the rays of light, seemed to him to require the most formal reservations. The ingenious instrument of Mr. Crookes seemed to be in reality a thermic apparatus, in which the rotation, with all its circumstances, may be simply ascribed:—(1) To a slight excess of temperature acquired by the discs as compared with the ambient medium under the influence of light. (2) To the inequality of the emissive and absorbent powers of the two opposite surfaces of each disc, the one blackened and the other polished. (3) To the inevitable presence in the apparatus of a small quantity of elastic fluid (gas, or watery vapour), the layers of which close to the blackened surface may acquire a slight excess of elastic force sufficient to propel the discs whose mobility is extreme. Certain inverse movements temporarily produced by cold will be the analogous results of the same causes. Moreover, M. Fizeau, at the request of several members of the Academy, made in their presence, at the end of the sitting, certain experiments with the instrument. He showed that if a stream of solar rays, limited by a screen, were thrown upon the disc so as to strike merely the polished surfaces of the discs the rotatory movement was still produced, but in such a direction that each disc moved to meet the solar rays instead of retiring from them, as ought to take place if the motion were the result of an impulsive power of light. Previous experiments have shown, further, that this result does not depend on accidental reflections in the interior of the apparatus.

[M]ODIFICATION OF THE JAGN VACUUM OR FILTER PUMP.

BY PROF. A. E. FOOTE.

[The] introduction of the Sprengel pump—so widely known since [Bunsen] applied it to rapid filtration—has been greatly limited by the [fact th]at most laboratories do not command the needful head of water. [The] pulsating pump, described in Liebig's *Annalen*, November, 1872, [is cap]able of producing a very good vacuum with a water fall of three [or four] feet. In adopting this pump for laboratory use, I found, in common with very many other persons, that the form given by the inventor has grave defects. Of these, the most troublesome lies in the caoutchouc valve, which, after a time, becomes stiff and acts imperfectly or not at all. The valve devised by Thorpe, described in the *Phil. Mag.*, October, 1872, has in my hands proved difficult of construction, works badly unless perfect, and quickly wears out.

My device is exceedingly simple and easily constructed. It can be made of common materials by any plumber or gas fitter. It has been in use in this laboratory for some months, and we easily produce by it a vacuum of twenty-five inches of mercury. The following is a description of the apparatus as modified by myself:



A A is a tube about four feet long, and from three-eighths to one inch in diameter. To the side of this an arm B is affixed, by means of a "T" coupling. B is from four to eighth inches in length, and may have a manometer tube attached. C is the caoutchouc vibrating tube which conducts the supply of water to A. The upper part of A, over which C is thrust, is cut off at an angle of 40°. The vibrations are regulated by a moveable arm D. To B is attached a rubber tube E, which leads to the vacuum bell jar or bottle. Within B, and near its connection with A, is fixed by cement the valve represented in Fig. 2.

The valve is constructed as follows: A cylindrical metal plug about one inch long, and of such diameter as to slip easily within the tube B, is cut away at one end (as shown in fig. 2, where it is represented in section, with a portion of tube B), leaving a tongue of metal *a*. This tongue of metal is driven down upon a flap of sheet caoutchouc, about one millimeter in thickness, *b*, which is thus held upon the bevel of the plug, and covers the two channels *c c*, one of [which] is seen in section. These channels communicate with the pass[age] made by filing away tangentially the metal of the plug as sho[wn in] the cut. The caoutchouc flap is represented as lifted away fro[m the] face of the plug in order to show the orifices which it closes wh[en the] water current in the tube B is checked. These holes, in order [to be] perfectly closed by the flap, must be at least one-sixteenth of a[n inch] in diameter. The sheet caoutchouc should be as thin as possib[le;] the thinner it is the smaller the holes may be, and the better it w[orks.] It is absolutely necessary that the plug should be tightly com[pressed] into the tube, so that not a trace of air can leak through. A [...] placed upon E, and used to retain the vacuum, may also be ma[de to] regulate the rapidity of exhaustion, but this may be done more [con]veniently by means of a stopcock F inserted in C, which regulat[es the] flow of water, or by means of a "globe valve" placed in the s[upply] pipe. The angle at which A is cut off at the top is also importan[t; if] not just right, the vibrations of the caoutchouc tube are not pe[rfect.] By the use of the ordinary gas fittings (stop cocks, pipes, etc.), we [have] connected one pump to several quite widely-removed bell ja[rs or] vacuum bottles.

I have been led thus fully to detail this piece of apparatus fr[om the] belief that, as soon as known, its simplicity, compactness, effi[ciency in] working and cheapness of construction will cause its general i[ntro]duction into laboratories even where a fall of thirty feet can b[e ob]tained without difficulty. Its value, not only for rapid and di[fficult] filtrations, but also for evaporations where the application of he[at is] objectionable, cannot be over-estimated.

I will here make note of a simple arrangement devised by one o[f my] students, Mr. F. D. Whitney, which quickens filtration sufficientl[y for] many purposes.

To the top of the shelving behind the sink fasten a tube vertic[ally.] Join one end of this to the water supply pipe, the other to the bu[lb of] a thistle tube, by means of a glass tube inserted through a ru[bber] cork; through another hole in the rubber cork is carried a tube w[hich] connects with a vacuum bottle. The vacuum produced is of co[urse] proportional to the column of water supported in the thistle tube [and] its connections.

For the platinum cone used in filtering, I take an old worn pie[ce of] platinum foil, one that has been used in blow pipe work, make it [per]fectly smooth, and cut it to the center on one side, bend it till it ne[arly] fits the bottom of the funnel, and then press it in place by means [of a] turned wooden cone. The more small holes in the foil the better.

I will add that these valves, as shown in Fig. 2, as well as [the] entire apparatus, Fig. 1, are made in the college workshops here, [and] will be furnished at cost on application to Professor Anthony.—*Am[er]ican Journal of Science and Arts.*

Chemical Laboratory of the Iowa State Agricultural College, Ames, I[a.,] Sept 8, 1873.

5

THE CHEMICAL NEWS.

Vol. XXXI. No. 791.

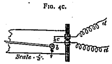
ON ATTRACTION AND REPULSION RESULTING FROM RADIATION.*

By WILLIAM CROOKES, F.R.S., &c.

(Continued from page 24.)

44. The pump was now kept at full work for an hour. The gauge did not rise perceptibly; but the metallic hammering increased in sharpness, and I could see that a bubble or two of air had been carried down. On igniting the spiral, I found that the critical point had been passed. The sign had changed, and the action was faint but unmistakable *repulsion*. The pump was still kept going, and an observation was taken from time to time during several hours. The repulsion continued to increase. The tubes of the pump were now washed out with oil of vitriol,† and the working was continued for an hour.

Fig. 4c.



45. The action of the incandescent spiral was now found to be energetically repellent, whether it was placed above or below the brass ball (figs. 4 c, 4 d). The finger exerted a repellent action, as did also a warm glass rod, a spirit-flame, and a piece of hot copper.

46. I now heated the sulphuric acid, in the U-tube desiccator attached to the pump, until it boiled. A little aqueous vapour was driven off; the sharpness of the hammering of the mercury changed to a duller sound; and on trying an experiment once more with the ignited spiral, the action was seen to have returned to one of attraction.

On leaving the pump to itself for an hour or two, the sulphuric acid, as it cooled, again took up the aqueous vapour; and as the absorption proceeded I could trace the action of the hot spiral from attraction, through the point of neutrality, up to decided repulsion.

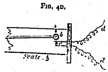
47. The critical point, in the case of brass balls, is much higher than with pith balls. In the case of pith, applying heat outside, I obtained neutrality when the gauge was about 7 millims. below the barometer, and decided repulsion when there was still a difference of 2 millims. With the apparatus just described, however, using brass balls and an internal source of heat, the critical point is very near the Sprengel vacuum. By close observation I can just distinguish that the gauge is a fraction of a millimetre below the barometer when the hot spiral ceases to exert an attractive action on the brass ball; but my unassisted eye is not able to detect a difference on the gauge between a Sprengel vaccum in which the ignited spiral is neutral to, and one in which it strongly repels, the brass ball.

48. I have experimental grounds for believing that the position of the critical point varies with the density of the mass on which radiation falls, with the relation of its mass to its surface, and with the temperature of the apparatus (62, 63, 64, 65, 67, 75). The temperature of the body used to attract or repel the brass or pith ball also affects the critical point, but it cannot, I think, modify it much; for with the apparatus last described no difference in kind of movement, but only in degree, was noticed, whether the spiral were ignited to full redness, or whether it were merely warmed by a momentary contact of the wires. Further experiments are in progress which may throw light on this point.

49. The very high amount of rarefaction needed before this neutral point is reached, and the change of direction of movement on applying a hot body to one arm of the balance, caused by a difference of exhaustion of a few millimetres on one side or the other of the point of neutrality, are, I think, a sufficient explanation of the anomalous results which were met with in my earlier experiments (2, 19, 20, 21, 22).

50. Although these results were sufficient to show that air-currents could not be the cause of the movements of the balance, I was anxious to decide this point once for all, by a form of experiment which, whilst it would settle the question indisputably, would be likely at the same time to afford information of much interest. Having found that the balance last experimented with had its neutral point close

Fig. 4d.



to an ordinary Sprengel vacuum, that the repulsive action only came on by still further pushing the exhaustion, and that, as I further exhausted, the repulsion got stronger, it was of interest to see what would take place in a vacuum so nearly perfect that it would not carry a current from a Ruhmkorff's coil.

In small tubes, and taking certain special precautions, I could prepare a vacuum with my Sprengel pump which would hardly allow an induction-current to traverse it, or would only show a faint, clould-like discharge; but it was impossible to effect this in the large tubes required for these experiments, and, in fact, all the Sprengel vacuum balance-tubes which I had hitherto prepared became brightly luminous when the current from an induction-coil was passed through them. I accordingly fitted up the apparatus shown in figure 5, in which a chemical vacuum could be prepared by a method first devised by Dr. Andrews. (*Philosophical Magazine*, February, 1852).

51. *a b* is the tube containing a straw beam with pith ball terminals; at *b* two platinum wires are passed through, to connect with an induction-coil; at *a* the tube is contracted to allow the apparatus to be sealed off; *c* is a portion of the tube containing a copper boat filled with freshly cast sticks of caustic potash; *d* is a tube bent as shown, and nearly full of strong sulphuric acid, which has been previously boiled for some minutes and then allowed to cool in a vacuum; *e* is a mercury joint, connecting the apparatus to the Sprengel pump. At the upper part of the tube *d* is a stopper fitting into a funnel joint and capable of being replaced (as shown in figure) by a tube through which I could pass carbonic acid when desirable. The carbonic acid was prepared by the action of hydrochloric acid on marble; when not being passed into the exhausted tube, the gas was kept bubbling through mercury, where a tube full could be collected from time to time (as shown in the figure) to test with potash. It was found necessary to keep the evolution going on all the

* From the *Philosophical Transactions of the Royal Society of London* vol. clxiv., part 2.

† This can be effected without interfering with the exhaustion. See *Philosophical Transactions*., 1873, vol. clxiii. p. 296.)

absorbed until, in the course of from a few days to a few weeks, the vacuum will again cease to conduct.

54. It is very difficult to get the vacuum in large tubes so nearly absolute as not to allow a white, cloud-like discharge to pass. I have tried experiments with balances sealed up in vacua of both kinds prepared in this manner, and I always find the repulsion on the approach of a hot body is very decided, although I do not think it is more energetic than with the same kind of balance enclosed in the best Sprengel vacuum I could prepare. These experiments have therefore set at rest the doubts which might have arisen had I only worked with the Sprengel vacua, that air-currents were the cause of the phenomena. They have decided the important point, that in a chemical vacuum which will not carry an induction-current the repulsion by radiation is decided and energetic.

55. Besides the straw and pith balance mentioned above (51, 52), I have prepared and sealed up in chemical vacua balances made of a glass beam and platinum terminals, and also of glass entirely, the ends being flat glass plates. They act in all respects as the straw and pith balance, only being somewhat less sensitive.

56. The delicacy of one of the straw and pith balances in a good vacuum is very great, as may be comprehended by the following experiment:—The balance-tube was supported on a stand, and immediately beneath one of the pith balls was placed the face of a bismuth-antimony thermopile. On connecting the terminal wires of the pile with a single cell-battery, so that the current flowed in one direction, heat was produced, and the pith ball was repelled. On reversing the current, cold was produced and the pith ball was attracted.

57. The rays of the sun allowed to shine on the terminal pith ball of one of these delicate balances *in vacuo* repel it strongly. If concentrated by a lens the focal point beats the ball away, as if it were struck with a material agent. If the sun's light be filtered through coloured glasses before concentrating them on the pith ball, the action is slightly diminished. Passing the light through two very clear plates of alum with parallel sides, and having an aggregate thickness of 8 millims., had but little action.

58. A beam of sunlight was passed through a prism *a* (fig. 6), and the spectrum was projected horizontally on to a screen (*b*) 18 feet off. In front of the screen, a little below it, was arranged the balance-tube *c*, having fixed above it a lens *d*, so that one of the pith balls was in the focus of the lens. A small right-angled prism (*e*) was then held in the different parts of the spectrum, so as to reflect any desired ray on to the lens and concentrate it on to the pith ball. By turning the right-angled prism sideways, the ray could be thrown off and on the ball, and the action readily noted. In the ultra-violet rays the repellent action was slight; the effect increased as I made the reflecting prism traverse the spectrum from the violet to the red. The maximum action was in the extreme visible red, and it gradually faded away as the invisible rays beyond the red were reflected down. An appreciable action of repulsion was, however, observed a full half spectrum in length below the least refrangible visible rays. The plates of alum, interposed in the path of the rays, cut off a small portion only of their action.

(To be continued.)

THE CHEMICAL NEWS.

Vol. XXXI. No. 790.

ON

ATTRACTION AND REPULSION RESULTING FROM RADIATION.*

By WILLIAM CROOKES, F.R.S., &c.

(Continued from page 13.)

32. When the balance was in air of ordinary density, and the hot body was placed *above* the pith ball in the position *a* (see fig. 2), it will be remembered that the action was to cause the ball to rise: the rising was, however, less decided than when the heat was applied below (27, 29). On re-exhausting the balance-tube and taking a series of observations, placing the hot bulb above the pith ball in the position *a* (fig. 2), instead of below it, the ascending tendency of the pith got less and less. Several millimetres below the previously ascertained point of neutrality the hot bulb at *a* ceased to exert an action, and when the neutral point was exceeded by some millimetres I could still detect no movement. However, at 2 millims. below a vacuum, I detected a tendency of the pith to sink when the experiment was tried, and in a good Sprengel vacuum there was an unmistakable repulsion exerted between the two bodies, the pith sinking in obedience to the radiation from above almost as strongly as it rose when the heat was applied beneath.

FIG. 4.

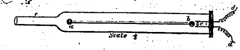


FIG. 4A.

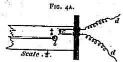
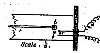


FIG. 4B.



33. I now wish to ascertain the effect of cold on the balance pith balls, and for this purpose a lump of ice was employed.

The experiments were first tried with the balance-tube full of air, cold being applied either above or below the pith ball; a lump of ice generally produced an upward movement of the pith, but it was very faint, and sometimes the motion appeared to be in the opposite direction. It was evident that the true action of a cold body, whatever it might be, was here masked by currents of air; and I therefore exhausted the apparatus and tried the effect of ice at the previously ascertained neutral point, viz., at about 7 millims. below the vacuum. It was absolutely inert. I then carried the exhaustion to the fullest extent, testing the balance with ice during its progress. As the gauge approached nearer and nearer to the height of the barometer, the ice commenced to attract the pith; and at last, when the gauge and barometer were level, the attraction of the ice, whether applied above or below, was very marked, being exactly opposite but equal to the action of the bulb of hot water.

34. In trying some of these experiments in a Sprengel vacuum an action was noticed which led me to think that some of these movements might be due to electricity. When a hot glass rod is held motionless against the lower side of the exhausted tube, the repulsion of the pith ball takes place in a perfectly regular manner; but if the glass rod has been passed once or twice through the fingers, or if it is rubbed a few times sideways along the exhausted tube, the beam immediately moves about in a very irregular manner, sometimes being repelled from and at others attracted to the side of the tube, where it sticks until the electrical excitement subsides. When the finger is rubbed against the exhausted glass tube, the same electrical interference takes place; attractions and repulsions occur by fits and starts, the pith sticks to the tube, and does not regain its ordinary state for some hours. When a small spirit-flame is passed beneath the pith end of the balance in the vacuum, a similar but much fainter electrical effect is noticed. This, however, is not sufficient to interfere with the repulsion due to radiation unless the vacuum is very good and free from aqueous vapour.

35. The end of a glass beam in a Sprengel vacuum was found to be attracted by either pole of an induction-coil, when the other pole was not well insulated.

To ascertain whether electricity exerted any special action in the ordinary repulsions in vacuum, the following experiments were tried:—

36. A straw beam with pith extremities was enclosed in a tube (24) and exhausted to the full power of the Sprengel pump. After adjustment by heat, till it was in equilibrium and very delicate to slight radiation, it was re-exhausted and hermetically sealed up. The tube was then completely surrounded with wet blotting-paper, with the exception of a small aperture through which the movement of the beam could be observed; the blotting-paper was connected to earth by a wire soldered on to a gas-pipe.

On bringing a piece of warm copper beneath the pith ball, it rose as readily as if the outside of the tube had been dry and insulated. The finger moistened with warm water also repelled the pith; and when cooled with melting ice, and then applied dripping wet either above or below the pith ball, there was attraction. The same result, but more strongly marked, took place when a piece of ice was used instead of the cold finger.

A straw beam furnished with brass balls at each end* was suspended in the usual manner on a double-pointed needle; and the brass balls and needle were placed in metallic connexion by means of a very fine platinum wire. The needle did not rest on the sides of the glass

* From the *Philosophical Transactions of the Royal Society of London*, vol. clxiv., par 2.

* Preliminary experiments showed me that the brass balls on th straw beam acted in every respect the same as the pith balls, wit regard to hot and cold bodies externally applied, both at ordinar pressures and in a vacuum; but they moved in a more sluggis manner.

8

10

70, Lansdowne Place, Brighton, June 13, 1876.

THE ORIGIN OF MOTION.

To the Editor of Engineering.

Sir,—Your contributor, the writer of the articles on "The Origin of Motion," told you in his last letter, written in reply to two previous letters of mine on this subject, that he has some difficulty in imagining that I can be serious in supposing that the molecular vibrations of a piece of card have anything to do with its attraction by a vibrating tuning-fork. To him there appears to be something supremely ridiculous in the supposition that the vibration of the molecules of the card can be the cause of anything. He gave me credit for more sense than is implied in asking him to criticise "such a theory" as mine. "When we talk," he says, "of the effect produced by a vibrating tuning-fork . . . . we allude to the effect produced on the air by the *mass* vibrations of the fork, not considering at all the vibrations of the molecules of the fork"—meaning, I suppose, that if the fork itself did not vibrate it could not by any possibility attract a suspended card.

Now, without wishing for a moment to question your contributor's right to refuse to criticise anything advanced by me, I may as well here point out—I ought to have done it before—that the *molecular* vibrations of a tuning-fork are not quite so insignificant as your contributor would have us believe. The fact is, a *non-vibrating* fork is as capable of attracting bodies suspended near it as a vibrating one is. We have only to increase the energy of the molecular vibrations of a non-vibrating fork, in other words, to raise its temperature, and it exerts an attractive influence upon pith balls, &c., probably as marked as is the influence exerted by a tuning-fork in vibration upon a suspended card, as Mr. Crookes long ago pointed out. A heated tuning-fork *a*, not in vibration, would, according to Mr. Crookes' experiments, attract another tuning-fork *b*, at ordinary temperature, suspended near it. That is, the vibration of the molecules forming *a*'s surfaces influences the surrounding air molecules in such a way as to cause the fork *b* to approach *a*, precisely as it would do if the fork *a* were itself in vibration. In fact the two cases seem to me to be precisely alike; and I would explain the attraction exerted by a *heated* tuning-fork in exactly the same manner as I have explained in my former letters (and too many times to render a repetition necessary), the attraction exerted by a vibrating one. *The molecules forming the surfaces of the fork b* have, in this case, in my opinion, as much to do with its movement towards *a*, as *the molecules forming a's surfaces* have to do with the matter, that is, their vibration has everything to do with it. And I submit that there is nothing whatever in this common-sense view to justify the use of such contemptuous phrases as "such a theory" which your contributor makes use of.

Your contributor has of course a perfect right, as well as my full permission, to refuse to criticise my views, but he has no right whatever to make it appear that he knows more about my opinions than I know myself, and to attribute to me opinions which I have again and again emphatically stated that I do not hold. Your contributor is content, he tells you, to leave my theory to the criticism of others. Then why not leave the theory alone? If he will not or cannot urge any valid objection against my theory that the molecular vibrations of the card are the cause of its attraction by a vibrating tuning-fork, why on earth does he raise objections against nobody's theory that the attraction of the card is due to the reaction of the card itself upon the medium, a theory which implies, as he says, that the card could not be attracted by the fork unless it (the card) vibrated; or, as he puts it in another place, which assumes that a body in order to be attracted *must vibrate*? I suppose that some careless expression of mine was the orginal cause of this misunderstanding, but surely I stated emphatically enough in my last letter that the above was not the theory that I wished your contributor to criticise. My views may be altogether nonsensical, may not even be worth discussing; but if they are so very absurd, why endeavour to make them more so by misstating them?

I may here remark (though I do so with no hope of reversing the decision of your contributor to leave my theory to the criticism of others) that this very theory which is now deemed so absurd, I submitted some time since to the notice of an eminent professor of physics, a F.R.S., and a contributor to the *Philosophical Magazine*, and that, in a very courteous and even kindly letter which I received in reply, he invited me to give an account of my theory to the —— Society, offering at the same time to give me every assistance in his power in the way of preparing diagrams, &c. I may also remark that he assured me that individually he "believed my ideas to possess very great merit," that after being read my paper would be considered with reference to its publication in the *Transactions* of the Society and in the *Philosophical Magazine*. And he even went so far as to promise to get some one to read my paper before the said society, adding that if he could not do so he would *read it himself*. All this commotion caused by a theory which your contributor is half inclined to regard as a sort of joke! Surely I could not be serious when I asked *him* to criticise "such a theory."

Perhaps your contributor's object in disposing of my theory in this off-hand manner was to induce me to follow his example by leaving *his* theory "to the criticism of others." If so, he shall not be disappointed. Seeing that your contributor emphatically refuses to criticise my theory, and that he seems disposed to take but the least possible notice of the objections that I ventured to urge against his own; and, moreover, seeing that it is eminently desirable that this controversy should for your readers' sake, have some definite result, I ask your permission to appeal to those of your readers and correspondents who interest themselves in the subject, and to solicit their opinion on the various points in dispute. I have scarcely anything to say, in addition to what I have already stated in my former letters, either in support of my own views or in support of my objections against those of your contributor. But the subject has been so confused by your contributor's having misstated my theory and my objections to his own (I am sure it cannot be said that I have erred in this respect) that a concise statement of the various issues between us may perhaps assist the jury to whom I appeal, in arriving at a unanimous verdict, which I submit cannot fail to be in every instance in my favour and against your contributor.

Although a great deal of our correspondence has been taken up in dealing with tuning-forks and cards, I believe I am not far wrong when I say that the profoundly mysterious, yet provokingly simple, problem which is the real one to be solved is this: Every molecule of every portion of what for distinction's sake may be termed *gross* matter, moves, or tends to move, at every instant as if it were attracted by every other molecule with a force varying with the inverse square of the distance between the molecules. A molecule at the centre of the sun, for instance, attracts, and is attracted by, a molecule at the centre of the earth. Your contributor and myself both claim to be able to present the world for the first time in history, with a satisfactory explanation of how the thing is done. This is rather presumptuous on our part no doubt; but fools, you know, rush in where angels fear to tread. Perhaps, nay probably, both our theories may be false. No matter. Repeated attempts of this sort may at last convince the "angels" that their fears are quite groundless, and we may thus aid, though indirectly, in bringing about a state of things more creditable to science than obtains at present.

On the one hand, your contributor is of opinion that the central molecule of the sun attracts the central molecule of the earth by means of an elastic medium called ether, which is composed of particles that are rapidly moving in all directions. Our two molecules are themselves in rapid vibratory motion and thus emit waves in all directions. Waves are reflected to and fro between the two molecules, and owing to this reflection of waves the particles of ether composing the column intercepted between the two molecules are continually receiving increments of energy, in consequence of which the column expands and becomes rarefied, and the pressure of the ether in the column becomes diminished. Besides this, owing again to the reflection of waves, the column of ether is thrown into *stationary* vibration. It becomes broken up into segments, which segments vibrate radially outwards, that is, laterally, and thus tend to expand the column radially, to rarefy the axis of the column, and to diminish ethereal pressure at its axis. But stationary vibration is also caused in another way. When one molecule advances towards the other it *bulges* the column radially, the converse taking place by the recession of the molecule, and thus a radial (and longitudinal?) vibration of the ether column about a central axis is set up and the column expands; the pressure in the column, owing to the combined influence of these causes, diminishes; and the pressure upon the remote sides of the two molecules urges them together.

Against this elaborate theory it is surely sufficient to object that the said intercepted column of ether is nearly a hundred millions of miles in length, whilst its diameter may be estimated by keeping in mind that (according to Sir W. Thomson) if we were to magnify a drop of water to the size of the earth, the coarseness of the graining of it would be something between that of cricket-balls and small shot.

I should, however, be content to stake my reputation (if I had any) upon the validity of any one of the following objections:

In the first place, the two vibrating molecules, by increasing the velocity of the particles of ether in the intercepted column, tend to increase and not to diminish the pressure in the column, for the motion of the particles of the ether is assumed by us both to be the sole cause of its pressure. No more conclusive demonstration of this proposition could be imagined than the following: Suppose that a column of ether exactly resembling in all respects the column actually intercepted between our two vibrating molecules were enclosed in an impenetrable tube. Your contributor insists that the pressure of the ether within the tube is less than the outside pressure. And so it might be as long as there were no communication between the ether within the tube and that outside. But directly we allow the ether in the tube to communicate freely with the rest of the medium, it is, I submit, absolutely impossible to give any reason why the inside pressure should not become immediately equal to the outside pressure, however much difference there may be between the density of the ether particles outside and the *density of the other particles inside the tube*. *There is*, you will perceive, a perfect parallel between this imaginary column and the column actually intercepted between our two vibrating molecules, for both columns communicate freely with the rest of the medium. Your contributor persists in ignoring this weighty objection. Until it is answered, I submit that the mere fact that the two molecules *do* approach each other is not sufficient to prove that their approach is due to an excess of ethereal pressure upon their two remote sides. The jury to whom I am now appealing will rightly demand something more from your contributor than the usual re-statement of his theory, or judgment will go against him in default.

In the next place, granting for the moment that by the reflection of waves between our two molecules, or by their bulging the intercepted column radially, or by any other means, the column is broken up into annular segments, which vibrate about a central axis (remember the length and diameter of the column), I contend that we have as yet no *vera causa* for the assumed diminution of pressure at the axis of the column. I do not deny that under the assumed conditions the column would tend to expand, but I assert that for this very reason the pressure at the axis would tend to increase and not diminish. In illustration of his position your contributor supposes that two elastic spheres are rebounding between two parallel planes in such a way that the two spheres strike each other at the middle point between the planes, and then rebound and strike the planes simultaneously, the spheres oscillating backwards and forwards. The spheres, he tells us, will exercise a pressure tending to propel the planes apart. Of course they would. But if the exterior surfaces of the two planes were subject to the pressure of the ether, and the interior surfaces merely to the pressure caused by the impact of the two spheres, they would not recede from each other, unless the pressure of the spheres were greater than the pressure of the ether. If this were the case they would recede from each other until the pressure due to the impact of the spheres had become exactly equal to the pressure of the ether upon their remote surfaces. The spheres would go on rebounding from each other and from the planes alternately, and the important point to be noted is this, they would rebound *from each other* with precisely the same force as they rebound from the two planes, so that if a third plane were placed parallel with the other two midway *between* them, the two spheres would rebound from the middle plane with exactly the same energy as they rebound with after striking the two outside planes. The application of which is obvious. The pressure of the ether at the axis of our imaginary column is, and would always remain in spite of any amount of "stationary vibration" of its imaginary annular segments, precisely equal to the pressure of the ether at every other part of the universe.

Thirdly, your contributor has entirely failed to grapple with the objection I raised against his theory on the ground that the so-called column of ether intercepted between our two molecules is only an imaginary one, seeing that (leaving out of consideration the by no means inconsiderable motion of our solar system through space) at least one of our molecules is moving round the other at a thousand miles per minute, so that no waves can possibly be reflected along our "column;" for by the time a wave has travelled from one molecule to the other, the first molecule is in quite a different part of space altogether from where it was when the wave first started on its immensely long journey; and by the time the wave is reflected back again (if it ever could be reflected, which is rather doubtful), our first molecule is still further removed from its former position. This objection is as yet unanswered, and I do not wonder that it is so. What your contributor says on this point falls quite wide of the mark. I have not (I am told) fully appreciated the facts of the case. I ought to have remembered that when a column of ether is in stationary vibration, it is broken up into longitudinal segments, and that the wave reflected towards one molecule is not reflected from the other molecule, but only from the immediately adjacent longitudinal segment. But I thought we were told, and on looking back I find we were told, that the *mutual reflection of waves* between the opposed pair of vibrating molecules *is the condition required* to throw the intercepted column into stationary vibration, and that no *effect at all* would be produced unless the waves were reflected. My objection therefore goes to the very root of the matter, for even if it were true that your contributor has met the difficulty, provided I admit that there is no necessity that waves ought to be continually reflected, the fact would still remain that I have proved past all contradiction (or at least according to your contributor's own showing) that no effect at all could be produced, because no breaking up of the column into longitudinal segments ever has or ever can take place, for this, we are told, entirely depends upon the reflection of waves between the two molecules within the intercepted column. Your contributor in his letter of May 12, used the expression "reflection of waves between the two molecules," or something equivalent to it, about, if not exactly, *thirteen times*. Had he but kept in mind the motion of our molecules through the ether, which comes to precisely the same thing as *the motion of the ether past the molecules*, the expression would never have been used once in connexion with a theory of gravitation.

Fourthly and lastly (but I am afraid the jury will think that I am breaking a butterfly upon the wheel) we have as yet not a syllable in answer to my objection that the column intercepted between the two molecules under consideration (the central molecule of the sun and the central molecule of the earth) is to a very great extent not composed of other particles at all, but of molecules of ordinary matter. Even if there were one molecule in the intercepted column it would prevent any wave from passing from one molecule to the other, but there are more than one. Thousands of miles of the so-called column are thickly studded with molecules, each one of which is a fatal stumbling-block in the way of your contributor's obtaining a favourable verdict from the jury of impartial inquirers to whom I am now appealing.

This, then, is my case against the theory of gravitation advanced by your contributor, and I venture to anticipate a unanimous and decisive verdict in my favour upon each of the above grounds. With regard to my own theory, seeing that your contributor declines to raise any objection against "such a theory," I have of course none to answer. I really cannot afford time to dispose of the ingenious difficulties urged by your contributor against the theory which he has been pleased to associate with my name, so that I have only to refer every one who wishes to see the clearest statement that I know how to write of the theory which I shall continue to advocate so long as I believe it to be true, to my letter on the "Origin of Motion" which you were good enough to publish in Engineering of May 26. I must conclude my remarks in another letter, meanwhile I remain,

Faithfully yours,

Thomas Inwood Pollard.

11

SCIENTIFIC NEWS.

Feb 1876

Whatever may be the ultimate outcome of Mr. Crookes' scientific toy, the radiometer, it cannot be doubted that it is a very important discovery. It is natural for its inventor to be sanguine in estimating its future; and as we never know what to-morrow may bring forth, it is possible that the radiometer may find some useful employment in one or other of the several practical applications which Mr. Crookes mentioned in his recent lecture at the London Institution. He suggests that the torsion balance which he has used for testing the amount of action of the radiometer should be employed for estimating the quality of our gas supply. The standard "candle" would first be tested, and then a comparison made between the gas and the candle, the slightest motion of the balance being easily recorded. Mr. Crookes has arranged the rotating wires and pith discs in such a manner that they carry with them a small magnet, which causes another magnet to oscillate, as the two poles of the first are respectively presented to it. The oscillating magnet makes and breaks an electric circuit, with which a Morse recorder is connected. By this means an automatic counter is constructed, which registers the number of revolutions made by the vanes, and so records the amount of light falling on the radiometer. Gossip is busy with these ideas, and it is stated that Mr. Crookes has "perfected" the apparatus for recording the quantity of light, and has named it the lucerometer. Mr. Crookes was to read a paper last night, at the Royal Society, in the course of which it is stated that he will show that his radiometer is not only capable of acting as a photometer but as a photo-barometer, or light-weigher. We can only hope there is no disappointment in store for us.

[27397.]—The Radiometer.—This is a subject on which much has been written, and many singular views advanced. It was at one time almost supposed that the undulatory theory of light would have to be altered or abandoned; and an extraordinary statement as to the number of tons pressure on the earth, owing to the sun's rays, appeared; and was duly marvelled at by outsiders, and marvellously laughed at by others. The correct explanation of the instrument seems to be as follows:—The vacuum not being absolute (not even so perfect as it could be made with a good Sprengel pump), there is, therefore, some air in the bulb, with the vanes. Any heat or light falling upon the dark side is absorbed, and heats in a very slight degree the air adjacent. This expands, and in so doing gives the vane a push, causing the rotation observed. The instrument will not act if the exhaustion be pushed too far. It seems there must be just sufficient air to give the requisite push, but not enough to clog the vanes.—Beacon Lough.

THE MECHANICAL ACTION OF LIGHT.*

By WILLIAM CROOKES, F.R.S.

(Concluded from page 174.)

THE advantage of a glass-thread suspension is that the beam always comes back to its original position.

An instrument of this sort, perfectly exhausted and then sealed off, is shown at work in Fig. 5. It has pith plates at the extremities of the torsion beam. A ray of light from the lamp is thrown on to the central mirror, and thence reflected on to the graduated scale. The approach of a finger to either extremity of the beam causes the luminous index to travel several inches, showing repulsion. A piece of ice brought near causes the spot of light to travel as much in the opposite direction. In order to insure the luminous index coming accurately back to zero, extreme precautions must be taken to keep all extraneous radiation from acting on the torsion balance. The whole apparatus is closely packed round with a layer of cotton-wool about 6 in. thick, and outside this is arranged a double row of Winchester quart bottles filled with water, spaces only being left for the radiation to fall on the balance and for the index ray of light to get to and from the mirror.

However much the results may vary when the vacuum is imperfect, with an apparatus of this kind they always agree among themselves when the residual gas is reduced to the minimum possible; and it is of no consequence what this residual gas is. Thus, starting with the apparatus full of various vapours and gases, such as air, carbonic acid, water, iodine, hydrogen, ammonia, &c., there is not found at the highest rarefaction, any difference in the results which can be traced to the residual gas. A hydrogen vacuum appears the same as a water or an iodine vacuum.

The neutral point for a thin surface of pith being low, and that for a moderately thick piece of platinum being high, it follows that at a rarefaction intermediate between these two points pith will be repelled, and that platinum will be attracted by the same beam of radiation. This has been proved experimentally. An apparatus showing simultaneous attraction and repulsion by the same ray of light is illustrated in Fig. 6.

The pieces $f\,g$ on the end of one beam consist of platinum foil exposing a square centimetre of surface, whilst the extremities $f'\,g'$ on the other beam consist of pith plates of the same size. A wide beam of radiation thrown in the centre of the tube on to the plates $g\,f'$ causes g to be attracted and f' to be repelled, as shown by the light reflected from the mirrors $c\,c'$. The atmospheric pressure in the apparatus is equal to about .0mm. of mercury.

In a torsion apparatus similar to the one shown in Figs. 4 and 5, I have submitted variously coloured discs to the action of the different rays of the spectrum. The most striking results, as yet, have been obtained when the different rays of the spectrum were thrown on white and on black surfaces. The result was to show a decided difference between the action of light and of radiant heat. At the highest exhaustions dark heat from boiling water acts almost equally on white pith and on pith coated with lamp-black, repelling either with about the same force. The action of the luminous rays, however, is different. These repel the black surface more energetically than they do the white surface, and, consequently, if in such an apparatus as is shown at Fig. 4, one disc of pith is white and the other is black, an exposure of both of them to light of the same intensity will cause the torsion thread to twist round, owing to the difference of repulsion exerted on the black and the white surface. If, in the bulb apparatus shown in Fig. 3, the halves of the pith bar are alternately white and lamp-blacked, this differential action will produce rapid rotation in the direction which keeps up until stopped by the torsion of the suspending fibre.

Taking advantage of this fact I have constructed an instrument which I have called the Radiometer, shown in section and plan at Figs. 7 and 8. It consists of four arms, of some light material, suspended on a hard steel point resting in a jewel cup, so that the arms are able to revolve horizontally upon the centre pivot, in the same manner as the arms of Dr. Robinson's anemometer revolve. To the extremity of each arm is fastened a thin disc of pith, white on one side and lamp-blacked on the other, the black surfaces of all the discs facing the same way. The whole is enclosed in a thin glass globe, which is then exhausted to the highest attainable point and hermetically sealed.

The arms of this instrument rotate with more or less velocity under the action of radiation, the rapidity of revolution being directly proportional to the intensity of the incident rays. Placed in the sun or exposed to the light of burning magnesium, the rapidity is so great that the separate discs are lost in a circle of light. Exposed to a candle 20 in. off another instrument gave one revolution in 182 seconds; with the same candle placed at a distance of 10 in. off the result is one revolution in 45 seconds; and at 5 in. off one revolution was given in 11 seconds. Thus it is seen that the mechanical action of radiation is inversely proportional to the square of the distance. At the same distance two candles give exactly double, and three candles give three times, the velocity given by one candle, and so on up to twenty-four candles. A small radiometer was found to revolve at the velocities shown in the following Table, when exposed to the radiation of a standard candle 5 in. off.

Time required for One Revolution.

Source of Radiation.		Time in Seconds.
Candle, 5 in. off, behind green glass	...	40
5 " " blue "	...	38
5 " " purple "	...	28
5 " " orange "	...	26
5 " " yellow "	...	21
5 " " light red "	...	20

[illegible] diffused daylight the velocity was one revolution in [illegible] seconds to 2.3 seconds, according to the intensity [illegible] incident rays. In full sunshine, at 10 a.m., it revolved once in 0.3 second, and at 2 p.m. once in [illegible] second.

When heat is cut off by allowing the radiation to pass through a thick plate of alum, the velocity of [illegible] somewhat slower, and when only dark heat is [illegible] fall on the arms (as from a vessel of boiling water) [illegible] tion whatever is produced.

In all respects, therefore, it is seen that the r[illegible] gives indications in strict accordance with theory[illegible]

Several radiometers, of various constructions [illegible] details, but all depending on the above-named [illegible] have been exhibited at the Royal Society, wh[illegible] novelty and unexpected indications excited a co[illegible] amount of interest.

This form of instrument is of too recent a constr[illegible] me to be able to do more than draw brief attentio[illegible] of the many uses for which it is applicable.

FIG. 5.

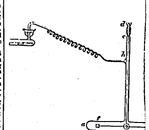


FIG. 6.

By timing the revolutions of the instrumen[illegible] exposed direct to a source of light — a candle,[illegible] stance — the total radiation is measured. If a [illegible] of alum is now interposed, the influence of [illegible] almost entirely cut off, the velocity becomes proport[illegible] less, and the instrument becomes a photometer.[illegible] means photometry becomes much simplified; fla[illegible] most diverse may readily be compared between the[illegible] or with other sources of light; a "standard cand[illegible] now be defined as one which at x inches off ca[illegible] radiometer to perform y revolutions per minute, th[illegible] of x and y having previously been determined by com[illegible] with some ascertained standard; and a statement,[illegible] gaslight is equal to so many candles may, with more ac[illegible] be replaced by saying that it produces so many revol[illegible]

To photographers the radiometer will be invaluab[illegible] it will revolve behind the orange-coloured glass used [illegible] mitting light into the so-called dark room, it is only [illegible] sary to place one of these instruments in the win[illegible] enable the operator to see whether the light enter[illegible] room is likely to injure the sensitive surfaces [illegible] posed; thus, having ascertained by experience [illegible] plates are fogged, or his paper injured, when the revo[illegible] exceed, say, ten a minute, he will take care to draw d[illegible] extra blind when the revolutions approach that n[illegible] Still more useful will the radiometer be in the photo[illegible] gallery. Placing an instrument near the sitter at th[illegible] mencement of the day's operations, it is found that [illegible] tain a good negative, the lens must be uncovered— [illegible] a particular number of seconds—but during the t[illegible] quired for the radiometer to make, say, twenty revo[illegible] For the remainder of the day, therefore, assum[illegible] chemicals not to vary, the operator need not troub[illegible] self about the variation of light; all he has to do is t[illegible] the radiometer, and expose for twenty revolutions,[illegible] negatives will be of the same quality,* although at [illegible] it may have taken five minutes, and at another [illegible] seconds, to perform the allotted number.

I have long been experimenting in the endeavour [illegible] some connexion between the movements of attrac[illegible] repulsion above alluded to, and the action of grav[illegible] Cavendish's celebrated experiment. The investigati[illegible] sufficiently advanced to justify further details, but [illegible] here an outline of one of the results.

I find that a heavy metallic mass, [illegible] broug[illegible]

* In this brief sketch I omit [illegible] ence to the oc[illegible] which the ultra violet rays [illegible] in a greater p[illegible] than the other rays.

Reprinted from the Quarterly Journal of Science.

to say how much influence it m[illegible] heavenly bodies at their respective [illegible]

So far as repulsion is concern[illegible] small things to great, from pieces [illegible] bodies; and we find that the rep[illegible] cold and warm body will equally [illegible] ice is substituted the cold surface [illegible] space, for a lump of pith a cele[illegible] artificial vacuum a stellar void.

Throughout the course of these [illegible] deavoured to remain unfettered by [illegible] theory, which, in the early stages o[illegible] of necessity be erroneous. Some [illegible] that they seem impelled to form a[illegible] experimental basis. There is the[illegible] becoming advocates, and uncon[illegible] which seem to prove their precon[illegible] ing others which might oppose t[illegible] fortunate, for the mind should al[illegible] the judicial function, and give it[illegible] phenomenon which is brought it. [illegible] for *some* facts; but only the true [illegible] *all* the conditions of the problem, [illegible] any theory which has yet come to [illegible]

My object at present is to asc[illegible] conditions of each experiment so a[illegible] necessary and what the accidental [illegible] phenomena. By working steadily [illegible] each group of experiments point [illegible] next group, and following up as cl[illegible] the main line of research, but also [illegible] often lead to the most valuable res[illegible] will group themselves together an[illegible] conditions under which the phenom[illegible] give the laws; and the theory [illegible] difficulty. The eloquent languag[illegible] contains valuable advice, alth[illegible] exaggerated. He says, "When [illegible] theories which may be formed on [illegible] one or two facts, I am convinced t[illegible] the true philosopher to avoid them[illegible] laborious to accumulate facts th[illegible] them; but one good experiment is [illegible] ingenuity of a brain like Newton's [illegible]

THE AVONMOUT[illegible]

By MR. JAMES B[illegible]

BRISTOL ranks as one of the m[illegible] kingdom, and from its geographi[illegible] perior advantages to any other po[illegible] England; but since the introdu[illegible] steamers, she has not had her [illegible] increased trade created by that [illegible] sequence of the tortuous course [illegible] falling tide in the narrow ch[illegible] dering the passage from King[illegible] ous to those steamers. To ob[illegible] of the Port and Pier Railway, [illegible] merchants connected with Bri[illegible] reference to the selection of a [illegible] of plans for a dock suitabl[illegible] large ocean-going steamers at [illegible] so as to give to Bristol her f[illegible] attendant on the steadily incr[illegible] commerce. The result of my ex[illegible] and the consideration of va[illegible] several engineers of eminence, [illegible] consulted by the Corporation [illegible] for the same purpose, was [illegible] plans for the construction of [illegible] site, but Parliamentary sanction [illegible] the following session, 1863-4. [illegible] work did not, however, follow [illegible] desirable. This arose from var[illegible] being the dissensions among the [illegible] buting towards the expense of [illegible] difficulties, when all help from the [illegible] attendant on financing so large [illegible] duals. I must here bear my te[illegible] perseverance of the directors, [illegible] often far more serious than ph[illegible] have after various vicissitudes bee[illegible] be most convenient to give first a[illegible] of the works, and then to desc[illegible] design and mode of execution. [illegible] chosen so that the centre line of [illegible] through the centre of the mou[illegible] what is known as the Swash-way [illegible] road. Between the Swash-way [illegible] a deep channel or approach, 450 [illegible] wide. That part which is immed[illegible] has a bell-mouthed shape, the sid[illegible] centre line of the lock at an angl[illegible] of about two acres in area. Th[illegible] 70 ft. wide from cope to cope, an[illegible] the lower sills at high water equi[illegible] 5 in. The dock itself is 1400 ft. [illegible] has an area of 16 acres. It will [illegible] 35 ft. at high water equinoctial s[illegible] nary springs, and 22 ft. 3 in. at c[illegible] but by locking vessels in and out [illegible] tion of a dam in front of the pro[illegible] the purpose of excluding the tide [illegible] done, and one that proved of co[illegible] level of the ground previous to [illegible] 21 ft. under high water equinocti[illegible] of the bank so formed is 3 ft. ab[illegible] first intended to make the day [illegible] many unsuccessful trials wo[illegible]

* Paper read before [illegible] British Association at B[illegible]

THE ATTRACTION AND REPULSION CAUSED BY THE RADIATION OF HEAT.—40.

APPARENTLY Mr. Crookes does not understand the nature of the forces which I have shown to result from the communication of heat between a gas and a surface; otherwise he would not bring forward as conclusive against the supposition that the phenomena which he has discovered are due to these forces, experiments which show entirely the other way. As I have previously explained, it follows as a direct result of the kinetic theory of gas, that if such forces as I have supposed exist for a certain tension of the gas surrounding the surface, they will not be diminished by diminishing the tension of the gas; and consequently no amount of pumping would destroy such forces where they once existed. Whereas the smaller the tension of the gas the freer the surface will be to move, and the less its motion would be opposed by convection currents; hence, on the supposition that the motion is due to these forces, the only effect of improving the vacuum would be to intensify the action. And this being the case, it is clear that Mr. Crookes' experiments, in which he finds that the action still remains in the most perfect vacuum which he has obtained, tend to support and not to upset my conclusion that the actions are due to these forces. The fact that Mr. Crookes finds it impossible to conceive this only shows, as I have said, that he does not comprehend the nature of the forces; for it certainly presents no greater difficulty than the fact that the velocity of sound is independent of the tension of the gas through which it is transmitted.

Mr. Crookes still appears to think that I attribute these forces solely to the presence of condensable vapour. It is true that the title of my first paper might have led him into this error had he read no further; but both in that paper and in a letter to the *Philosophical Magazine* for November, 1874, it is clearly shown that this is not the case.

I am in hopes that ere long we may hear something on this subject from Professor Maxwell, who probably knows more about the kinetic theory of gases than anyone else. If I am right, these experiments afford a direct proof of the truth of this theory; and as far as I know, this is the only direct proof that has ever been obtained. I do not mean to say that this is the most conclusive proof, but the most direct, or, to quote a remark of Dr. Balfour Stewart, "These experiments stand in much the same relation to the kinetic theory of gases that Foucault's pendulum occupied with regard to the rotation of the earth." No one can admire more than I do the experimental skill with which Mr. Crookes has brought the phenomena to light; nor can I see, should it turn out as I maintain, that they have led to the discovery of a law of nature, that this will detract from their importance, even if they lose somewhat in general interest from the breaking up of the halo of mystery with which they have hitherto been surrounded.

Osborne Reynolds.

Owen's College, May 24. 1875

40.—From the Engineer.

[24000.]—Vacuum Tube.—The essentials for making vacuum tubes are, first, a good air-pump; second, a Bunsen's burner with bellows for blast; and, third, but not least, practical acquaintance with glass-blowing and manipulation. The cost of the apparatus requisite to obtain good tubes is beyond the limits of ordinary experimentalists. Of course you can make a vacuum tube out of a narrow test tube. All that has to be done is to exhaust the tube and hermetically seal both ends, having first inserted platinum terminals; but then, although a vacuum tube, it would hardly deserve that appellation. There is as much, I might add more, trouble in making small vacuum tubes (good ones, I mean) than large ones; and, considering that your query refers to small ones, I must really recommend you to purchase them, instead of attempting to make them yourself. Small ones can be purchased from 1s. 6d. each. I have watched the men making these cheap ones, and have been amazed at the neatness and cleverness requisite for the manufacture of a well-proportioned tube. This could only be obtained after years of practical work.—W. J. LANCASTER.

E. M. Nov. 75

13

Comptes Rendus Hebdomadaires des Seances de l'Academie des Sciences. No. 17, October 26, 1875.

New Spectro-Electric Tube (Modification of the Fulgurator).—MM. B. Delachanal and A. Mermet.—This tube is said to possess the following advantages:—Fixity of the spark, permitting a prolonged observation of the spectra; suppression of the meniscus, and consequently of the absorptions which it produces, and which partially hide the spark; removal of the electrodes into a special tube, which preserves the instrument from corrosive projections; possibility of collecting the total of the substance examined; possibility of forming a collection of spectroscopic tubes, containing permanently the solutions of various substances, and allowing of rapid demonstrations and comparisons. The description of the instrument would be unintelligible without the accompanying illustration.

RADIOMETER—OXYGEN—"NONSENSE."

E. M. Feb. 76

[10122.]—I AM glad "B. P. A." has raised a discussion concerning that curious instrument, the radiometer, and I think that further experiment with it cannot fail to do good. However, I believe even Mr. Crookes himself, after several years' work at the subject, is unable to enunciate a theory which satisfactorily accounts for all the effects observed. Under such circumstances any theorising on the subject must be conducted with great caution.

I see "B. P. A." has twice referred to my condemnation of an explanation (on quite a different subject) by a well-known correspondent as "nonsense," and "B. P. A." expresses a hope that I shall not "see fit to designate his *experiments* as nonsense." Now, the observer who fairly states what he has observed can never be accused of talking nonsense. At the worst he can but have observed incorrectly, which has occurred to our best experimentalists, but, as long as he honestly states his belief, he is secure from criticism. When Mr. Lancaster made the remarkable statement that oxygen and hydrogen were consumed in the lime-light in the proportion O_4H_3, I asked, with all respect, if he could account for consumption in such anomalous proportion. Mr. L. ignored my question entirely, and when I again referred to the subject, after many months' interval, told me he could give no explanation of the fact. Still sceptical of the accuracy of his observation, I asked him to state his method of measurement, and was met by a flat refusal. As it turns out, Mr. Lancaster's observation is substantially correct, and I have never denied the truth of it. I was certainly very sceptical of his accuracy of observation, and pointed out the reason of my doubt. As it is, the anomaly remains quite unaccounted for, and certainly deserves further attention. Now, to have called Mr. L.'s statement "nonsense"—however astonishing it might be—would have been entirely out of place; but I contend that the expression was completely justified when Mr. Lancaster ventilated an original *theory* which was not even supported by the facts known to him, and which showed him to be but very imperfectly acquainted with the subject upon which he was undertaking to give information. By all means let correspondents ask for information, and state their views upon the subjects on which they write, but they should scarcely be permitted to give erroneous explanations on well-known subjects without being checked. Besides, it appears to be forgotten that I expressed my opinion that Mr. L.'s *theory* was "nonsense" in direct reply to his request to be informed whether I thought it *was* "nonsense;" and I stated at the time that I should not have used the term had he not specially asked if I thought it applicable to his writing.

Correspondents who write merely under initials, instead of employing a *nom de plume*, like "Sigma" and "Eclecticus," suffer from a want of recognition as individuals. On this account "B. P. A.'s" contributions are not held so clearly in our minds as could be wished, but, as far as I am aware, "B. P. A." only writes on subjects he understands, and does not venture to lay down the law on questions with which his acquaintance is but slight. In

[illegible] for the benefit of the readers of the ENGLISH MECHANIC.

Alfred H. Allen.

Action of Magnets upon Rarefied Gases Enclosed in Capillary Tubes, and Illuminated by an Induced Current.—M. J. Chautard.—The spectral modifications produced by the action of magnets upon the induction light traversing rarefied gases are subject to very complex laws. The most striking result is an increase of resistance on the part of the induced current under the influence of the magnet. As long as the magnet is inactive the light circulates uniformly in the two tubes. It is suddenly arrested in the shorter and narrower tube at the moment when this is submitted to the action of the magnet. The effect may be produced with chlorine, iodine, sulphur, and selenium.

Magnetic Action on the Rarefied Gases of Geissler's Tubes.—M. J. Chautard.—The author states that it is perfectly well known that gases, and even metallic vapors, present spectra which differ according to the conditions in which they are accidentally placed, among which are temperature, pressure, and the combinations in which the substances occur. The experiments which he has made enable him to add to these modifying causes the action of a powerful electro-magnet. He insists that every spectroscopic observer, before attempting to calculate the numerical results of his experiments, should first determine his peculiar personal error.

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ON

REPULSION RESULTING FROM RADIATION. INFLUENCE OF THE RESIDUAL GAS.*

(Preliminary Notice.)

By WILLIAM CROOKES, F.R.S., &c.

I have recently been engaged in experiments which are likely to throw much light on some obscure points in the theory of the repulsion resulting from radiation. In these I have been materially assisted by Prof. Stokes, both in original suggestions and in the mathematical formulæ necessary for the reduction of the results. Being prevented by other work from completing the experiments sufficiently to bring them before the Royal Society prior to the close of the session, I have thought that it might be of interest were I to publish a short abstract of the principal results I have obtained, reserving the details until they are ready to be brought forward in a more complete form.

In the early days of this research, when it was found that no movement took place until the vacuum was so good as to be almost beyond the powers of an ordinary air-pump to produce, and that as the vacuum got more and more nearly absolute so the force increased in power, it was justifiable to assume that the action would still take place when the minute trace of residual gas which theoretical reasoning proved to be present was removed. The first and most obvious explanation therefore was that the repulsive force was directly due to radiation. Further consideration, however, showed that the very best vacuum which I had succeeded in producing might contain enough matter to offer considerable resistance to motion. I have already pointed out that in some experiments, where the rarefaction was pushed to a very high point, the torsion beam appeared to be swinging in a viscous fluid (194), and this at once led me to think that the repulsion caused by radiation was indirectly due to a difference of thermometric heat between the black and white surfaces of the moving body (195), and that it might be due to a secondary action on the residual gas.

On April 5, 1876, I exhibited, at the *Soirée* of the Royal Society, an instrument which proved the presence of residual gas in a radiometer which had been exhausted to a very high point of sensitiveness. A small piece of pith was suspended to one end of a cocoon fibre, the other end being attached to a fragment of steel. An external magnet held the steel to the inner side of the glass globe, the pith then hanging down like a pendulum, about a millimetre from the rotating vanes of the radiometer. By placing a candle at different distances off, any desired velocity, up to several hundreds per minute, could be imparted to the fly of the radiometer. Scarcely any movement of the pendulum was produced when the rotation was very rapid; but on removing the candle, and letting the rotation die out, at one particular velocity the pendulum set up a considerable movement. Prof. Stokes suggested (and, in fact, tried the experiment at the time) that the distance of the candle should be so adjusted that the permanent rate of rotation should be the critical one for synchronism corresponding to the rate at which one arm of the fly passed for each complete oscillation. In this way the pendulum was kept for some time swinging with regularity through a large arc.

This instrument proved that, at a rarefaction so high that the residual gas was a non-conductor of an induction current, there was enough matter present to produce motion, and therefore to offer resistance to motion. That this residual gas was something more than an accidental accompaniment of the phenomena was rendered probable by the observations of Dr. Schuster, as well as by my own experiments on the movement of the floating glass case of a radiometer when the arms are fixed by a magnet.†

My first endeavour was to get some experimental means of discriminating between the viscosity of the minute quantity of residual gas and the other retarding forces, such as the friction of the needle-point on the glass cup when working with a radiometer, or the torsion of the glass fibre when a torsion-apparatus was used. A glass bulb is blown on the end of a glass tube, to the upper part of which a glass stopper is accurately fitted by grinding. To the lower part of the stopper a fine glass fibre is cemented, and to the end of this is attached a thin oblong plate of pith, which hangs suspended in the centre of the globe: a mirror is attached to the pith bar, which enables its movement to be observed on a graduated scale. The stopper is well lubricated with the burnt india-rubber which I have already found so useful in similar cases (207). The instrument is held upright by clamps, and is connected to the pump by a long spiral tube. The stopper is fixed rigidly in respect to space, and an arrangement is made by which the bulb can be rotated through a small angle. The pith plate, with mirror, being suspended from the stopper, the rotation of the bulb can only cause a motion of the pith through the intervention of the enclosed air. Were there no viscosity of the air, the pith would not move; but if there be viscosity, the pith will turn in the same direction as the bulb, though not to the same extent, and, after stopping the vessel, will oscillate backwards and forwards in decreasing arcs, presently settling in its old position relatively to space.

No good

It was suggested by Prof. Stokes that it would be desirable to register not merely the amplitude of the first swing, but the readings of the first five swings or so. This would afford a good value of the logarithmic decrement (the decrement per swing of the logarithm of the amplitude of the arcs), which is the constant most desirable to know. The logarithmic decrement will involve the viscosity of the glass fibre, but glass is so nearly perfectly elastic, and the fibre so very thin, that this will be practically insensible.

According to Prof. Clerk Maxwell the viscosity of a gas should be independent of its density; and the experiments with this apparatus have shown that this is practically correct, as the logarithmic decrement of the arc of the oscillation (a constant which may be taken as defining the viscosity of the gas) only slightly diminishes up to as high an exhaustion as I can conveniently attain—higher, indeed, than is necessary to produce repulsion by radiation.

I next endeavoured to measure, simultaneously with the logarithmic decrement of the arc of oscillation, the repulsive force produced by a candle at high degrees of exhaustion. The motion produced by the rotation of the bulb alone has the advantage of exhibiting palpably to the eye that there *is* a viscosity between the suspended body and the vessel; but once having ascertained that, and admitting that the logarithmic decrement of the arc of oscillation (when no candle is shining on the plate) is a measure of the viscosity, there is no further necessity to complicate the apparatus by having the ground and lubricated stopper. A movement of the whole vessel bodily through a small arc is equally effective for getting this logarithmic decrement; and the absence of the stopper enables me to have the whole apparatus sealed up in glass, and I can therefore experiment at higher rarefactions than would be possible when a lubricated stopper is present.

* A Paper read before the Royal Society, June 15, 1876.

† *Proc. Roy. Soc.*, March 30, 1876.

16

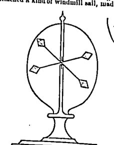
Radiometer of Mr. Crookes.—M. G. Govi.—The author combats the objection raised against his theory from the fact that a radiometer surrounded by a circle of lights does not come to a stop. He argues that in a circle of candles, where the intensity of the light varies without ceasing, and where currents of air may cool the small glass case irregularly, the point of thermic equilibrium, which would stop the rotation, would only be reached with great difficulty. He maintains that a uniform temperature ought to produce continual rotation as well as a continual access of light. He describes an experiment in which a very sensitive radiometer, with discs of aluminium polished on one side, and of mica blackened on the other, and placed in a cylinder of glass, into which the steam of boiling water was passed continuously, began to turn with great velocity, the aluminium sides foremost as soon as the steam had begun to raise the temperature of the case. By-and-bye, the temperature remaining invariable, the rotation slackened, and finally stopped as long as the heat was constant. When the access of the steam was cut off the radiometer began to turn in the contrary direction, and continued so for a long time. Any radiometer may be made to turn in this direction by plunging it into a vessel of cold water. It begins to move immediately, the blackened side of the discs foremost, and only stops after a certain time, *i.e.*, when a new state of thermic equilibrium has been reached. If the instrument is then taken out of the cold water it begins to turn in the same manner as if it had been exposed to light, even though it is all the time in the most profound darkness. If for the discs of aluminium and blackened mica we substitute a set of burnt mica, blackened on one side, the phenomena are complicated, whether because of the bad conductibility of the mica, or because at a certain temperature the nacreous surface of the mica absorbs much obscure heat, and gives off more gas than the blackened side. Thus, in the case heated to 100°, this radiometer turns regularly for a certain time with the nacreous surfaces foremost, then stopped, and began to turn in the contrary direction. The author then describes some unsuccessful attempts made to eliminate the gases adhering to the discs.

Explanation of the Movement of the Radiometer by the Aid of the Theory of Emission.—M. W. de Fonvielle.—The blank surface which reflects the light, and behaves like an elastic surface, ought to be more energetically repelled than the black if the luminous molecules act like masses striking the surfaces of the radiometer. But this principle supposes that the speed of the shock is not superior to the speed of the propagation of molecular movements, which latter is less than that of a ball proceeding from a revolver. This applies *a fortiori* to the shock produced by the luminous molecules, whose speed is a thousand times greater than that of a bullet. In this case, therefore, the absorbing or obscure surfaces should be repelled.

Radiometer of Mr. Crookes.—M. E. Ducretet.—The radiometer being exposed to ordinary daylight, its discs take a movement of direct rotation, the black surfaces being repelled. If ether is poured upon the case the movement is stopped, and then re-commences in an opposite direction. This reaction soon ceases, and we see the discs resume the original direct movement, in spite of the evaporation on the glass case, kept up by a gentle sprinkling with ether. At this moment the rotation becomes more rapid than at first, the evaporation seeming to act as if it were a source of heat, and yet the fall of temperature caused by the evaporation of the ether is very distinct. As soon as the application of ether ceases the movement resumes its normal speed, and remains direct. To repeat these experiments it is necessary to wait till the interior temperature of the radiometer has become equal to that of the surrounding air. The author has exposed a radiometer fixed in a dark place to the action of some tubes filled with phosphorescent powders, rendered very luminous by a previous exposure to the sun. There was no movement. The author is constructing a radiometer in which the reflecting surfaces are covered with very phosphorescent powders, whilst the other surfaces are blackened.

THE RADIOMETER.

THE members of the Photographic Society of France were lately very much interested by the presentation of the "radiometer" of Mr. Crookes. Although this pretty little instrument has been the subject of much controversy in England and Germany, still it is very little known in France even at the present day. The radiometer presented to the Society was of the form and size of a large swan's egg, and made of blown glass. In the centre is a pedestal of the same substance, and rising half-way up the egg. Another pedestal descends from the top and meets the lower one to within about an eighth of an inch. The two ends of these pedestals are hollow for about a quarter of an inch; the pedestals are employed, the lower one to support, the upper one to hold a light steel axis, to which is attached a kind of windmill sail, made of four pieces



176

of very thin mica, a quarter of an inch square, and of exactly the same weight; one side of the mica is painted black and the other is silvered. This kind of four-sail mill is placed in vacuum is then obtained, and, what is extraordinary, if the apparatus be placed in sunlight, it will revolve with astounding rapidity; if put in the shade, it will turn slowly; if in the dark, it will remain stationary. It might be supposed that the great stumbling-block to photographers was now removed, and that the actinic power of light could now be measured with precision, and that they would now be enabled to expose their models the exact length of time at any hour of the day without making a single error. Alas! it was soon discovered that not only light but heat had a great influence upon this instrument. Nevertheless, I am of opinion that we ought not to go to an excess in an opposite direction and cast it away as useless, because it does not fill up the conditions of our enthusiasm; with a little patience, common sense, and a few experiments, the instrument even as it is would render great service to photographers. A cross, star, or other sign could be painted on one of its sails, and the instrument be fixed in a corner of the studio. Now, if a certain number of observations were made daily of the number of rotations per minute at a certain hour with the temperature at that moment, together with the time required for the exposure of the wet plate employed to make the portrait of the sitter, if all this were noted down carefully for a short time, the value of the instrument would soon become apparent, a table could then be drawn up for the time of exposure required at a certain temperature, the instrument making so many revolutions per minute.—*French Correspondence of the Philadelphia Photographer.*

17

the Society must be getting in a bad way, and it is time for the Council to take the matter in hand.—I am, &c.,

THOS. FLETCHER.

Warrington, July 18, 1876.

CHEMICAL NOTICES FROM FOREIGN SOURCES.

NOTE.—All degrees of temperature are Centigrade, unless otherwise expressed.

Comptes Rendus Hebdomadaires des Seances, de l'Academie des Sciences. No. 26, June 26, 1876.

Maximum of the Possible Repulsive Power of the Solar Rays.—M. G. A. Hirn.—The attention of the scientific world has been latterly drawn to the singular phenomena which Mr. Crookes has studied with the radiometer. The conclusion which has presented itself to the mind of many is that these phenomena are due to an impulsive action of the luminous rays, and that it is thus demonstrated that light is a movement of ponderable matter. Nevertheless, the phenomena discovered by Mr. Crookes have been elucidated, if not in their cause, still in their form and their starting-point. The ingenious counter-proof to which M. Arthur Schuster has submitted them places it beyond doubt that it is by no means the direct action of the rays emanating from the luminous source which determines the movement of the discs of the radiometer, but that the repulsive power here called into play has its seat in the walls of the transparent vessel which serves to contain the mill, and that this power is set in action by the pencil of rays directed upon the apparatus. As the true explanation of the totality of the phenomena has not yet been given, and as the hypothesis of the materiality and of the impulsive force of light will probably not soon be abandoned, the author thinks it useful to submit this hypothesis to the test of the method of successive elimination. Mr. Crookes has calculated the apparent repulsion exerted by the solar rays at 1 grm. per square metre. This pressure is more than one thousand times greater than the maximum value possible for reflecting bodies, and more than two thousand times superior to the maximum value possible for absorbing bodies. We may, then, affirm that the phenomena which Mr. Crookes has made known are nowise due to the effect of an impulsion of light, and do not imply the idea of mass of density as regards radiant light and heat. However carefully the vacuum in the vessel enclosing the radiometer or torsion balance may be made, there remain, nevertheless, quantities of gas or vapour relatively enormous. The maximum pressure which the solar radiation can exert upon 1 square metre of absorbing surface is 0·0004157 grm.: let us suppose that the discs of the radiometer are 10 square centimetres, the maximum pressure upon them will be 0·000004157 grm., or a little more than 1/240000th of 1 grm. The slightest agitation of the small quantity of gas remaining in the apparatus will produce upon the radiometer pressure comparable to this. However transparent may be the glass case of the radiometer, it still absorbs a part of the calorific or luminous rays; one of its surfaces is heated more rapidly than the other. This inequality of temperature necessarily determines electric polarity, or the manifestation of static electricity. The vacuum, it is said, is so perfect that the electric spark cannot traverse the apparatus. But electric attractions and repulsions traverse the vacuum. However feeble may be this cause of attraction and repulsion, it may nevertheless have a considerable value in comparison with our maximum of 0·000004157 grm.

New Experimental Considerations on the Radiometer of Mr. Crookes.—M. A. Ledieu.—The author's experiments become less and less favourable to the theory of the apparatus based upon the movements of gases and vapours remaining within the glass case after the vacuum has been made. This theory, as we know, is subdivided into various doctrines, of which a very complete and lucid exposition has been given by M. Bertin in the June number of the *Annales de Chimie et de Physique*. The capital objection which mechanicians oppose to these different explanations is, they are all reduced to admit, that the radiometer is an instrument of reaction. But in such apparatus, having regard to the impossibility of the motive power being rapidly produced with a sufficiently constant intensity, there ensue merely rotations accompanied by retardations and bounds far from being reconcilable with the perfect regularity of the radiometer. Moreover, the theory in question expressly requires that there shall never be an equilibrium of temperature between the gas in the case and the discs of the radiometer. But how are we to admit that in every experiment this equilibrium is not ultimately established? Moreover, the rotation ought to stop at last instead of maintaining itself indefinitely at the same speed. The author then cites certain experiments difficult to explain by the supposed movement of gases in the interior of the apparatus. Thus the instrument was heated nearly to redness, when it commenced turning, but the rotation was sensibly accelerated by the momentary presence of a single flame, which joined its action to that of the radiant heat. An apparatus was constructed with discs exclusively polished. On throwing a pencil of solar rays upon one of the two hemispheres of the glass case a perfect rotation was obtained, without interruption, and as free and rapid as with an ordinary radiometer fully exposed to the light. The author bases his explanation of the phenomena upon a mechanical action of the "ether" perpendicular to the direction of its rays of propagation, and not in the same direction as these rays. This interpretation is calculated to calm the legitimate disquiet of the partisans of undulation. In Germany there is a leaning to an explanation based upon electricity. They rely upon the experiment that when a radiometer with discs exclusively polished, and where one of the hemispheres of the case is traversed by a continuous electric spark, the instrument takes a rapid rotation always opposite to the direction of the spark, this direction being understood according to the common convention. "In any case the radiometer of Mr. Crookes seems to us a serious instrument, and not a paradoxical apparatus destined to enjoy an ephemeral scientific repute and then to rank as a mere physical amusement. Its experimental study, pursued under all modifications and with an indefatigable perseverance, will certainly lead to important results as to the mechanical properties of the ether."

Process for the Manufacture of Soda from Seaweed by Endosmotic Lixiviation.—M. L. Herland.—The author gives the following reasons for the depressed state of the seaweed industry: the weed is collected indiscriminately without regard to its greater or less richness in iodides or other useful salts. The weed destined for incineration is dried on the shore in the open air, whence results a decomposition and a loss of salts from the spray of the sea, dew, rain, &c. The process of incineration itself is the main cause of the weakness of the product in iodine, as a certain quantity is volatilised, but it is chiefly to the siliceous sand mixed with the weed that the great loss is due. In fact, silica at high temperatures reacts upon the iodides, producing alkaline-earthy silicates, and eliminating a certain quantity of iodine. The author, therefore, proposes the following method:—The fresh weed is placed in baskets of iron-wire, moved by a turning crane, and steeped in a series of vats containing about 50 kilos. of good quicklime per cubic metre of water, and arranged in circular batteries. The weed passes in succession from vat to vat, and is exhausted of all its useful salts. The same series of successive immersions is pursued with fresh weed until the first vat marks 4·3° to 4·5° on the hydrometer (pèse-sels, probably a Baumé's glass, adapted for saline solutions). During this operation a double exchange takes place between the weed and the lime-water, by means of endosmosis. The time of steeping

Sc. Am. Sup. 26

18

RADIOMETERS.

THESE novel instruments have recently, as our columns testify, attracted considerable attention, not only amongst scientific amateurs but also amongst savants in different parts of the world. Since Mr. Crookes introduced the subject to the Royal Society, several communications have been submitted to that learned body, and to some of these and to certain outside critics the inventor of the instrument has now replied. At the meeting of the Royal Society, on March 23d, Dr. A. Shuster read a paper on the "Nature of the Force producing the Motion of a Body exposed to Rays of Heat and Light," of which the following is an abstract:

Mr. Crookes has lately drawn attention to the mechanical action of a source of light on delicately suspended bodies *in vacuo;* I have made a few experiments with the view of finding out the seat of the reaction which evidently must tend to move either the inclosure or the source of light. I have found that the action and reaction is entirely between the light bodies suspended *in vacuo* and the exhausted vessel.

Mr. Crookes' "Light-Mill" was suspended by means of two cocoon fibres, forming a bifilar suspension from the top of a vessel which could be exhausted. A slight movement of the inclosure could be easily detected by means of a concave mirror attached to it. A beam of the oxyhydrogen lamp was concentrated on the light-mill, which then revolved 200 times a minute. The light was cut off at the beginning of the experiment by means of a screen, and the position of rest of the glass vessel was read off by means of the dot of light on the scale. The screen was then suddenly removed, and in every case a large deflection of the glass vessel was observed. The vessel was deflected in the opposite direction to that in which the mill turned. When the velocity of the mill had become constant, the vessel turned to its original position of rest, but on suddenly cutting off the light the vessel was again deflected, but in the opposite direction as on starting the experiment. The vessel, therefore, now turned in the same direction in which the mill turned.

These experiments are easily explained on the assumption that the force acting on the vessel inclosing the light-mill is exactly equal and opposite to that acting on the mill itself. While the velocity of the mill in one direction is increasing, a force acts in the opposite direction on the vessel. When the velocity has become constant, the force which tends to drive the mill round is exactly counterbalanced by the resistance which opposes the motion of the mill. The two forces acting on the vessel will therefore counterbalance, and the vessel will return to its original position of rest. When the light is cut off, the resistance will stop the motion of the mill. The reaction of the resistance will act on the inclosure, and the inclosure will turn in the same direction as the mill. By means of the reaction on the inclosure I have been able to calculate the strength of the force; and I have found that the pressure on a surface on which the light of equal intensity to that used in my experiments falls is equal to that produced by the weight of a film of water equal in thickness to the length of a wave of violet light.

At the last meeting of the Royal Society Mr. Crookes read a paper on the "Movement of the Glass Case of a Radiometer," in which he said: During the discussion which followed the reading of Professor Reynold's and Dr. Shuster's papers at the last meeting of the Royal Society, I mentioned an experiment bearing on the observations of Dr. Shuster. I have since tried this in a form, and as the results are very decided and appear calculated to throw light on many disputed points in the theory of these obscure actions, I venture to bring a description of the experiment, and to show the apparatus at work, before the society.

A large radiometer in a four-inch bulb was made with ten arms, eight of them being of brass, and the other two being a long watch-spring magnet. The discs were of pith, blackened on one side. The power of the earth on the magnet is too great to allow the arms to be set in r[illegible] candle is brought near, but once started it will continue to revolve with the light some distance off. This radiometer was floated in a vessel of water and four candles were placed round it, so as to set the arms in rotation. A mark was put on the glass envelope so as to enable a slight movement of rotation to be seen. The envelope turned very slowly a few degrees in one direction, then stopped and turned a few degrees the opposite way; finally it took up a uniform but excessively slow movement in the direction of the arms, but so slow that more than an hour would be occupied in one revolution.

A powerful magnet was now brought near the moving arms. They immediately stopped, and at the same time the glass envelope commenced to revolve in the opposite direction to that in which the arms had been revolving. The movement kept up as long as the candles were burning, and the speed was one revolution in two minutes. The magnet was removed, the arms obeyed the force of radiation from the candles, and revolved rapidly, whilst the glass envelope quickly came to rest and then rotated very slowly the same way as the arms went.

The candles were blown out; and as soon as the whole instrument had come to rest, a bar-magnet was moved alternately from one side to the other of the radiometer, so as to cause the veins to rotate as if they had been under the influence of a candle. The glass envelope moved with some rapidity (about one revolution in three minutes) in the direction the arms were moving. On reversing the direction of movement of the arms the glass envelope changed direction also. These experiments show that the internal friction, either of the steel point on the glass socket, or of the vanes against the residual air, or of both these causes combined, is considerable. Moving the vanes round by the exterior magnet carries the whole envelope round in opposition to the friction of the water against the glass.

As there is much discussion at present respecting the cause of these movements, and as some misunderstanding seems to prevail as to my own views on the theory of the repulsion resulting from radiation, I wish to take this opportunity of removing the impression that I hold opinions which are in antagonism to some strongly urged explanations of these actions. I have on five or six occasions specially stated that I wish to keep free from theories. During my four years' work on this subject I have accumulated a large fund of experimental observations, and these often enable me to see difficulties which could not be expected to occur to an investigator who has had but a limited experience with the working of one or two instruments.—*English Mechanic.*

A few days since, at the London Institution, Dr. Crookes read a paper on the radiation of light, in which he spoke of some practical applications that might be made of his discoveries. His scientific work is already well known, but these applications were for the first time laid before the public. He suggests that the torsion balance, which he has throughout used for testing the amount of action caused by the approach of light to it, should be employed as a test for the purity of our gas supply. First he would test the quality of the standard candles used, which it is known really vary very much when that variation is regarded from the standpoint of scientific accuracy. Then with the torsion balance, he would test the comparison between the gas and the standard candle, the slightest motion of the balance being capable of being recorded by the index scale on which the reflecting mirror shines. The other suggestion was the application of the existing apparatus to meteorological purposes. He has arranged the windmill rotating wires with pith balls, so that they carry round a small magnet suspended beneath them. Their rate of rotation depends on the amount of light that falls on them.

Near the magnet attached to them is suspended another magnet, which oscillates as the attached magnet presents alternately its north and south poles. This oscillation is arranged to make and break an electric circuit, which, by a wire that may be of any length, is connected with a recording Morse machine worked by clockwork. Each revolution of the rotating pith balls is thus recorded by a punch of the Morse on a strip of continuous paper, and so a self-recording account of the amount of light falling at any place may be kept.

In our present meteorological records, Dr. Crookes observes, we notice heat, rain, and pressure of atmosphere; but light, the most important influence, both as regards health and agriculture, is neglected, because not till now have means of measuring it been known.

THE RADIOMETER OF MR. CROOKES.

IN a memoir read before the Academy of Padua by Prof. F. Rosetti, the author concludes his paper as follows: "After the exhibition which I have performed you will be convinced that the radiometer is not an instrument destined merely to attract general attention by reason of its novelty and the curious phenomena which it presents, but that it may serve as a prompt and sensitive thermoscope, and, if used with proper precautions, also as a photometer. It is a novel acquisition for science, both from a theoretical and a practical point of view, and as such it is capable of many applications." The author then describes a modification of the instrument for the purpose of registering the intensity of the solar radiations.

MOVEMENTS PRODUCED BY LIGHT AND HEAT, AND ON THE RADIOMETER OF MR. CROOKES.

By Dr. A. G. BARTH.

A LUMINOUS or thermic pencil which falls upon any body produces a movement due to four causes—(1) Action of the heated sides. (2) Currents of air produced around the heated body itself. (3) Reaction of gases or vapours liberated by heat. (4) Reaction of air heated by contact with the surface upon which the rays fall. On suppressing these causes in the best possible manner, incident light was no longer found to produce attraction or repulsion. These results, however, do not prove that a very feeble impulsive action is not exerted by heat or light.

Dec '76

since been sent to keep company with Phlogiston and the four elements. It can be used, however, to explain the action of the radiometer with charming simplicity. If we hang a thin board from the end of a string so as to make a pendulum, it will suffice to throw a handful of shot at the board to set it in motion. Substitute for the board one of the discs of a radiometer, and for the shot, light corpuscules, projected, say, from a candle, and we have our explanation complete. It is known now, however, that light is not a fluid ponderable or imponderable, but is a mode of motion of that ether which pervades the universe, and that the sensation of colour is not due to the specific force of impact of corpuscules, but to the varying length of the light waves of vibration in the ether. We need not, we think, excuse ourselves for not giving here a more complete exposition of the undulatory theory of light. If our readers will realise the existence of a still pond of ether in which a luminous body sets up waves, as when a stone is thrown into a pool, they will have grasped all that it is for our present purpose necessary that they should comprehend. Let it be clearly understood that the true corpuscular theory supposes the motion of a molecule in a direct line, at a velocity of, in the case of white light, 190,000 miles in a second; but that, according to the undulatory theory, there is no direct movement of translation whatever, but that particles moving through a very small range transmit that motion to other particles with which they come in contact.

It will be seen that it is by no means an easy thing to supply a satisfactory explanation of the rotation of a radiometer on the undulatory theory. Mr. Crookes, in all cases, speaks of repulsion by radiation; that is to say, the heat or the light radiated by a hot or cold body *repels* the surface of the waves of the radiometer. This circumstance of repulsion must not be forgotten; it is really a very important phenomenon. Those who have had any experience in hydraulic works, know that waves which are not waves of translation exert no force of impact. A bottle will rise and fall quickly on an Atlantic swell without falling an inch to the right or left; if, then, light waves, as they are called, were strictly analogous to the ring waves found on a pond when a stone is thrown into it, the radiometer would remain at rest. It is rendered clear, however, not only by the action of the radiometer, but by other considerations, that a light wave is in only a limited sense identical with a water wave. A true wave cannot be created within the mass of a fluid; it is essentially a phenomenon proper to extended surface; but in the ether we have a something which is without surface, inasmuch as it pervades all space, and we are driven to the conclusion that the force operating on the blackened pith of the radiometer is that which would have been communicated to succeeding portions of ether had not the pith surface intervened, and that, in a word, we are supplied with direct evidence of the united force of vibration of the molecules at the extremity of a column of ether, the section of which is equal in area to that of a radiometer vane. Mr. Crookes, in some sense accepting this view, has actually weighed a beam of light, and finds that the sun, when unclouded, exerts a repulsive force on the surface of the earth of 57 tons per square mile, or on the whole semi-surface of the earth of three thousand millions of tons. And here we come upon a direct and very beautiful analogy between the action of light considered as a mode of motion in the ether, and the phenomena of dilation, or more strictly speaking, of pressure, in a gas. To use Tyndall's illustration, air distends a bladder, because the molecules of the gas continually hammer on the inside the walls of the bladder limiting the range of vibration of those molecules next to them. In the same way the vibrating molecules of the ether hammer at the disc of a radiometer and cause its repulsion. So far the theory is rational; and we find that the rotation of the disc of a radiometer is consistent with the undulatory theory. But it will be found, we think, on examination, that the satisfactory character of this hypothesis is more apparent than real. If we are to derive motion from that of molecules of ether in vibration, then it is clear that the more impenetrable the surface is to these molecules, the greater will be the effect produced on that surface. But the fact is, that although a metallic surface brightly polished is just that which we may conceive as being best adapted to receive an impulse from a vibrating ether molecule, yet it is found that a black or absorbent surface into which the light wave sinks as a hammer would into putty, is really that which is most forcibly repelled in the case of the radiometer. This objection has already been urged against the vibratory impulsive theory; and different attempts have been made to explain the objection away. To the consideration of these we may return another time. There is, however, a most important phenomenon connected with the radiometer which up to the present moment has, so far as we are aware, received no attention whatever, and which must meet with some explanation before it is worth while to go into more or less abstract questions connected with the varying influence of different surfaces on the performance of the apparatus.

The phenomenon to which we allude was first exhibited by Mr. Crookes at a *soirée* given at Burlington House on the 5th inst. One of the instruments exhibited we shall describe in Mr. Crookes' own words:—"Radiometer showing rotation of the glass envelope when the vanes are held fixed in space. The radiometer carries a magnet on its arms, and is floated on water so as to be free to move. The vanes are held stationary by an outside magnet. *On allowing radiation to fall on the black surfaces of the vanes the glass envelope rotates.*" The italics are ours. Let us see what they imply. Mr. Crookes has apparently failed himself to see anything specially noteworthy in the circumstance as stated, that if the arms are held the glass globe revolves, and yet it is not too much to say that this is really an exceedingly startling fact which may go far to upset the whole theory of the radiometer. At the first glance, many of our readers will no doubt be disposed to regard the rotation of the glass as an instance of what we may term reciprocity of force. Thus, we know that if the paddle-wheels of a steamer were held at rest and the engines were sufficiently powerful, the whole ship would be caused to rotate round the shaft. A screw steamer would rotate in a different plane, from the same cause. In the case of the Cigar Ship, a vessel with extremely small initial stability, a balance weight consisting of about 15 tons of lead had to be shifted when the engines were started to counteract their tendency to rotate the ship in one direction while the screws revolved in the other. Now, if we regard Mr. Crookes' radiometer wheel as analogous to a ship's paddles, and the glass envelope as corresponding to the hull, there is nothing at first sight anomalous in the rotation of the glass envelope. It will be seen in a moment, however, that there is no analogy whatever between the ship and the radiometer. In the first case the motion of the paddle-wheels is derived from within, and the ship is the fulcrum. If the engines were fitted up outside the ship, their action would set up no rotating force on the hull. Now, in the case of the radiometer, it is obvious that according to received ideas no fulcrum is required to cause its rotation except that supplied by the body giving out the light. Let us suppose this to be a candle, then as action and reaction are always equal and opposite, it follows that the force repelling a radiometer disc in one direction is equally exerted in repelling the candle flame in an opposite one; the glass globe, being transparent, can take no part in the matter whatever. But if we find that, instead of this being the case, it is practically a matter of indifference whether the globe being held fast the radiometer revolves, or the radiometer wheel being held fast the globe revolves, it is impossible to escape one of two conclusions; either the presence of an envelope is essential to the rotation of the radiometer wheel—apart altogether from the circumstance that without it we could have no vacuum—or that the light reflected from the radiometer vanes exercises some peculiar influence on the glass of the envelope. To name only one of several perplexing things connected with the phenomena of rotation of the glass, we have the fact that although Mr. Crookes finds it desirable or even necessary to blacken his pith surfaces, the glass requires no blackening to insure its rotation. For the moment we shall leave the subject here. It is one well worth further investigation, and it is to be hoped that some satisfactory solution of the problem of the rotation of the glass envelope will be supplied. It is the most bewildering phenomenon that has recently been remarked in the world of physical science.

20

16

THE EXHIBITION OF SCIENTIFIC APPARATUS.

PHYSICS (HEAT).

As regards this branch of the section of physics the Exhibition is peculiarly interesting, as it contains a comparatively large number of instruments used by distinguished physicists in determining data of high theoretical importance.

Our attention is first attracted by a large ungainly-looking and quasi-cylindrical vessel. It is the ice-calorimeter constructed and used by Lavoisier and Laplace. The diameter at the top is just a foot and a half. Lifting the lid, we see the compartment in which was placed the body, the specific heat of which it was required to determine. The walls of this chamber were formed by numerous interlacing wires, the interspaces of which facilitated the radiation of heat from the body to the surrounding ice. The diameter of this chamber is 9 in., its length 1 ft. Concentric with this compartment are two others, each of which has at its under-surface a stop-cock to afford free exit to the water of fusion. Knowing the temperature of the body at the beginning and at the end of the operation as well as the weight of the water obtained from the fusion of the ice, we have sufficient data to calculate the specific heat of the body in question. The length of the third and outermost compartment as measured from the stop-cock to the lid is 2 ft. 2 in.; the whole apparatus is supported on a tripod stand, the upper surface being just 3 ft. from the ground. Although the results obtained from this calorimeter are wanting in accuracy, still the apparatus is invested with the twofold interest that must invariably attach to the earliest instruments used in any special subject of research, as well as to its having been devised and used by such eminent men of science as Lavoisier and Laplace.

At a few paces from this calorimeter is a model of the apparatus used by Dulong in his studies on the same subject of specific heat. The method adopted by this savant is known as the "method of cooling," and depends upon the principle that bodies of different specific heats will take different times to cool through the same number of degrees. Close beside the model, which was sent from the Ecole Polytechnique, is the identical cylindrical vessel used by Dulong, and contiguous with this cell is a very small "worm" or serpentine of gold used by De la Rive in his researches upon the specific heat of gases.

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(1)

certained. The weight of the water being next determined, and its increase of temperature observed, it was shown that every pound-degree Fahrenheit was equivalent in energy to 772 foot-pounds. The same experiment was repeated, a slight modification being introduced by substituting mercury for water, the equivalent thus found was 775.* This second apparatus may also be seen in the same case as the first. To many this must be among the most interesting objects in the Loan Exhibition.

The subject of radiant heat is well represented by a complete set of instruments contributed by M. Ruhmkorff, of Paris. The instruments are similar to those used by Melloni in his laborious and delicate investigations, and by Tyndall in his verification of the results obtained by the Italian philosopher. Together with these is placed the apparatus used by our distinguished professor in his researches on the absorption of radiant heat by gases and vapour. This latter consists of a brass tube 2½ in. in diameter and 4 ft. long. The two ends are closed by plates of a very diathermatous substance, viz., rock-salt. By means of two lateral tubulures, the tube may be exhausted and subsequently filled with any gas whose absorptive power it is desired to determine. The exhausted tube is placed in a horizontal position, heat from a Leslie's cube is allowed to fall upon one plate of rock-salt; it radiates through the whole length of the tube, emerges through the other diathermatous plate, and is received upon the surface of a delicate thermo-pile which is connected with a very carefully calibrated galvanometer. In the mean time, rays from a second source of heat, a compensating cube, are concentrated upon the other side of the pile, and the distance is so arranged that the needle of the galvanometer stands at zero when there is a vacuum in the tube. If the tube be now filled successively with atmospheric air, with carbonic acid, and with ammonia, the needle will be but very slightly affected in the first case, but will undergo a considerable deflection with the carbonic acid, which will be further increased with the ammonia. Taking the quantity of heat absorbed by air as unity, the carbonic acid will be found to absorb 90 and the ammonia 1135 such units. Repeated experiments have shown that air, hydrogen, oxygen, and nitrogen differ but very little from a vacuum in their absorbing power. The whole of this important matter has been thoroughly investigated by Professor Tyndall, and it is not without singular pleasure that we gaze upon the very instruments used by him in that elaborate series of experiments.

In connexion with the above subject, we may add that there are some very fine specimens of rock-salt exhibited by W. Steeg, of Homberg, viz., a prism of this material 50×60 mm., a lens 75 mm. in thickness and 300 mm. in radius, and a plate measuring 60×60 mm.

In the same case in which these apparatus are disposed, viz., that of radiant heat, we find a number of those tiny instruments, equally remarkable for their ingenuity, and the hot warfare to which they have recently given rise. We mean the radiometers of Professor Crookes. It is plain that the organiser of this section was ready to do battle in favour of the theory which regards heat and not light as the *primum mobile* of this admirable scientific toy, which may yet forsooth revolutionise some of our cherished and well-framed theories.

There is a goodly collection of pyrometers. The most interesting, from an historical point of view, are those made by Wedgwood, Daniell, and the many-sided Muschenbroek. They are all small, but involve principles of considerable theoretical and practical value. These instruments are, however, superseded by the electrical pyrometer of Dr. Siemens, an invaluable instrument, which will be referred to later on.

Professor Tait, of Edinburgh, has contributed several apparatus relating to conductivity, viz., a bar of German silver about 9 ft. long, and 1¼ in. thick, with nine thermometers inserted at different points of the length; a second of the same dimensions but of iron, and a third of copper about 4 ft. long, and carrying fourteen thermometers. These bars are intended for repeating Despretz's celebrated experiments, by which he showed that if the distances of the thermometers from the source of heat be in arithmetical progression, the excess of the recorded temperatures over that of the surrounding air will decrease in geometrical progression. We may observe that the homogeneousness of the bar is altered by the insertion of the thermometer bulbs, and hence a source of error is introduced which detracts from the value of the data obtained by such experiments. The same subject was investigated by Wiedmann and Franz by applying a very small thermo-pile to different parts of the bar. The numbers obtained differ considerably from those given by Despretz. There is yet another appliance based upon the principle of conduction, which few will fail to recognise as Sir Humphrey Davy's safety-lamp. Its very look is a fair guarantee of its originality; all doubt, however, is removed by the manuscript label, which states that it has been sent from the collection of the Royal Society. The wire gauze is extremely fine. This precious model was made by Sir Humphrey and presented to the Royal Society, together with his memorable paper upon the same subject, on the 11th of January, 1816.

Theomometry is very well represented; there is no lack of maxima, minima, wet and dry bulb, differential, and other thermometers. There is also a good collection of manometers with drawings, &c. But by far the most curious measurer of temperature is the thermometer of Galileo, which is exhibited together with the other instruments of this illustrious philosopher. Until recently the physician Sagredo was considered the inventor of the thermometer; but there is now strong positive evidence that Galileo's was made some time before the year 1597. It is an air thermometer, consisting of a bulb and a tube dipping into a small cistern of water. It was originally intended for medical purposes. It is still in excellent order, and high authority has stated that its delicacy is such as not easily to be surpassed.

We find another thermometer in this most valuable collection, which is also an early specimen, having been made in the seventeenth century. It originally belonged to the Florentine Accademia del Cimento, but now belongs to the Royal Institution, having been presented by Sir Henry Holland. There is also another thermometer which deserves attention from the novel feature of its graduation. It is called the Milligrade thermometer, from the fact that the interval between the freezing and the boiling point of mercury is divided into 1000 parts. The interchange of readings between this and Centigrade scale will be obvious from the consideration that mercury freezes at —40 deg. C., and boils at 360 deg. C.; hence 400 deg. C. must equal 1000 M., or 1 deg. C.=2½ deg. M. According to this scale water boils at 350 deg.. and freezes at 100 deg., the interval (250 deg.) being just one-fourth that between the freezing and boiling points of mercury. The practical advantage of such a graduation seems to be: first, the avoidance of the minus sign, all readings under 100 M. indicating temperatures below zero; and, secondly, the avoidance of fractions (owing to the smallness of the degrees) which are often necessary to express the boiling point under certain resistances. The exhibitor of this novel instrument is John Williams, F.C.S.

This section, as will now appear, is replete with interest, and will amply repay several visits.

* The value now generally accepted in this country is 772.

April 27/76

Floating Radiometers

IN Mr. Crookes' paper reported in NATURE, vol. xiii. p. 489, occur the following words: "The envelope turned very slowly a few degrees in one direction, then stopped and turned a few degrees the opposite way." Assuming that this is rightly reported, it is inexplicable to me how Mr. Crookes could have written it. For, as the lawyers say, it is "void from ambiguity." The whole question between Mr. Crookes and Dr. Schuster appears to me to turn on the one point ignored by the former. When the rotation of the envelope began, in which direction was the first oscillation? To say that the envelope first turned in one direction and then in the other is simply to say that it oscillated, which, while it is a shorter mode of expressing the same thing, is an equally useless expression. The very nerve of the problem lies in the point omitted. If the first oscillation of the envelope was in the direction opposite to that of the mill, it is surely incontestable that the kick, which caused it, could not be the effect of any external force acting on the discs only.

Valentines, Ilford C. M. INGLEBY

21

RADIOMETERS[1]

DURING the discussion which followed the reading of Prof. Reynolds's and Dr. Schuster's papers at the last meeting of the Royal Society I mentioned an experiment bearing on the observations of Dr. Schuster. I have since tried this in a form; and as the results are very decided and appear calculated to throw light on many disputed points in the theory of these obscure actions, I venture to bring a description of the experiment, and to show the apparatus at work, before the Society.

I made use of a radiometer described in a paper com-

[1] "On the Movement of the Glass Case of a Radiometer." By William Crookes, F.R.S., &c. Read at the Royal Society.

Nature April 20/76

municated to the Society in January last. I quote the description from paragraph 181. "A large radiometer in a 4-inch bulb was made with ten arms, eight of them being of brass and the other two being a long watch-spring magnet. The discs were of pith, blackened on one side. The power of the earth on the magnet is too great to allow the arms to be set in rotation unless a candle is brought near, but once started it will continue to revolve with the light some distance off."

This radiometer was floated in a vessel of water and four candles were placed round it, so as to set the arms in rotation. A mark was put on the glass envelope so as to enable a slight movement of rotation to be seen. The envelope turned very slowly a few degrees in one direction, then stopped and turned a few degrees the opposite way; finally it took up a uniform but excessively slow movement in the direction of the arms, but so slow that more than an hour would be occupied in one revolution.

A powerful magnet was now brought near the moving arms. They immediately stopped, and at the same time the glass envelope commenced to revolve in the opposite direction to that in which the arms had been revolving. The movement kept up as long as the candles were burning, and the speed was one revolution in two minutes.

The magnet was removed, the arms obeyed the force of radiation from the candles, and revolved rapidly, whilst the glass envelope quickly came to rest and then rotated very slowly the same way as the arms went.

The candles were blown out; and as soon as the whole instrument had come to rest, a bar-magnet was moved alternately from one side to the other of the radiometer, so as to cause the vanes to rotate as if they had been under the influence of a candle. The glass envelope moved with some rapidity (about one revolution in three minutes) in the direction the arms were moving. On reversing the direction of movement of the arms the glass envelope changed direction also.

These experiments show that the internal friction, either of the steel point on the glass socket, of the vanes against the residual air, or of both these causes combined, is considerable. Moving the vanes round by the exterior magnet carries the whole envelope round in opposition to the friction of the water against the glass.

As there is much discussion at present respecting the cause of these movements, and as some misunderstanding seems to prevail as to my own views on the theory of the repulsion resulting from radiation, I wish to take this opportunity of removing the impression that I hold opinions which are in antagonism to some strongly urged explanations of these actions. I have on five or six occasions specially stated that I wish to keep free from theories. During my four years' work on this subject I have accumulated a large fund of experimental observations, and these often enable me to see difficulties which could not be expected to occur to an investigator who has had but a limited experience with the working of one or two instruments.

2 22

PROCEEDINGS OF SOCIETIES.

PHYSICAL SOCIETY.

December 16th, 1876.

Professor G. C. FOSTER, F.R.S., President, in the Chair.

THE following candidate was elected a Member of the Society:—Mr. W. Baily, M.A.

Mr. CROOKES described some of the most recent results he has obtained in his experiments on the radiometer, and exhibited many beautiful forms of the apparatus, most of which have been devised with a view to decide on the correct theory of the instrument. He commenced by describing the arrangement he has used for some time past in studying the resistance offered by air and other gases to the rotation of a mica disc. It consists of a mica plate suspended by a fibre of glass, and enclosed in a chamber which can be exhausted to any required extent. A mirror is attached to the mica, and the movement of a luminous point reflected from it shows that the decreasing swings form a logarithmic curve, and Mr. Crookes takes the logarithms of the decrements of the swings as a measure of the viscosity of the gas under examination. From the normal atmospheric pressure to the best vacuum which can be obtained by the ordinary air-pump this decrement remains nearly constant, and these experiments have been carried on in vacua of remarkable perfectness, the highest exhaustion obtained being represented by 1 millimetre on a scale of 10 miles, a point which was attained by means of a Sprengel pump with improvements by Mr. Gimingham, and measured by a McLeod gauge. If the "logarithmic decrement" be represented by 125 at a pressure of 760 m.m., it is not reduced to 70 until the pressure has been reduced to 35-millionths of an atmosphere, and at this point the action of light on a radiometer is at a maximum. On continuing the exhaustion this influence is found to decrease, and Mr. Crookes concludes that in a perfect vacuum the log dec. would not be zero, but about 0·01; that is, a mica plate would not continue to oscillate for ever, a fact probably due to the viscosity of the glass fibre. About fifteen different forms of the radiometer were exhibited, and their inventor has satisfied himself that the theory of their action proposed by Mr. G. Johnstone Stoney is the only one capable of completely accounting for their action, and he considers it to be in all probability the correct one. By means of a double radiometer, consisting of two globes of different diameters, and having a wide opening between them, and provided with a four-armed fly which can be made to rotate in either bulb, it has been shown that, other things being equal, the velocity of rotation decreases as we increase the diameter of the bulb. As, on the molecular-movement theory, the rotation is due to a throwing off of particles from the blackened surface of the mica, it follows that, if a piece of transparent mica be attached to each fly in front of the blackened surface, the rotation will take place in the opposite direction, and this proved on experiment to be the case. And, further, when such a plate is placed on either side of the vanes, the motion of the instrument is almost entirely stopped. As these facts can be explained on the "molecular movement" or the "evaporation and condensation" theory, Mr. Crookes arranged a radiometer having four transparent mica vanes, and mounted in a rather large bulb. At the side of the bulb a plate of mica, blackened on one side, is so fixed in a vertical plane that the vanes can pass, and when light shines on this fixed plate the fly is found to rotate, a fact which in itself disproves the latter theory. Many other curious forms were exhibited, in some of which the vanes were cup-shaped, as Mr. Crookes has found these to act as well as the ordinary form, a convex surface acting as though it were blackened. In conclusion, he exhibited a photometric four-vaned radiometer, in which the fly was attached to a small magnetic needle, and this might be so checked by an external magnet that the strongest light would be incapable of causing the needle and vanes to make a half rotation. If the circumference of the globe be graduated, and the apparatus be brought within the influence of a source of light, the angle to which the needle is deflected will be a direct measure of the intensity of the light, and Mr. Crookes showed that by a simple arrangement such an instrument might be rendered self-recording.

Prof. DEWAR exhibited a simple electrometer which he has designed, founded on the discovery of Leipman that the capillary constant is not really independent of the temperature or the condition of the surface, but is a function of the electromotive force. If a capillary tube be immersed in mercury, and dilute sulphuric acid be placed in the tube above the mercury, and a current from a Daniel's cell be so passed through the liquids that the mercury forms the negative pole, the column will be depressed to an extent dependent on the diameter of the tube. In making an electrometer, Prof. Dewar has increased the sensitiveness by connecting two vessels of mercury by means of a horizontal glass tube filled with the metal, except that it contains a bubble of dilute acid. The tube must have an internal diameter of 2 millimetres, and it is essential that it be perfectly clean, uniform in diameter, and horizontal. The instruments exhibited were constructed by Messrs. Tisley and Spiller, and Prof. Dewar showed that it is possible by means of them to measure an electromotive force equal to 1-10,000th of a Daniel's cell; forces capable of decomposing water must be measured by causing two currents to act against each other. The index bubble is brought to zero by uniting the mercury cups by a wire. The apparatus is very convenient, as it requires no preparation, and is extremely simple in its action. He then showed an instrument arranged by Mr. Tisley for producing a current by the dropping of mercury from a small orifice into dilute sulphuric acid. If the vessels containing the mercury and the sulphuric acid be connected by a wire a current is found to traverse it, and Prof. Dewar explained how the electrolysis of water might be effected by this means. He then exhibited a delicate manometer suitable for measuring very slight variations of pressure, and he illustrated the use of it for proving Laplace's law that the internal pressure, multiplied by the diameter of a soap-bubble, is constant. It consists of a U-tube, one arm of which is about 15 inches long, and is bent horizontally, and levelled with great care. If the shorter arm be connected with a tube on which a bubble has been blown, and the diameter of the bubble be varied, the position of the extremity of the alcohol column will be found to vary in accordance with the above law.

23

up with sandstones, conglomerates, and breccias. The red stain of these deposits, occasional pseudomorphs of rock-salt and layers of gypsum, combined with ripple-marks and sun-cracks seem, as Prof. Ramsay has suggested, to indicate the concentration of the saline waters which filled these basins; while further evidence of the unwholesome nature of the water may be indicated by the general paucity of fossils in the strata, and by the immense numbers of well-preserved fishes which are sometimes met with crowded into a small space, as if they had come from fresher water elsewhere, and had been inclosed and killed in scattered pools. The peculiar breccias and brecciated conglomerates of the Upper Old Red Sandstone have been compared to some recent Glacial deposits, and the resemblance has been pointed out between the form of the stones in these deposits, and those in common boulder-clay. It should be noted also that in many cases these breccias occur in old valleys, and bear many of the characters of valley-moraines. Such are those to the east of Ullswater, and those which flank, and in some places penetrate the Lammermuir Hills. In the latter district worn dome-shaped bosses of rock underlying the breccias recall the aspect of true *roches moutonnées*. Another glacial feature is suggested by the basin-shaped hollows (apparently sometimes true rock-basins) in which the deposits lie. Further indications of ice are given by the remarkable patches of angular and rounded stones scattered through the red sandstones of Arran, the occurrence and position of which may be accounted for on the supposition that they are portions of shore-gravel, which have been frozen and transported in cakes of floating-ice.

Indications of terrestrial disturbance during the accumulation of the Upper Old Red Sandstone in Scotland are furnished by the Lammermuir Hills. Towards the close of the period, and thence through the deposition of the Lower Carboniferous rocks, volcanic action which seems to have been quiescent for a long interval, broke out again over the south of Scotland. To this period belongs the chain of old lavas and tuffs which may be traced from the mouth of the Nith eastwards by Langholm and the Tarras Water, to the head of the Slitrig Valley, and through the plain of the Tweed as far northwards as the Whiteadder. The Garlton Hills, Campsie Fells, and the ranges of hills which run down Renfrewshire and the north-east of Ayrshire, and are prolonged into Bute, the Cumbrays and Arran mark a prolonged series of volcanic eruptions during this same period. Probably the terraced hills of Lorne are of similar age. Traces of contemporaneous volcanic action occur likewise in the Upper Old Red Sandstone of the north of Scotland, and form a remarkable feature in the cliffs of Hoy, one of the Orkney Islands.

The author brought forward evidence to show that while the Upper Old Red Sandstone was being deposited in the British area, there existed outside that area a sea in which some of the characteristic corals, brachiopods, and other organisms of the time of the Carboniferous Limestone already existed. He pointed out the intercalation of limestone bands in the Red Sandstone series in Arran and elsewhere, a long way below the base of the Cementstone group which underlies the Carboniferous Limestone. These calcareous bands, full of species of fossils which are familiar in the Carboniferous Limestone, seem to indicate that while, on the whole, the Upper Old Red Sandstone, and the red strata at the base of the Carboniferous system were deposited under conditions unfavourable to the presence of at least corals, crinoids, and molluscs, their formation was interrupted by intervals during which clearer and less saline water prevailed, perhaps owing to the removal of barriers which allowed the access of the main ocean with its animal forms into the closed lagoons and inland seas of the Upper Old Red Sandstone.

ON REPULSION RESULTING FROM RADIATION[1]

THIS paper contains an account of experiments on the action of radiation on bodies the surfaces of which have their radiating and absorbing powers modified by various coatings. The difference between a white and a lamp-blacked surface in this respect was at first not very decided, and experiments have been instituted with the object of clearing up some anomalies in the actions observed. Two pith discs, one white and the other black, are suspended on a light arm in a glass bulb by means of a fine silk fibre; after perfect exhaustion the white and black discs are found to be equally repelled by heat of low intensity, such as from the fingers, warm water, &c. A copper ball is then tried at gradually increasing temperatures. Up to 250° C. it repels both equally, above that the black is more repelled than the white, and at a full red heat the repulsion of the black disc is very energetic. A lighted candle acts with more energy than the red-hot copper.

The presence of even a small quantity of aqueous vapour in the exhausted apparatus almost, if not quite, neutralises the more energetic action which luminous rays appear to exert on a blackened surface.

After describing several different modifications and some new forms of apparatus devised to facilitate experiment, the author gives a drawing of an instrument which enables him to get quantitative measurements of the amount of incident light falling on it. It consists of a flat bar of pith, half black and half white, suspended horizontally in a bulb by means of a long silk fibre. A small magnet and reflecting mirror are fastened to the pith, and a controlling magnet is fastened outside so that it can slide up and down the tube, and thus increase or diminish sensitiveness. The whole is completely exhausted and then inclosed in a box lined with black velvet, with apertures for the rays of light to pass in and out. A ray of light reflected from the mirror to a graduated scale, shows the movements of the pith bar. The degrees of deflection produced by the light of a candle at distances from 6 feet to 35 feet are given.

The experimental observations and the numbers which are required by the theoretical diminution of light with the square of the distance, are sufficiently close, as the following figures show:—

Candle	6	feet off	gives a deflection of	218°
"	12	"		
"	18	"	"	54
"	24	"	"	24·5
"	10	"	"	13
"	20	"	"	77
"	30	"	"	19
			"	8·5

The effect of two candles side by side is practically double, and of three candles three times that of one candle.

The action of various solid and liquid screens is next given.

A candle three feet off, giving a deflection of 180°, has its action reduced to the following amounts by

Yellow glass	161°
Blue "	102
Green "	101
Red "	128
Water "	47
Alum "	27

A candle on each side of the apparatus, and equidistant from it, keeps the index ray of light at zero; by shading off either one or the other the light flies off to either extremity of the scale. This gives a ready means of balancing two sources of light one against the other. Thus, &c. Part III.

[1] Paper read at the Royal Society, Feb. 10, by William Crookes, F.R.S.

24

25

THE CHEMICAL NEWS.

Vol. XXXIV. No. 892.

EXPERIMENTAL CONTRIBUTIONS TO THE THEORY OF THE RADIOMETER.*

Preliminary Notice.

By WILLIAM CROOKES, F.R.S., &c.

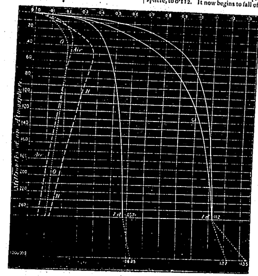
Instead of bringing another preliminary notice before the Society, I should have preferred reserving the announcement of my new results on the Repulsion resulting from Radiation until they were fit to be offered in a more complete form; but the radiometer is now so much occupying the attention of scientific men, and results of experiments with this and allied instruments are appearing so frequently in the scientific journals at home and abroad, that were I not to adopt this method of bringing the results of my more recent experiments before men of science, I might find myself anticipated in some or all of the conclusions at which I have arrived.

On June 15th last I mentioned to the Society that the repulsion resulting from radiation increases up to a certain point as I exhaust the air from the torsion apparatus. After long-continued exhaustion the force of radiation approaches a maximum, and then begins to fall off. I have since succeeded in experimenting at still higher exhaustions, and with different gases in the apparatus; and by means of a McLeod gauge attached to the mercury pump I have been able to measure the atmospheric pressure at any desired stage of exhaustion. I have not only measured the force of repulsion, but also the viscosity of the residual gas, and from the results plotted I have the observations in curves which accompany this paper, and which show how the viscosity of the residual gas is related to the force of repulsion exerted by radiation. These curves must not, however, be considered as representing more than the broad facts, for I have not included in them my final observations, which in all probability will introduce modifications in them.

In plotting these curves I have supposed my scale to be 1000 metres long, and to represent one atmosphere. Half-way up the scale therefore, or 500 metres, represents half an atmosphere; 999 metres up the scale represents an exhaustion of 1-1000th of an atmosphere; each millimetre, therefore, stands for the millionth of an atmosphere.

My results have principally been obtained at the top of the scale, and it is the last quarter of a metre which supplies the diagrams accompanying this paper.

When the residual gas is air, the viscosity (measured by the logarithmic decrement of the arc of oscillation) is practically constant up to an exhaustion of 250 millionths of an atmosphere, or 0·19 millim. of mercury, having only diminished from 0·126 at the normal pressure of the atmosphere, to 0·112. It now begins to fall off: at 200 millionths it is 0·110; at 100 millionths it is 0·096; at 50 millionths it is 0·078; at 20 millionths it is 0·052; at 10 millionths it is 0·035; and at 0·1 of a millionth of an atmosphere, the log. dec. has fallen to about 0·01. Simultaneously with this decrease in the viscosity, the force of repulsion exerted on a black surface by a standard light varies. It increases very slowly till the exhaustion has risen to about 70 millionths of an atmosphere; at about 40 millionths the force is at its maximum; and it then sinks very rapidly, till at 0·1 millionth of an atmosphere it is less than one-tenth of



* A Paper read before the Royal Society, November 16, 1876.

meter probably requires more experimental investigation

THE CHEMICAL NEWS.

Vol. XXXIV. No. 888.

ON REPULSION RESULTING FROM RADIATION.—PART II.*

By WILLIAM CROOKES, F.R.S., &c.

(Continued from p. 220).

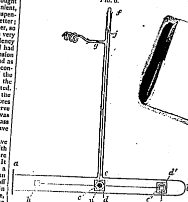
101. The difficulty which attended experiments with the balances and bulb apparatus used at first was to bring the moving part accurately back to zero, and also to measure the deflection produced. I therefore tried several plans of giving a fixed zero-direction to the movable index. Thus a piece of magnetic oxide of iron was cemented to one end of the index, and a permanent magnet was brought near it. This answered pretty well, but was inconvenient, besides not being sufficiently accurate. A bifilar suspension from cocoon-fibres seemed likely to succeed better; but the difficulty of suspending the rod in this manner, so as to get exactly the same tension on each fibre, was very great, and unless this was done there was more tendency to move in one direction than in the other. When I had succeeded in suspending the needle with an equal tension on each silk fibre, I found their elasticity to vary; and as soon as the vacuum was approached one was sure to contract more than the other, twisting the needle out of the axis of the tube, and sometimes causing it to touch the side. This method of suspension was therefore abandoned.

By increasing the length of the needle, and also of the fibre used to suspend it, it was possible to employ fibres with a considerable amount of torsion, and still preserve the delicacy of the apparatus. Fine platinum wire was first tried; but this was soon abandoned in favour of glass fibres, which were found to answer so perfectly that I have since used nothing else.

102. Fig. 7 shows the form of apparatus which I have finally adopted, as combining the greatest delicacy with facility of obtaining accurate observations, and therefore of getting quantitative as well as qualitative results. It is a torsion apparatus in which the beam moves in a horizontal plane, and may be called a horizontal torsion balance. *a b* is a piece of thin glass tubing, sealed off at the end *b* and ground perfectly flat at the end *a*. In the centre a circular hole, *c*, is blown, and another one, *c'*, at the end; the edges of these holes are ground quite flat. *a*, *c*, and *c'* can therefore be sealed up by cementing flat transparent pieces of plate glass, quartz, or rock-salt, *a*, *d*, and *d'* on to them (83). To the centre of *a b* an upright tube, *e f*, is sealed, having an arm, *g*, blown on to it for the purpose of attaching the apparatus to the pump. *h i* is a glass index, drawn from circular or square (22) glass tube, and as light as possible consistent with the needful strength. A long piece of this tube is first drawn out before the blowpipe; and it is then calibrated with mercury until a piece is found having the same bore throughout: the necessary length is then cut from this portion. *j k* is a very fine glass fibre, cemented at *j* to a piece of glass rod, and terminating at *k* with a stirrup, cut from aluminium foil, in which the glass index, *h i*, rests. In front of the stirrup is a thin glass mirror, shown at *k*, silvered by Liebig's process, and either plane or concave as most convenient. At the ends of the glass index (*h i*) may be cemented any substance with which it is desired to experiment; for general observations I prefer to have these extremities of pith, as thin as possible, and exposing a surface of 10 millimetres square. The pith may be coated with lampblack or silver, or may retain its natural surface.

103. The preparation of the suspending thread of glass requires some care. It should be drawn from flint glass, as this gives much tougher threads than foreign glass. The diameter varies with the amount of torsion required; it may be 0·001 inch or less. I select the piece best adapted for the special experiment in the following way:—Several threads of glass are first drawn out before the blowpipe, and a certain number selected as being likely to answer the purpose. These are then suspended side by side to a horizontal rod and equalised as to length. A piece of glass rod, about 2 inches long, which is always kept for this purpose, is then cemented by shellac on to the end of one of the threads. Air currents are then cut off by a glass screen, and the thread being set in movement by a slight twist, the torsion is measured by timing the oscillations. This having been done with each thread in succession, one is selected and mounted in the apparatus. If it works properly, well and good; if not, it is easy to select a thread having the requisite amount of torsion, more or less, and substitute it for the one first used.

Fig. 6.



In fitting up one of these apparatus threads were drawn out which were found to require, respectively:—

44 seconds,
30 „
28 „
11 „
and 3½ „

for a half oscillation when the glass weight was hung on to their ends. The one oscillating in 30 seconds was first used, but was found to give insufficient torsion. The one making half an oscillation in 11 seconds was then used, and was found to answer well. Before I adopted this plan days were frequently wasted in the attempt to hit upon a glass thread of the requisite degree of fineness.

104. In taking accurate observations with an apparatus of this description, it is necessary to support it on a stand firmly fastened to a main wall. When resting on a bench, or connected in any other way to the floor, there is a constant oscillation which keeps the index from zero.

The apparatus being fastened firmly to its stand, accurately levelled, and sealed on to the pump, a divided scale, *a b* (fig. 8), is placed four feet from the small mirror; and immediately beneath the scale is a narrow brass slit,

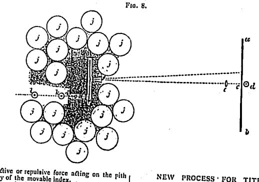
c, illuminated by a lamp, *d*. In front is a lens, *e*, which throws the image of the slit on to the mirror, where it is reflected back again on to the divided scale. Here the angular movement of the bright line of light shows the minutest attractive or repulsive force acting on the pith at the extremity of the movable index.

In order to keep the luminous index accurately at zero, except when experiments are being tried, extreme precautions must be taken to keep all extraneous radiation from acting on the apparatus. A slightly conical paper tube, *f*, about 6 inches long, and as narrow as the angular movement of the ray of light will admit of, is cemented on to the glass window in front of the mirror; and a similar tube, *g*, is cemented on to the quartz window in front of the pith surface on which radiation is to act. The latter tube is furnished with card shutters, *h*, *i*, at each end, capable of easy movement up and down. The whole apparatus is then closely packed on all sides with a layer of cotton-wool, about 6 inches thick, and outside this is arranged a double row of Winchester quart bottles, *j*, *j*, filled with water and covered with brown paper, spaces being only left in front of the paper tubes. *k* and *l* represent the positions of the candle 140 and 280 millims. distant from the pith. The whole arrangement has the appearance shown in fig. 8.

105. I will not discuss at present the phenomena presented when the apparatus is full of air, or when the vacuum is imperfect, but will proceed to the effects observed when the exhaustion has been pushed to the highest attainable degree. However much the results may vary when the vacuum is imperfect, or when the apparatus is full of air, I always find them agree amongst themselves when the residual gas is reduced to the minimum possible; and I have also ascertained that it is of no consequence what this residual gas is. Thus I have started with the apparatus filled with various vapours and gases, such as air, carbonic acid, water, iodine, hydrogen, or ammonia; and at the highest rarefaction I find no difference in the results which can be traced to the residual vapour, assuming any to be present. A hydrogen vacuum seems neither more nor less favourable to the phenomena than does a water or an iodine vacuum. If moisture be present to begin with, it is necessary to allow the vapour to be absorbed by the sulphuric acid of the pump, and to continue the exhaustion with repeated warming of the apparatus until the aqueous vapour is removed; then only do I get the best results. When pith surfaces are used at the extremities of the glass beam, they should be perfectly dry; and they are more sensitive if the apparatus has held a vacuum for some weeks, as the residual moisture in the pith will then have been absorbed by the sulphuric acid in the pump.

(To be continued.)

FIG. 8.



NEW PROCESS FOR TITRATING ASTRINGENT SUBSTANCES.

By M. FERDINAND JEAN.

WHEN we pour drop by drop a solution of iodine into any decoction of an astringent matter, previously mixed with an alkaline carbonate, we remark that this solution is absorbed with a great energy. I have observed that the absorption of the iodine takes place, in these conditions, in the direct ratio of the quantity of astringent matter taken, and that 1 part by weight of tannic acid absorbs 4 parts of iodine before we can observe the presence of free iodine in the liquid. It is on this action of iodine on astringent matters that the process of titration is based which forms the subject of this note. The solution of iodine necessary for titrating tannin is obtained by dissolving in iodide of potassium 4 grms. of iodine, and adding to the solution distilled water in quantity sufficient to make a volume of 1000 c.c. To ascertain the value of the solution of iodine, we introduce into a beaker 10 c.c. of a solution of tannin at 0·1 grm. per cent; we mix it with 2 c.c. of an alkaline lye containing 25 per cent of crystallised carbonate of soda; then, by the aid of a graduated burette, we cause to fall into the alkaline liquid the solution of iodine until a drop of the mixture, taken with the glass stirrer and put on a leaf of starched paper, produces a light violet spot, which indicates the presence of free iodine and the end of the operation. The value thus obtained must be corrected, that is to say we must deduct from the number of cubic centimetres of the solution of iodine corresponding to 0·01 grm. of tannin, the volume of this solution, which it is necessary to employ as pure loss before obtaining a coloured reaction on starched paper. For this purpose we measure 10 c.c. of distilled water, which is mixed with 2 c.c. of the alkaline solution; then we pour drop by drop the solution of iodine until we obtain a spot on the starched paper. With a solution of iodine, containing 4 grms. iodine per litre, the correction is commonly from 0·1 c.c., but the greater or less purity of the carbonate of soda may perhaps affect this correction very slightly. For 0·01 grm. of tannic acid dissolved in 10 c.c. of water we must generally use 10·5 c.c. of the solution of iodine at 4 per thousand. Under the influence of iodine the alkaline solutions of tannin, even diluted, take a colouration so intense that it

THE CHEMICAL NEWS.

VOL. XXXIV. No. 884.

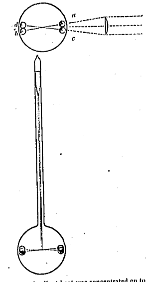
ON REPULSION RESULTING FROM RADIATION.—PART II.*

By WILLIAM CROOKES, F.R.S., &c.

(Continued from p. 176).

90. EXPERIMENT proves the above reasoning to be correct. A bulb-tube was prepared in the manner already described (84), but in it were suspended, by separate silk fibres, two glass stems, each having pith balls at its extremity. Fig. 3 shows the elevation and plan of the apparatus. The torsion of the silk fibres was so arranged that the pith balls *a b* hung freely about a millimetre from the balls *c d*. The glass stems were looped in the middle, and bent so that they did not touch each other. After complete exhaustion the following experiments were tried.

FIG. 3.



A beam of radiant heat was concentrated on to the two balls *a c*. When applied momentarily and then removed the radiation simply drove the balls apart, and immediately allowed them to come together again. When, however, the beam was allowed to play upon the balls for about half a minute they became warm and widely separated; and upon now removing the beam of heat the balls did not fall together at once, but took several minutes to regain their original position. This experiment therefore proves Case I.

The bulb and contents being of the ordinary temperature, a spirit-flame was rapidly passed round the bulb to warm it quickly on all sides. The balls were thus in the condition imagined in Case II., being in a space warmer than themselves. They immediately came together, *a* touching *c*, and *d* touching *b*.

Many experiments were tried with the object of proving experimentally the propositions in Cases III. and IV.; but with this apparatus it was found impossible to warm one of the balls without at the same time producing repulsion of the ball by the beam of radiation concentrated upon it. There is, however, little doubt, from the experimental proof of Cases I. and II., that the reasoning is equally correct in the other cases.

91. With a highly exhausted bulb and light pith index, which was found to be exceedingly sensitive to radiation, numerous experiments were tried to see if there was any difference in action between the fingers and a tube of water of the same temperature. Many persons believe that there is a peculiar emanation or *aura* proceeding from the human hand, and Baron Von Reichenbach* considered that he had proved this to be the case. Were this true it was not impossible that the emanation would affect the pith index. I have been unable, however, to detect the slightest action exerted by my own or any other person's hand which I could not entirely explain by an action of heat.

92. A similar series of experiments were tried with various large crystals, which were presented in different ways and with various precautions to the pith index. At first a decided action was observed; but in proportion as precautions were taken to eliminate the effect of heat, so was the action seen to diminish, until very little doubt was left in my mind that the slight residual action would have been entirely stopped had it been possible, with the apparatus then used, to altogether eliminate the action of heat.

93. Attempts were made to see if chemical action would attract or repel the index. I could not, however, produce chemical action close to the exhausted bulb, without at the same time liberating such an amount of heat as to mask any other action.

94. Although I most frequently speak of repulsion by *heat*, and in illustrating any of the results obtained I generally use either the fingers or the flame of a spirit-lamp as a convenient source of radiation, it must be clearly understood that these results are not confined to the heating-rays of the spectrum, but that any ray, from the ultra red to the ultra violet, will produce repulsion in a vacuum. I have already mentioned this fact in my first paper (58, 68). Experiments proving the similarity of action of all rays of the spectrum were shown before the Physical Society on June 20, 1874.† They were, however, tried with a less perfect apparatus than the one I have since used for the same purpose, and need not be further alluded to till I describe the most ecent results obtained with the spectrum (110, 111).

95. Some experiments were tried with the object of ascertaining whether the attraction by heat, which, commencing at the neutral point (30 *et seq.*), increased with the density of the enclosed air, would be continued in the same ratio if the apparatus were filled with air above the atmospheric pressure. Two bulbs containing ivory needles suspended by silk fibres were accordingly adjusted to show the same sensitiveness to a hot body. One was

* A Paper communicated to the Royal Society, March 20, 1875. From the *Philosophical Transactions of the Royal Society of London*, vol. clxv., pt. 2.

* "Researches on Magnetism, &c.," translated by Dr. Gregory. London, 1850.

† *Phil. Mag.*, August, 1874.

28

described in paragraph 102. The beam was of glass, and at one extremity was fitted with a spring clip, also of glass, so that different bodies could be experimented with. Disks of platinum foil, 1 centimetre in diameter and weighing 1·28 grs. each, were prepared, and they were fixed in the clip at the end of the torsion beam, either singly or two, three, or four together, in such a manner that while the disk exposed was always 1 centim. in diameter, the weights should be in the proportion 1, 2, 3, 4. At the other end of the beam a movable counterpoise was arranged, so that the length of beam from the platinum disk to the centre was always the same.

The neutral points were as follows:—

No. of Disks.	Barometer.	Gauge.	Diff. = Neutral point.	Differences.
1.	760	682	78	
				8
2.	760	690	70	
				16
	760	706	54	
				24
	760	730	30	

114. Two pieces of platinum, *a* and *b*, were now cut from the same sheet, each having 1 square centim. of surface. *a* was left the full size, but *b* was carefully folded in four, so as to expose a surface of only a ¼ of a square centimetre, the weight remaining the same. The neutral points were then taken. The average of several observations (which, however, were not quite so concordant as could have been wished) were, below a vacuum,

a.	*b.*
136 millims.	70 millims.

The pieces of foil were then coated with lampblack, and observations again taken. This time the neutral points came out—

a.	*b.*
66 millims.	124 millims.

An intimate connection is thus shown to exist between the absorbing (and radiating) power of the surface on which radiation falls and the atmospheric tension at which the movement is reduced to a minimum. Further experiments on this subject are in progress.

(To be continued.)

NOTE ON ATACAMITE.

By T. C. CLOUD, A.R.S.M.

This mineral is found in large quantities in this district, and some mines have produced magnificent specimens. In many cases it is evident that this mineral has been formed from the oxide most probably by the action of salt water. I have specimens in my possession consisting of a central portion of massive cuprite with crystals of the same, the whole being converted to a depth of about 0·1 inch into atacamite.

When this mineral occurs in contact with limestone rock near the surface of the country it is invariably converted more or less into green carbonate of copper; in some cases this change has only extended to a slight depth, while in others the whole mass is thus converted.

The following are the results of an analysis of a well crystallised specimen of atacamite from this district (Yorke's Peninsula).

Copper	13·73
Chlorine	15·38
Protoxide	55·91
Insoluble residue..	1·47
Water, by difference	13·51
	100·00

The crystals selected for the analysis were about ⅛ inch long, of a clear dark green colour, and perfectly transparent.

It was desired to ascertain the combined action of heat and air on oxychloride of copper. For this purpose a portion of the substance employed in the above analysis was placed in the centre of a combustion tube between two plugs of asbestos; air from a gas holder was passed slowly through the tube, while the latter was heated gradually up to the highest temperature obtainable with a charcoal combustion furnace. This temperature was maintained until the sublimate did not appear to increase further in quantity. When cold the contents of the tube were examined. At the cooler part of the tube a sublimate had formed varying in colour from light yellow to dark brown. On examination this proved to be subchloride of copper. In the place of the original substance there remained a brilliant black fritted mass of protoxide of copper. The internal portion of the tube extending for a short distance from the point where the original substance was placed, towards that part of the tube where the sublimate had formed, was converted into a bluish green glass. At the commencement of the experiment, when the temperature was comparatively very low, oxygen was evolved. I do not know whether this reaction has been noted before, but it is readily observed on heating a small portion of atacamite in a test-tube.

The experiment detailed above was repeated, the atacamite powder in this case being placed in a platinum boat, all the other conditions remaining the same; the results were identical with those obtained in the former experiment. The reaction which takes place when oxychloride of copper is heated with access of air would therefore appear to be as follows:—

$$CuCl_2+3CuO+4H_2O=Cu_2Cl_2+2CuO+O+4H_2O.$$

Laboratory, Wallaroo Smelting Works,
Wallaroo, South Australia,
October 5, 1876.

BUTTER ANALYSIS.
AN IMPROVED METHOD OF ASCERTAINING THE SPECIFIC GRAVITIES OF FATS.

By C. ESTCOURT, F.C.S.
Analyst to the City of Manchester, Borough of Oldham, &c.

The great advance which has been made in food analysis since the passing of the "Food Adulteration Act of 1872" is nowhere so apparent as in the methods employed to detect adulterations in butter. It is scarcely three years since the time when the only methods of butter analysis, so-called, consisted entirely of smelling and tasting. Thus we had a butter taste, a tallow taste, and a lard taste. The first advance made was the observations of the fusing-points of different fats, and the next one was the estimation of the fatty acids present in fats of various origin. The last named process has, since its discovery by Messrs. Angell and Hehner, been so elaborated by various workers, amongst whom are Drs. Dupré and Muter, that nothing further in this direction can be expected.

The process, however, which recommends itself by its simplicity, and its good results, if properly carried out, is that of taking the specific gravities of various fats, butter fat amongst others. This process, devised by Mr. James Bell, F.C.S., principal of the Inland Revenue Laboratory, has only been slightly modified since its first application. The modifications were the change of temperature in the water used to compare with the fat, and the use of specific gravity beads.

In ascertaining the presence of, and estimating the quantity of foreign fat in butter by either the fatty acid, or the ordinary specific gravity method, several difficulties present themselves. In the first

29

THE MECHANICAL ACTION OF RADIATION.

By LeRoy C. Cooley, Ph.D.

[Read before the Albany Institute, February 1, 1876.]

Sc. Am. Apl/76

The motion of light bodies under the influence of radiant heat and light seems to have been noticed, independently, by several observers, at long intervals during the last half century, but only within the half decade just past can it be said to have gained a place among the phenomena of acknowledged interest in science.

In the *Edinburgh New Philosophical Magazine* for 1828 is a record of what seems to have been the earliest experiments on this subject. They were made by Mr. Mark Watt, and I quote from his interesting paper the following description of the first instance of a light body indicating, by its motion, the impression it received from the sun's rays. "Twelve or fifteen magnetized sewing needles were stuck into a thin circular slice of cork an inch in diameter, at a distance of one sixth of an inch from each other. The heads of the needles were so fixed into the piece of cork that they stood perpendicularly and all the points, being south poles, stood uppermost. The cork was then placed on the centre of a surface of water 1¼ feet in diameter. The needles, in this situation, being prevented from evincing any polar attraction by their perpendicular position, were attracted by a moderate degree of light, heat, or electricity, but were repelled by the more powerful impulses imparted by the concentration of any of these bodies.

After the elapse of twenty years the phenomenon seems to have been rediscovered by Mr. Mitchel. A description of his experiment may be found in the first chapter of *Dick's Practical Astronomer* (see also *Scientific American*, vol. xxxiii. 9), and reads very much as follows:

A plate of very thin copper, an inch square, was fixed upon the end of a fine wire ten inches long. A very delicate magnet was fastened to the middle of the wire and the whole, balanced on a pivot, was enclosed in a glass case. The rays of the sun, collected by a concave mirror of two feet diameter, were thrown to a focus on the copper plate. The plate began to move under the influence of the condensed sunbeam, and in about two seconds it had traversed as many inches and struck against the side of the box. This experiment was made with a view to prove that "Light, though exceedingly minute, has a certain degree of force momentum."

Many years later—it was in 1863—the energy of radiation seems to have revealed itself anew to the eminent Prof. Joule. "By means of a cylindrical glass vessel, divided in a vertical direction by a blackened pasteboard diaphragm, which extended to within one inch of the cover and of the bottom of the vessel, and in the upper of which spaces was delicately suspended a magnetized sewing-needle furnished with a glass index, he was able to detect the heat from a pint of water heated to 30° C., placed in a pan at nine feet distance; also that of a moonbeam admitted through an opening in a shutter as it passed across his apparatus." This description is extracted from a lecture by the Earl of Rosse on the heat of the moon, given at the Royal Institution in May, 1873.

In April, 1873, ignorant of all these earlier observations, I read, in this room, a paper on "Convection applied to the Detection of Heat," showing that a delicately-suspended needle would move in obedience to slight changes of temperature in any body brought into its vicinity, and describing a *Thermoscope*, quite sensitive, acting on this principle (*Journal Frank. Inst.*, vol. lxvi. 343). Further experiment soon afterwards resulted in the construction of an instrument so sensitive that the needle would swing in response to the heat radiated from the face of a person sitting at a distance of thirty feet (*Jour. Frank. Inst.*, vol. lxvii. 408). The form of instrument finally adopted, and used also in experiments to be described in the sequel, may be briefly described as follows: In a chamber whose walls are, to a considerable degree, impervious to heat, a glass thread, very long and very light, is suspended horizontally by means of two parallel silk fibres eighteen inches in length. One end of this a slender needle carries a small vertical disk of paper. The small end of a conical metallic reflector passes through the wall of the chamber, and its opening is covered with a piece of thin, partially-charred paper. The radiations from any distant source of heat are concentrated upon this scorched paper by the reflector. The needle-disk is on a level with the lower part of this paper, and moves toward or from it under the influence of every change of temperature it experiences, approaching if it be warmed and receding if it be very gently cooled, but approaching when the reduction of temperature is considerable.

In the meantime Dr. William Crookes, "while weighing heavy pieces of glass apparatus in a chemical balance enclosed in an iron case from which air could be exhausted," noticed that "when the substance weighed was of a temperature higher than that of the surrounding air and the weights, there appeared to be a variation of the force of gravitation." His first paper was sent to the Royal Society in May, 1873. "Experiments were thereupon instituted with a view to make the action more sensible and to eliminate sources of error."

By ingeniously devised apparatus Dr. Crookes was able to subject light bodies to the action of radiant heat and light in a vacuum perfect, doubtless, beyond precedent. While the exhaustion proceeded he found the motion of his slender balance-beam to be towards the source of heat, until, a very high degree having been attained, the motion *turned the other way*, the light body receded from the source of radiation as if driven by a delicate repulsion. (See *Quarterly Journal of Science*, 1875.) His second paper communicated to the Royal Society the interesting discovery of the mechanical effect of radiation in a vacuum, and *Repulsion by Radiation* is a phrase describing a new-found fact in physical science for which we are indebted to this capital research of Dr. Crookes.

These experiments of the English scientist, pronounced, by the President of the Mathematical and Physical Section of the British Association, to be among the most interesting in the whole range of physical science, have attracted much attention to the phenomenon. Prof. Dewar in Scotland and Herr Neesen in Germany have made valuable additions to the experimental data.

Prof. Dewar employed a novel means of obtaining the necessary vacuum. When the pump refused to reduce the tension of the rarefied gas, the residue was removed and the vacuum perfected by the absorbent power of charcoal. The vacuum thus obtained, like that of Mr. Crookes, forbade the passage of the induction-spark, and so sensitive was his instrument that "an ordinary lucifer-match held at a distance of four feet produced instant action, which was observed by means of a telescope." (*Nature*, xii. 217.) Of his results more is to be said as we proceed. Herr Neesen's apparatus consisted of a rectangular case of sheet-iron with an aperture in one side closed by a glass plate near to which hung a small and delicately-suspended mirror. The radiations were received by the glass plate, through which they passed to fall upon the mirror beyond, and the mirror was compelled to turn in obedience to their influence. (*Nature*, xiii. 10.)

By the experiments of these several observers it is well established that very light and mobile bodies are affected quite differently by radiant heat or light according as they are suspended in air or in vacuo. *Attraction* in air and *repulsion* in vacuo, are the terms employed by Mr. Crookes to describe these effects. These terms are convenient, but unobjectionable only when we use them to indicate the *direction* of the motion and not to describe the nature of the forces acting to produce it.

Of the nature of these forces views are not yet in accord. Mr. Crookes considers the air-current theory as altogether incompetent to account either for the attraction or the repulsion, but awaits the accumulation of all the facts before attempting to explain any of them. Professor Dewar regards the *heating of the movable disk* as the cause of the motion. He is reported as saying that "While the action takes place in air of ordinary density it is probably due to air currents" but, from the report, he seems not to have based this opinion upon any direct experimental proof. Nor does he allow the repulsion in vacuo to be due to any new forces of repulsion: he attempts to refer it to the molecular energy of the minute residuum of gas still left in the most perfect attainable vacuum. "What takes place," he says, "is this, the particles are flying in all directions with velocity depending upon the temperature. When they impinge against the heated disk their velocity is increased. They go off with a greater velocity than those which go off from the colder side, and hence there is a recoil of the disk." And this recoil, he thinks competent to put the disk in motion even in his excellent vacuum, "where we know that the exhaustion has reduced the density to [illegible] of its original."

Professor Osborne Reynolds claims that whenever a surface imparts heat to a gas, there must be a reaction of the gas against the surface. A surface free to move would be propelled by this reaction. Moreover in a vacuum this motion would encounter less resistance and hence would be more conspicuous, as if it were due to a stronger force. Repulsion in vacuo, according to this view, is the effect of this gaseous reaction. (*Nature*, vol. xii. 405.)

If others have engaged in the investigation of this interesting subject, their work has, down to the present time, escaped my attention.

In July, 1875, I read a paper before the *Poughkeepsie Society of Natural Science*, giving a synopsis of several series of experiments, some of which were made before the publication of Mr. Crookes' remarkable discovery, but many of them afterward, with a view to determine the nature of the force as far as the so-called attraction in air is concerned. (*Jour. Frank. Inst.*, vol. lxx. 134.) The points then made are these: 1st. The motion of the needle having proved to be, under a great variety of conditions, exactly what air-currents are competent to produce, we may justly infer that it is due to convection. 2d. If this motion shall cease to occur when the air is removed (and Mr. Crookes has proved that it does), the evidence in favor of convection is complete.

Whatever may be the nature of the repulsion in vacuo, convection will, doubtless, in the end, be admitted to be the cause of the motion in air. The two motions are, I am persuaded, altogether distinct phenomena manifestations of two antagonistic forces, the repulsive being the more delicate and able to produce its effect only when the overwhelming power of convection currents is overcome by perfecting the vacuum.

But there is another phase of this curious action which seems to have escaped the notice of former observers. It may be described as *repulsion in air*. The application of a very gentle heat will, under certain conditions, drive the disk away from the warmed surface, even in air of ordinary density.

At intervals, from the time of my earliest experiments, this puzzling motion would thrust itself before me until I was convinced that it was not an experimental accident but that it was a legitimate effect of some rare combination of conditions. What these conditions are I set myself to discover.

It was an effect which I could not, at first, produce at will. Sometimes it would appear in the early morning but refuse to be reproduced as the day advanced. Sometimes it would occur in the evening when no trace of it had been seen during the day. A day of alternate showers and sunshine seemed to be most favorable to its production. Remembering that the walls of the chamber were to a considerable degree impervious to heat, so that the temperature within suffered no rapid changes as did that without, these facts suggested the direction in which to seek for the cause of the action. By inserting a thermometer into the chamber and placing another outside, the difference of temperature between the interior of the instrument and the air outside could be measured and its relation to the motion of the needle could be studied. A multitude of observations followed. In every case when the repulsion occurred the temperature of the interior of the chamber was found to be higher than that of the external air. With a difference of a single degree (F.) the needle would be repelled by the gentle heat of the hand held at a distance of twelve inches, while by a somewhat stronger heat the motion would be reversed. With a larger difference of temperature the repulsion would respond to a greater heat, becoming attraction again, however, if a certain limit of intensity was passed. Such observations finally revealed the necessary conditions. Repulsion in air occurs when: 1st. The temperature of the interior of the instrument has been for some time a little higher than that of the external air; and 2d. The degree of heat applied is appropriate to this difference of temperature.

The next step was to carefully determine the place of the zero of the needle scale. Call to mind the arrangement. The slender needle is suspended horizontally by two parallel silk fibres. The torsion of these fibres is a delicate force tending to hold the needle in a certain position. The place of the disk thus held at rest is the zero of the scale. Now the swinging of the needle toward the zero can indicate no positive action of any force other than the torsion of the fibres. Its swinging away from zero, however, can be due to nothing less than some positive force which overcomes the torsion. Having determined the place of the zero, repeated observation showed that the repulsion was real, since the needle moved beyond its zero in opposition to the torsion of its fibres.

In explanation of this curious effect I offer the following suggestions. It is well known that a cooled surface will cause a downward air-current in contact with it, and again that heat being applied will reverse the direction of this current. But this reversal can not be affected instantaneously. The effect of a *gentle* heat will be first, to *slowly* neutralize the cold and thus *gradually* diminish the downward current, and second, afterward to produce, as gradually, a current upward. Now while the cold current is being neutralized, the torsion of the fibres will carry the disk to its zero and when the upward current is established the disk will be again wafted toward the warmed surface. But if this transition from a downward to an upward current is very slow there must be an appreciable time when there is equilibrium, when the air is in contact with a surface warmer than itself and yet for a brief period is free from convection currents.

Again it is well known that the air is perfectly elastic and further that an elastic body will transmit the energy of blows which do not put its mass in motion. Then let us conceive a mass of air, lying between the disk and the surface which receives the heat, subjected on the surface side to a temperature higher than its own and yet free from convection currents. Under these conditions the elastic medium must transmit the heat energy to the disk in a manner not altogether unlike the transmission of the force of a blow by a series of elastic balls. As I conceive the molecular motion it is this. The molecules of air are in motion with a velocity depending upon temperature. When they impinge against the warmed surface they are thrown off with an increased velocity. This velocity is transmitted until the molecules in contact with the disk receive it and they strike the disk with greater energy than do those against the opposite side. This excess of energy drives the disk along.

If this explanation is correct then while the attraction in air is the manifestation of the well-known convection currents, this repulsion in air is the manifestation of *a molecular transmission of energy* by the air in straight lines outward from a heated surface. Now if such a molecular action do exist, then a light body near a heated surface must, in every case, be subject to the influence of these antagonistic forces, being solicited toward the heat by convection, and repelled from it by the energy transmitted. Because convection is the more powerful, the motion is toward the source of radiation, except when by careful choice of conditions the delicate repulsion can be made visible.

Whether this repulsion in air is at all related to the repulsion in vacuo, I am not prepared to consider clear. The effect of exhaustion, on the relative strength of these two forces, is, however, an interesting point in this connection. In a good vacuum the power of convection must be vastly reduced and as the vacuum approaches perfection, this power must approach annihilation. On the other hand nothing short of an absolute vacuum can forbid the molecular transmission of energy. It seems highly probable that at a certain high degree of exhaustion this molecular energy would be the more powerful of the two, and hence that repulsion would be the normal instead of the exceptional indication of the instrument.

"WEIGHING" A BEAM OF LIGHT.

On Friday last Professor Crookes, F.R.S., fulfilled a promise previously made and much discussed in scientific circles by "weighing" a beam of light in the presence of a distinguished audience at the Royal Institution. The general interest which the recent discoveries of Mr. Crookes have excited could not have been better testified than by the crowded state of the lecture room on this occasion, for the fog was so dense that coachmen had to descend from the box and grope their way to Albemarle-street by the aid of lanterns. This practical recognition of the exceptional importance of the evening's work was especially pleasing to the friends of Professor Crookes, though probably a matter of indifference to himself, for it is but too notorious that the originality of some of his collateral researches has raised up a little band of detractors. Few scientific men have the courage of their convictions to the same extent as Mr. Crookes, who we have little doubt would join without hesitation in an incantation scene or dance round Macbeth's cauldron, impervious to ridicule, if he had reason to believe that ever so little territory might thereby be won or reclaimed from the unknown land. Both at the commencement and the end of his address the lecturer very properly directed attention to the fact that the discovery of the remarkable phenomena submitted to the audience was due simply to his having followed upon the clue afforded by an apparently insignificant anomaly. We think there must have been an unpleasant, though unintentional, sting in these words to some present, for there were amongst the listeners one or two science popularisers, pets of society, who had somewhat ostentatiously slighted the discoveries at first, but would now give their ears to be able to "stump the provinces" with the radiometer as a child of their own, and there were others present who had also taken little pains to keep out of Goldsmith's category of "fools who go to scoff."

Desiring to weigh some small quantities without the disturbances inseparable from the operation as ordinarily conducted, the lecturer stated that he made arrangements to do the weighing in a vacuum, but was surprised to find that he had apparently called into existence another set of disturbing causes no less embarrassing than the former, since upon approaching a light to the exhausted vessel the action of gravitation appeared to be appreciably modified. Professor Crookes at once set to work to determine the general conditions and intensity of this new force, and his investigations have culminated in the experiment performed on Friday evening last, when he weighed the pressure resulting from the light of a standard candle 6 in. off, falling upon a surface *in vacuo*, 2 square inches in area. It was thought at first that the force to be measured must be inconceivably small, so a horizontal pendulum of extreme sensitiveness was constructed, so sensitive, in fact, that as Mr. Crookes graphically put it, by changing your position in a room you altered the centre of gravity of the whole house, and so threw out the readings of the instrument. The horizontal pendulum then was incapacitated from *trop de zèle*, but a suitable servant was found in the torsion balance, which as first constructed consisted, we believe, of a flat bar or index of pith suspended by a cocoon fibre. When one-half of each face of the index was blacked on alternate sides of the vertical centre line, and the apparatus was placed in the light, rotation commenced and continued until the torsion of the fibre caused a retrograde movement. From this movement to continuous rotation was only a step, but it was a step which placed the world in possession of the now famed "radiometer" of Professor Crookes.

In its simplest form the radiometer consists of two cross-arms carrying at their extremities four pith discs blackened on one side, delicately balanced on a vertical pivot, and enclosed in a glass vessel exhausted to as perfect a vacuum as can be obtained by any known means. At the lecture on Friday the rotation of an instrument having alternate circular and star-shaped pith discs was very effectively shown by projection on a screen. When the heat rays of the electric light were cut off by the interposition of an alum solution, rotation still continued, but at a decreased velocity. Experiments have been made by Mr. Crookes to ascertain the relative influences of the different coloured rays of the spectrum upon the rotation of the radiometer, and a diagram of the results was exhibited. It was found that the ultra-red rays were the most powerful of all—a not altogether surprising result when it is remembered that the emission of heat from those invisible rays is nearly eight times the entire luminous emission. Numerically expressed the dynamic force of the ultra-red rays being 100, that of the violet rays is 5 only, and it would appear that the experimenter considers the dynamic force of the rays to be simply proportional to the revolutions of the radiometer, although it would have appeared more probable that at least an appreciable portion of the resistance of the instrument would have increased as the square of the velocity.

The relatively small effect of the interposition of coloured glass on the speed of rotation was well shown by a radiometer having a mirror at its centre, which caused a dot of light to describe a circle on the ceiling of the theatre. At first it was thought that great lightness of construction was essential, but here we have a radiometer carrying a mirror, and if a mirror why not a magnet? Such was the reasoning which led the professor to the construction of the instrument, which with good grounds he

SOME RECENT RADIOMETRIC EXPERIMENTS IN GERMANY.

76

SINCE the radiometer was described by Mr. Crookes, it has been the subject of a large amount of observation, both in this country and on the Continent. We propose here to give a short account of two series of experiments lately made with it in Germany, where it generally passes under the name of the "Lichtmühle," or light mill. They appear to give some useful aid towards comprehension of the action of this somewhat enigmatical apparatus. The radiometers used were of the kind constructed by Geissler, of Bonn. They are wheel-shaped, the wings consisting of small leaves, apparently of annealed mica, blackened on one side with lamp-black; they are connected by platinum wires with a small cap, which turns on a fine needle point. The mill is enclosed in a vessel of thin glass, in which the air has been rarefied as much as possible. One series of experiments is that by M. Wartmann, described in the *Archives des Sciences* for March; the second by M. Weinhold, in *Carl's Repertorium für Experimental Physics* (Bd. xii., p. 105).

M. Wartmann had two radiometers, the one, A, with square, the other, B, with round wings. If both are exposed to the action of flame, or a glowing metal, or dark heat from an intense source of heat, they rotate with more or less rapidity, and the black surface is repelled. This may be called the "direct" rotation. The same occurs when the rays fall only on the black surfaces of the wings. On the other hand, there is a distinct difference between A and B, when the black surfaces are covered and the others exposed to the sun. While A shows a slow, direct rotation, B shows a distinct reverse rotation. In order to obtain this reverse rotation with A, the sunlight must be concentrated with a lens, and made to fall on the uncovered surfaces, while the blackened surfaces are very carefully protected against any radiation. If a less energetic source be made to act on B—namely, a glowing platinum spiral or a moderator lamp—then, without a lens, the reverse rotation is obtained slow and discontinuous; but it can be obtained easily, if two sources are used, acting in opposite directions on the uncoated surfaces, at the two ends of a diameter. If the source be removed, or its energy diminished, the motion of the mill takes place in a jerking manner. The velocity is greatest if the plane of the wing stands at right angles to the line of shortest distance from the source of radiation, the velocity diminishes with increasing obliquity of the repelled wing, then it becomes greater at the moment that the following wing receives the heat rays at a right angle.

On the two opposite surfaces of the same wing of B are concentrated by similar lenses the rays from two moderator lamps of the same calibre. By changing the distance of the lamps, one may succeed in entirely neutralizing their opposite actions. The action exerted on the black surface is then 11.9 times weaker than that on the white surface, "whence it follows, that to obtain equilibrium the intensity of the pressure must be in inverse ratio of the power of absorption. The least change of the distance, or the energy of the lamps, renews the motion." In a horizontal plane, and concentric with the radiometer, was placed an iron ring which had been raised to a red heat. Forthwith the rotation began, and it became very strong if the plane of the ring coincided with that of the arms. At equal distances above and below from this plane the velocity is the same. The radiometers were placed in a blackened case, which was perforated with an opening above. By means of a mirror a thin bundle of sun rays was reflected vertically and parallel to the plane of the wings. There always occurred a direct motion, whether the light was directed before the white or before the black surface; in the latter case the motion appeared to be quicker. If a moderator lamp be used instead of sunlight, the rays must be concentrated with a lens. The interposition of a very transparent plate of alum weakens to a great degree the action of a good lamp on A and on B. "The two radiometers are unresponsive to the largest sparks of a Ruhmkorff coil or a Holz machine, but the wings are distinctly attracted on approximation of an electrified body. In the magnetic field of a large electro-magnet, the mills show the ordinary actions of induction. In water of 13 deg. within a cylindrical glass vessel A behaved as in air, but its rotation was under these conditions slower. The radiometer B, on the other hand, showed the reverse rotation when the rays of a strong moderator lamp were concentrated with a lens on an uncoated wing. If the water in which the instruments are be heated to 60 deg., they remain motionless. When the radiometers are placed over a stream of heat, for example, an alcohol lamp with flue, the rest or motion of the mills is no way affected. When, however, the rising stream of hot air has raised the temperature of A to melting of the shellac on the point of the apparatus, the mill moves a little with frequent intermittence, and at length shows a slow, direct rotation. This suddenly ceases if the source of heat be removed, and it is slowly reversed during the first phases of cooling.

"The difference," M. Wartmann observes, "in behavior of the two radiometers, could not arise from the unequal surface of their wings. It appears to me rather that in the interior of B the rarefaction of air had not been carried so far as in A. Further, the white surfaces of B have a higher polish and brightness than those of A, their power of reflection must therefore be greater. These various experiments appear to confirm the view which attributes the movements of the mills to the expansions of the gaseous bodies under very weak pressures." The experiments made by M. Weinhold had the direct object of testing the different explanations that have been offered of the phenomenon. He, therefore, made a number of changes in the radiometers, some of which we shall notice. He first convinced himself that different specimens of the instrument are sensitive in quite different degrees to radiation of varying strength; and, therefore, that the wheel-shaped radiometer is not directly reliable as a measuring instrument for the strength of the radiation. M. Weinhold obtained radiometers which ran backwards on the radiation being cut off by using transparent mica leaves instead of the annealed and untransparent ones. If such an instrument be exposed a few seconds to strong radiation from a gas flame, and the flame be then removed, the mill first comes to rest and then begins to make a number of rotations in the opposite direction. This backward motion, however, is not due to action of backward radiation through the mica; for on interposition between the four wings of four new unblackened wings, consisting, in one case, of transparent mica, and in the second of annealed mica, the backward motion occurred in both cases. It is more probable that the backward motion is simply a consequence of radiation of the blackened surfaces, but that it only occurs when the wings have sufficient capacity for heat and conducting power. Indeed, radiometers with wings of magnesium metal show the backward motion in a remarkable manner. Some further modifications of the radiometer by inclination of the wings to the horizon, and by alternate use of blackened and unblackened annealed and transparent mica-leaves—for particulars of which we must refer to the original—convinced M. Weinhold that the motion is neither due to currents of minute quantities of gaseous matter, nor to the impellent force of evaporating water. It is rather, he thinks, due to some action—yet to be elucidated by experiment—of rays absorbed by the surfaces, and is in proportion to the amount of this absorption.

ROYAL INSTITUTION. 76

The Mechanical Action of Light.

AT the Royal Institution on Friday last, Mr. Crookes, F.R.S., delivered a lecture on "The Mechanical Action of Light." Mr. Justice Grove presided, and among the listeners were Professor Tyndall, Dr. Frankland, F.R.S., Prof. W. K. Clifford, Mr. William Spottiswoode, F.R.S., and Mr. Warren de la Rue, F.R.S. The experiments were of an unusually complicated and delicate description; and in their performance the lecturer was aided by Mr. C. Gillingham and by his son, Mr. Henry Crookes. Mr. Crookes said that all the physical forces render their action perceptible by the production of motion, but that light had never been directly converted into mechanical motion until the experiments had been devised which he had to bring before them that evening. Once in attempting to weigh bodies in an approximately perfect vacuum, he witnessed anomalies for which he could not account, but upon which information had been thrown by his more recent discoveries. He found, as published some time ago, that the light of a candle would attract an arm of pith suspended in an imperfect vacuum, but repel a similar arm suspended in the very perfect vacuum obtainable only by the aid of the Sprengel pump. Of this pump he exhibited a most perfect and improved specimen, so perfect that it would produce a vacuum through which the electric spark would not pass. In all his experiments he had been indebted, to a very great extent, to the industry and marvellous powers of glass-blowing possessed by his assistant, Mr. C. Gillingham. He then described the construction of his "radiometer," and stated that the propelling force of light was not so weak as he had once supposed. Instead of radiometers in which all the moving parts weighed sometimes as little as a quarter of a grain, he found that he could make the instruments to carry little magnets, and he exhibited one in which ten discs of pith were required to carry round one magnet. Outside the bulb of this instrument was a magnetic arm, which was attracted every time one pole of the magnet inside the bulb came near it, and the consequent "bowings" of the magnet outside were made to convey electrical impulses to a Morse telegraphic instrument, whereby a series of dots was made upon a slip of paper, and the more rapid the rotation inside the bulb the closer together were the dots. Thus his radiometers had been made self-registering and suitable for meteorological purposes. He also pointed out that no good photometer had ever been made, and he exhibited apparatus infinitely more exact for measuring the illuminating power of gas, or any kind of light, than those founded upon the supposed unvarying illuminating power of the very untrustworthy "standard candle." After many experiments, magnified and projected on the screen by the aid of the electric lamp, he exhibited one of his latest, in which he directly measured the mechanical force of the impact of light, not its weight, for the experiments did not remove light from the class of imponderables. By means of the force of torsion of a filament of glass, brought into play against an iron weight of one-hundredth of a grain, all in vacuo, he could so adjust a mirror to a zero point that it would move when parts of the apparatus were submitted to the action of light; thus, he proved that the push of a candle six inches off amounted to ·00162 grain. By calculation he estimated that the pressure of sunlight on the earth was not less than 2 cwt. per acre, 57 tons to the square mile, and 3,000 millions of tons upon the whole earth, all this power acting in opposition to the force of gravitation. In conclusion, he said that all the results he had exhibited had been obtained in consequence of his examination of an anomaly contrary to all ordinary experience. Anomalies were of the utmost value to men of science; they were gateways leading to new researches, and to the establishment of new relations.

THE RADIOMETER.

76

[10396.]—THERE is a very simple method for demonstrating the repulsive action of heat upon both the bright and the blackened sides of the radiometer vanes, and at the same time the preponderating influence it exerts upon the most actively radiating surface of the two, which I have not yet seen noticed. It is this: the radiometer being at perfect rest, and the radiant heat from the body and face of the observer being cut off by the intervention of a glass trough containing a saturated solution of alum in water, or something equivalent, press the warm finger and thumb on opposite sides of the vacuum globe. One of the black surfaces will be repelled from one warm point, until a bright surface advances to the opposite point, when that, too, will be repelled as it approaches; the action will then be repeated, and an oscillating movement kept up, until sufficient momentum has been acquired (from the stronger repulsion of the black surface) to force the bright surface of the vane past the dead point as it were, when complete rotation will take place.

Your correspondent, "B. P. A." (10369), seems to have no notion of even the elementary conditions necessary for experimenting on the radiometer with light rays. Hence perhaps his nervousness about Mr. Allen.

H. C. Key.

THE RADIOMETER.

76

THE following curious experiment with the radiometer has been lately made by M. Ducretel. When it is rotating as usual in ordinary daylight, some ether is poured on the envelope; the direct rotation stops, and inverse rotation occurs. This reaction presently ceases, and the vanes resume the original direct rotation, notwithstanding the evaporation kept upon the envelope by light sprinkling of ether. The rotation now, however, becomes faster than at the first, the evaporation apparently acting like a source of heat, though it perceptibly cools the envelope. When the sprinkling of ether has stopped, the movement resumes its nominal velocity, and remains direct. M. Ducretel also tried the effect of phosphorescent powders presented before the radiometer in darkness, after they had been exposed to sunlight; but the instrument showed no motion. The chief objection brought against the emission-theory explanation is that the white face, reflecting the light and behaving like an elastic surface, should be more strongly repelled than the black. M. Giffard illustrated this by letting a small piece of agate fall from a constant height on one plate of a balance. The depression is much greater when the plate is of annealed steel—that is, elastic or like the white face—than when it is of copper and like the black. But M. de Fonvielle remarks that this is supposing the velocity of the shock is not superior to the velocity of propagation of the molecular movements. A revolver ball makes a hole in a pane of glass because the molecules directly struck have not time to communicate their motion to neighboring molecules. Now the luminous molecules have a velocity vastly greater than that of the ball. And it is really the degree of absortion, other things equal, that must rule the velocity of propulsion.

LETTERS TO THE EDITOR.

(We do not hold ourselves responsible for the opinions of our correspondents.)

THE MECHANICAL POWERS OF LIGHT.

SIR,—I have read with much interest the article which appeared in your pages on the 14th of April on Crooke's radiometer. I had previously been familiar with all that has been written on the instrument, and I had seen it in action under varying circumstances. It is not too much to say, as you have done, that its phenomena are to the last degree perplexing; but in spite of this circumstance, I feel assured that a consistent theory of this instrument will be produced. Such a theory will be the result, most probably, of the careful study of many minds. My purpose in writing now is to endeavour to clear the ground on a single point connected with the radiometer. I cannot attempt at present to lay before your readers a theory, which, although comparatively satisfactory to my mind, does not as yet admit of verification as a whole. But it cannot do harm, and it may do good, to place a portion of this theory before the world for discussion, and perhaps for refutation.

One of the great difficulties about the radiometer is that the blackened surface of the pith discs retreats from the light. It has been stated that this should not be the case. As bright surfaces radiate light, and blackened surfaces absorb it the pressure of light ought to be greater on the bright than on the black surface. It is perhaps a fortunate circumstance that it is not the foil surface of the radiometer that retreats. If this were the case, a theory which is, I think, unsound on dynamical principles, would have been accepted as correct, and error would have been propagated and inquiry checked.

I am about to show that, so far from the metallic surfaces retreating, they are the surfaces which ought to advance. For this purpose I must for the nonce use the corpuscular theory of light; not because that theory is necessarily sound, but because it affords a very easy illustration of the statements I am about to make.

Let us suppose then, that, to use your own illustration, light resembles in its impingement on a body the effect of a handful of small shot thrown forcibly against a board.

To simplify matters I shall deal with only a single light corpuscule, or grain of shot, which I shall style *a*. The energy stored up in *a* is represented at the moment it strikes the disc of a radiometer by $\frac{Wv^2}{2g}$.

Let us assume that our light-corpuscule is infinitely elastic, so elastic that the elasticity of the foiled face of a pith disc is as nothing. The latter may, therefore, as compared with *a*, be regarded as infinitely hard and impenetrable. Now it may be shown, that if an infinitely elastic body strikes an infinitely rigid body, the elastic body—in this case *a*—can do no work upon it. For let us suppose that *a* weighed a pound, and fell on a rigid surface from a height of 10ft., all resistance of the air, &c., being removed, then the ball would rebound to a height of 10ft., and under the conditions, it would so continue to fall and rebound to all eternity, and no work of any kind could be done on the rigid surface.

From which it appears that light-corpuscules impinging on a foiled disc rebound from it and do no work upon it. They transfer none of their energy to the disc.

Now let us suppose that a light-corpuscule falls upon a surface which is yielding or inelastic. The corpuscule in such a case cannot rebound. It is fixed and held fast in, so to speak, a viscous medium. Under such a condition, the whole of the energy $\frac{Wv^2}{2g}$ stored in a corpuscule must either be wholly transformed into heat, or into work, or into motion. In any case, the energy in the corpuscule is transferred to the medium in which its progress has been arrested. Now the blackened disc of the radiometer is the medium which stores up all the energy put into it by the impact of light corpuscules, while the foiled surface stores up none of the energy contained in the infinitely elastic light corpuscules. Consequently the blackened surface, continually receiving force always in the same direction, retreats from the impact of light, while the foiled surface of the disc remains unaffected by the impingement of rays, which retain all the force they originally possessed after they have struck it.

To show that this theory is consistent with known laws, I shall go a step further, still retaining, without prejudice—to use a legal phrase—the corpuscular theory. I have shown that the energy stored in a corpuscule must be converted into heat or motion if the motion of the corpuscule be destroyed. Now what do we find to be a fact in nature? Bright surfaces which reflect light well, are not heated by the sun's rays as fast as darker surfaces. Let us suppose that the sun gives off no heat, that its energy is displayed in imparting motion to countless millions of corpuscules of light, and light alone. Strange as it may appear, it is possible to conceive of a body being raised through successive conditions of vibration, until such an exaltation is at last reached that nothing is given off but light. If my readers will excuse a paradox, we may suppose that a body is heated so intensely that it ceases to be hot, and gives off light alone. Assume this to be the condition of the sun. We have then countless myriads of corpuscules impinging on the surface of the earth, and doing what? Those which fall on surfaces impenetrable and hard to them, are in no wise affected, therefore such surfaces remain cold. This is the case with a plate of polished silver placed in the sun—it reflects the sun's rays and remains unheated. If it were absolutely hard and bright it could not be raised in temperature at all. No work is done on or in the plate; the motion of the corpuscules is undestroyed.

But what happens if we place a blackened surface in the sun? The corpuscules impinging on it have their motion at once arrested. They cannot recoil. Their store of energy is at once converted either into motion or into heat. Motion, save in the radiometer, cannot, in one sense, take place. The result is that we have heat. The black surface becomes warm, but it is not true to say that that warmth has come from the sun, for that would be to say that the sun is hotter to a bit of tin coated with lampblack than it is to a bit of tin highly polished, which is absurd. The sun then gives off energy alone in a form which we call light. This energy is convertible into heat, and it is only so convertible when the substance on which it impinges is in a condition to arrest the movement of the corpuscules, and, to use an engineering phrase, "to take the work out of them." Nor is the phenomena proper to reflecting surfaces only. Glass is not heated by the sun's rays because the corpuscules can pass through it without loss of motion.

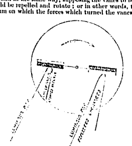
If, then, it can be proved that the impact of light corpuscules is transformable into work in the way I have shown, we have so far a consistent explanation of the fact that the blackened surface of the radiometer recedes instead of the bright surface.

I am well aware that the mere colour alone will not suffice, and that material exercises a considerable influence on the phenomena, but it would be impossible for me to go into these points now. I have sketched hastily certain heads of a theory, which are complete in themselves, although they do not constitute a complete theory of the radiometer. Perhaps some of your readers will point out the weak points in this communication, and so help a fellow worker in the field of science.

Should it appear that my views are on the whole satisfactory, I hope, with your permission, to show in a future letter how all that I have advanced on the corpuscular basis is equally applicable if we accept the received vibratory theory of light. X.

Streatham, May 15th.

SIR,—I was much struck on reading your article on the radiometer in THE ENGINEER of April 14th, by the fact which you note therein that the pith vanes being held by a magnet, the glass envelope rotates. And I would, rather diffidently, as becomes one who has not made the subject a special study, offer the following explanation of the fact. Glass, as everybody knows, is perfectly pervious to light—that is, to the luminous rays of light; but it shuts out those rays which may be called the heat rays of light. Now, lamp-black absorbs the luminous rays of light perfectly, but does not absorb so well the non-luminous or heat rays. Now may not this explain the above phenomenon? For the silvered side of the vane would reflect light, which would readily pass through the glass, while the lamp-black side would only reflect that which would not pass through, but would be checked by the non-diathermanous character of the glass. Now this check to the passage of the rays might cause a repulsion of the blackened vanes, thus causing their rotation; and in the same way, supposing the vanes to be held, the glass would be repelled and rotate; or in other words, the glass is the fulcrum on which the forces which turned the vanes act.



The diagram explains the meaning of my words. Now, it would be easy for Mr. Crookes to test whether this is the case, by using an envelope of rock salt, which is diathermanous to all the rays of heat and light, and if the vanes rotated in this envelope, my explanation falls to the ground. The experiments on which the above assertions are based are those of Melloni on radiant heat, recorded in Ganot's "Physics." I offer this explanation with some reluctance; but, although the way in which I have stated it may not be strictly correct, yet there may be a germ of truth in the idea. Whether it is so, could only be determined by experiments which I have not the means of making. ALFRED CLIFT.

47, West Derby-street, Liverpool.

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ON

REPULSION RESULTING FROM RADIATION.

PRELIMINARY NOTE ON THE OTHEOSCOPE.*

By WILLIAM CROOKES, F.R.S., &c.

I COMMUNICATED to the Royal Society, in November last, an account of some radiometers which I had made with the object of putting to experimental proof the "Molecular pressure" theory of the repulsion resulting from radiation. Continuing these researches, I have constructed other instruments, in which a movable fly is caused to rotate by the molecular pressure generated on fixed parts of the apparatus.

In the radiometer, the surface which produces the molecular disturbance is mounted on a fly, and is driven backwards by the excess of pressure between it and the sides of the containing vessel. Regarding the radiometer as a heat-engine, it is seen to be imperfect in many respects. The black or driving surface, corresponding to the heater of the engine, being also part of the moving fly, is restricted as to weight, material, and area of surface. It must be of the lightest possible construction, or friction will greatly interfere with its movement; it must not expose much surface, or it will be too heavy; and it must be a very bad conductor of heat, so as to retain the excess of pressure on one side. Again, the part corresponding to the cooler of the engine (the side of the glass bulb) admits of but little modification. It must almost necessarily be of glass, by no means the best material for the purpose; it is obliged to be of one particular shape; and it cannot be brought very near the driving surface.

A perfect instrument would be one in which the *heater* was stationary; it might then be of the most suitable material, of sufficient area of surface, and of the most efficient shape, irrespective of weight. The *cooler* should be the part which moves; it should be as close as possible to the heater, and of the best size, shape, and weight, for utilising the force impinging on it. By having the driving surface of large size, and making it of a good conductor, of heat, such as silver, gold, or copper, a very faint amount of incident radiation suffices to produce motion. The black surface acts as if a molecular† wind were blowing from it, principally in a direction normal to the surface. This wind blows away whatever easily movable body happens to be in front of it, irrespective of colour, shape, or material; and in its capability of deflection from one surface to another, its arrest by solid bodies, and its tangential action, it behaves in most respects like an actual wind.

Whilst the radiometer admits of but few modifications, such an instrument as the one here sketched out is capable of an almost endless variety of forms; and as it is essentially different in its construction and mode of action to the radiometer, I propose to identify it by a distinctive name, and call it the Otheoscope (ὠθέω, I propel).

The glass bulb is an essential portion of the machinery of the radiometer, without which the fly would not move; but in the otheoscope the glass vessel simply acts as a preserver of the requisite amount of rarefaction. Carry a radiometer to a point in space where the atmospheric pressure is equal to, say, one millimetre of mercury, and remove the glass bulb; the fly will not move, however strong the incident radiation. But place the otheoscope in the same conditions, and it will move as well without the case as with it. In the preliminary note already referred to*, I described a piece of apparatus by which I was able to measure the thickness of the layer of molecular pressure generated when radiation impinged on a blackened surface at any degree of exhaustion. At the ordinary density of the atmosphere the existence of this molecular disturbance was detected several millimetres off, and its intensity increased largely as the generating surface and movable plate were brought closer together. It would be possible, therefore, to construct an otheoscope in which no rarefaction or containing vessel was necessary, but in which motion would take place in air at the normal density.‡ Such a heat-engine would probably work very well in sunlight.

Aided by the mechanical dexterity of my assistant, Mr. C. H. Gimingham, I have constructed several varieties of otheoscope. These I propose to exhibit at the Soirée of the Royal Society on Wednesday next, as illustrations of the very beautiful manner in which, at this stage of my investigations, theory and experiment proceed hand in hand, alternately assisting each other, and enlarging our knowledge of those laws of molecular movement which constitute a key to the relations of force and matter.

The following is a list of the otheoscopes I have already made, together with some new experimental radiometers, which will be exhibited for the first time on Wednesday:—

1. *Otheoscope.*—A four-armed fly carrying four vanes of thin clear mica is mounted like a radiometer in an exhausted glass bulb. At one side of the bulb a plate of mica blacked on one side is fastened in a vertical plane, in such a position that each clear vane in rotating shall pass the plate, leaving a space between of about a millimetre. If a candle is brought near, and by means of a shade the light is allowed to fall only on the clear vanes, no motion is produced; but if the light shines on the black plate, the fly instantly rotates as if a wind were issuing from this surface, and keeps on moving as long as the light is near.

2. *Otheoscope.*—A four-armed fly carries roasted mica vanes, and is mounted in an exhausted glass bulb like a radiometer. Fixed to the side of the bulb are three plates of clear mica, equidistant from each other in a vertical plane, but oblique to the axis. A candle brought near the fixed plates generates molecular pressure, which, falling obliquely on the fly, causes it to rotate.

3. *Otheoscope.*—A large horizontal disk, revolving by the molecular disturbance on the surface of inclined metallic vanes, which are blacked on both sides in order to absorb the maximum amount of radiation.

4. *Otheoscope.*—Inclined aluminium vanes driven by the molecular disturbance from the fixed blacked mica disk below, blowing (so to speak) through them.

5. *Otheoscope.*—A large horizontal coloured disk of roasted mica, driven by inclined aluminium vanes placed underneath it.

6. *Otheoscope.*—A bright aluminium disk cut in segments, and each segment turned at an angle, driven by a similar one below of lampblacked silver.

7. *Radiometer.*—A vertical radiometer, made with eight disks of mica blacked on one side, and the whole suspended on a horizontal axis which works in two glass cups. The motion of the radiometer is assisted on each side by driving vanes of aluminium blacked on one side.

8. *Radiometer.*—A vertical turbine radiometer, the oval vanes of roasted mica blacked on one side.

9. *Radiometer.*—A spiral radiometer of roasted mica blacked on the upper side.

* Read before the Royal Society, April 26, 1877. Received April 23, 1877.

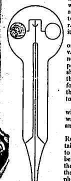
† *Molecular*, not *molar*. There is no wind in the sense of an actual transference of air from one place to another. This molecular movement may be compared to the movement of the gases when water is decomposed by an electric current. In the water connecting the two poles there is no apparent movement, although eight times as much matter is passing one way as the other.

* *Proc. Royal Soc.*, Nov. 16, 1876, p. 310.

‡ Since writing this I have constructed such an instrument. The movement takes place in the way I had anticipated.—W. C., April 26, 1877.

SIR WILLIAM GROVE ON THE RADIOMETER.[1]

SIR WILLIAM GROVE described some experiments he had recently made with a modification of Crookes's radiometer. After a few prefatory trials, such as coating one-half of the bulb with tinfoil and electrising it, which gave no notable results, he devised a method, shown in the accompanying sketch, by which he could electrise the whole of the internal system. Four aluminium vanes, each blackened on one side, had metallic arms and a metal point at their crossing that rested in a metal cup. The latter was united to a platinum wire that passed through a glass tube and was fused into it, the platinum wire protruding. Lastly, the glass tube was fused inside the apparatus and hermetically sealed, the end of the platinum wire being exposed. The vacuum in this apparatus was considered by Mr. Crookes[2] to be as perfect as in his radiometers generally, but Sir William Grove doubted that it was so. The following were the results:—



1. With the faint light of a lucifer match or of one or two candles, the vanes invariably turned the opposite way to the normal, the polished surface being repelled. With a dark heat, as from an iron shovel heated short of redness, they went the normal way. These effects continued for several days, but not permanently; the apparatus seemed to have leaked and to have become sluggish and irregular.

2. On electrising the protruding platinum wire with a rubbed rod of glass or sealing-wax, the vanes rotated sometimes one way and sometimes the other.

3. On connecting the negative pole of a Ruhmkorff's coil the results were uncertain, but the positive pole caused the vanes to rotate steadily, and its effect was even better than that from light or heat. In the dark the effect was very beautiful, as the dark vanes moved through a phosphorescent glow. The total results were considered by Sir William Grove to be somewhat negative, but they tended to show that all the effects were due to residual air. He suggested in explanation of the last experiment, that more electricity would escape from the rough than from the polished faces of the vanes, as the former presented a vast number of points. Consequently the rough faces would produce more disturbance of the gas in front of them, and would themselves be more affected by the reaction than the plane faces. The polished surfaces being repelled by luminous heat is, however, very difficult of explanation.

In his second notice Sir William Grove described some further experiments he had made with Crookes's radiometers since the last meeting of the club. He did not now entertain much doubt that these movements are due to the effect of residual air. Mr. Crookes had kindly made a second instrument for him, and the one that he described at the last meeting, of which the vanes were metallic and in metallic connection with a platinum wire that protruded outside the apparatus, had been re-exhausted. Both now act normally, the black faces of the vanes being repelled by light and by heat. When the protruding wire is now electrised by a Ruhmkorff's coil the effects that were previously observed are altogether absent, there is not the slightest luminosity round the vanes, and the current does not pass. But although the current is now incapable of traversing the small space of one-tenth of an inch that separates the vanes from the glass, induction acts across it just as well as before. This is shown by the readiness with which the vanes follow the movements of a piece of rubbed glass or sealing-wax held near the apparatus. It is therefore evident that the effects of attenuation of air upon discharge and upon induction are not the same. When attenuation has commenced and is increasing, the discharge passes more and more rapidly, until it becomes a glow, or according to the old theory of electricity, polarisation becomes more and more readily subverted; but a further attenuation stops the discharge entirely. On the other hand, induction continues, and appears to be in no way lessened by extreme attenuation. These results cannot be accounted for by the old theory that discharge is the consequence of subverted induction.

It farther appears that a radiometer is a most delicate electroscope. By tilting it until the vanes touch the glass, the interior of the glass may be electrised, and it will then remain for days in that condition. He had performed this operation eight days ago, and the movements of the instrument by light or heat have been thereby wholly checked. Every endeavour has been made to discharge or neutralise the electricity on the glass surface, as for example, by covering the exterior of the globe with tinfoil and connecting this with the platinum wire, nevertheless the glass remains charged, showing what a perfect insulator a good vacuum is.[1]

[1] Abstract of two communications by the Hon. Sir William Grove, F.R.S., to the Philosophical Club, May 18 and June 15, 1876.

[2] Who kindly made it for me from my description.—W. R. G.

RESEARCHES ON THE RADIOMETER.

By Prof. PAUL VOLPICELLI.

1. ALL radiometers do not possess the same sensibility necessary for every experiment.

2. The most sensitive of the two which are in the physical museum of the Roman University shows that the freezing mixture of chloride of sodium and snow, applied to the upper hemisphere of the small globe, produces a rotation of the mill in the same direction in which it is produced by heat radiation, *i. e.*, with the white face of the small discs in advance.

3. If to this lowering of temperature be added a radiation of heat, the rotation of the apparatus is accelerated at the same time.

4. If the freezing mixture referred to be placed on the lower hemisphere of the same small globe, the apparatus will rotate with the absorbing, *i. e.*, the black faces in advance, and consequently in the direction contrary to that of the preceding experiment, *i. e.*, to the direction produced, if to the same lower hemisphere, radiant heat be applied.

5. If during the rotation produced by the application of the freezing mixture to the lower hemisphere of the small globe we cause radiant heat to strike the same globe, the apparatus will be brought to a stop; and, as soon as the source of heat is withdrawn, the rotation will immediately commence.

6. If the small globe is plunged entirely in a heated liquid, or even in a freezing mixture, the apparatus will remain at rest.

7. It should be noted that the freezing mixture applied to the upper hemisphere of the small globe produces a rotation in the direction opposite to that produced by the same mixture when applied to the lower hemisphere.

8. It has been stated that the radiometer in darkness remains at rest; but it should be remarked that if even in darkness it is affected by dark radiant heat, the apparatus will assume a rotatory movement; yet the instrument may remain at rest even when placed in a dark space.

9. The luminous rays of the full moon, focussed by means of a lens, do not cause rotation of the instrument.

10. If the radiation of the flame of a Locatelli lamp is caused to traverse several plates of perfectly transparent glass, it will be seen by the number of turns of the instrument that the law of De la Roche is verified regarding the absorption of radiant heat through these plates, however many they may be. I have been able by this means to diminish the radiant heat to such an extent as to cause the rotation of the radiometer to cease, although the light of the same radiation was increased by means of a lens.

11. The same radiation, that, viz., produced by Locatelli's lamp, by traversing a saturated but perfectly transparent solution of alum, before reaching the radiometer, did not set it in motion, although the radiant light was but little diminished; and the same is the case when the light is increased.

12. It would appear at present that the rotation of the radiometer depends on radiant heat and not on the luminous rays.

13. It appears also that the mechanical cause of the rotation of the radiometer consists in the motion of the molecules of very rarefied gas in the small globe, which is in accordance with the opinion of modern thermodynamics.—*Nature.*

RADIOMETER.

[12358.]—AN interesting discussion took place in the pages of the ENGLISH MECHANIC a short time ago upon the radiometer, and various conjectures were hazarded as to whether the rotary movement of the vanes was caused by heat, electricity, or the expansion of the residual air contained in the bulb of the radiometer, or so-called vacuum. There is apparently a difficulty in forming a perfect vacuum. Would it not be possible to construct a radiometer with a vacuum equal to that in a good barometer? Suppose a glass tube, say of the same bore as a barometer tube, but widening at the top to, say, 2½ or 3in. in diameter, fitted with an air-tight screw-on brass cap, would it not be an easy matter to fit in the broad part of the tube a coil of fine silk covered with wire, the ends of which might project through the bulb? The vanes, which appear to be made of iron, might be pivoted in the same way as vertical galvanometer needles, on a fine point. Now screw off the cap, put on the vanes, stop up the lower end of the rod with the finger, fill the tube, screw on cap, invert rod, and drive out with heat what air there may be in the mercury, and invert in a vessel of mercury. Should the vanes be liable to fall off during the operation a current of electricity through the coil would prevent them, the mercury would be allowed slowly to fall until at the same height as that in a barometer; the bulb would then be a perfect vacuum.

JOHN.

RECENT RADIOMETER EXPERIMENTS.

AT a recent meeting of the Physical Society, London, Professor G. C. Foster, F.R.S., President, in the chair, Mr. Crookes described some of the most recent results he has obtained in his experiments on the radiometer, and exhibited many beautiful forms of the apparatus, most of which have been devised with a view to decide on the correct theory of the instrument. He commenced by describing the arrangement he has used for some time past in studying the resistance offered by air and other gases to the rotation of a mica disk. It consists of a mica plate suspended by a fibre of glass, and enclosed in a chamber which can be exhausted to any required extent. A mirror is attached to the mica, and the movement of a luminous point reflected from it shows that the decreasing swings form a logarithmic curve, and Mr. Crookes takes the logarithms of the decrements of the swings as a measure of the viscosity of the gas under examination. From the normal atmospheric pressure to the best vacuum which can be obtained by the ordinary air-pump this decrement remains nearly constant, and these experiments have been carried on in vacua of remarkable perfectness, the highest exhaustion obtained being represented by 1 millimetre on a scale of 10 miles, a point which was attained by means of a Sprengel pump, with improvements by Mr. Gimingham, and measured by a McLeod gauge. If the "logarithmic decrement" be represented by 125 at a pressure of 760 m.m., it is not reduced to 70 until the pressure has been reduced to 35 millionths of an atmosphere, and at this point the action of light on a radiometer is at a maximum. On continuing the exhaustion this influence is found to decrease, and Mr. Crookes concludes that in a perfect vacuum the log. dec. would not be zero, but about 0·01; that is, a mica plate would not continue to oscillate forever, a fact probably due to the viscosity of the glass fibre. About fifteen different forms of the radiometer were exhibited, and their inventor has satisfied himself that the theory of their action proposed by Mr. G. Johnstone Stoney is the only one capable of completely accounting for their action, and he considers it to be in all probability the correct one. By means of a double radiometer, consisting of two globes of different diameters, and having a wide opening between them, and provided with a four-armed fly which can be made to rotate in either bulb, it has been shown that, other things being equal, the velocity of rotation decreases as we increase the diameter of the bulb. As, on the molecular-movement theory, the rotation is due to a throwing off of particles from the blackened surface of the mica, it follows that, if a piece of transparent mica be attached to each fly in front of the blackened surface, the rotation will take place in the opposite direction, and this proved on experiment to be the case. And, further, when such a plate is placed on either side of the vanes, the motion of the instrument is almost entirely stopped. As these facts can be explained on the "molecular movement" or the "evaporation and condensation" theory, Mr. Crookes arranged a radiometer having four transparent mica vanes, and mounted in a rather large bulb. At the side of the bulb a plate of mica, blackened on one side, is so fixed in a vertical plane that the vanes can pass, and when light shines on this fixed plate the fly is found to rotate, a fact which in itself disproves the latter theory. Many other curious forms were exhibited, in some of which the vanes were cup-shaped, as Mr. Crookes has found these to act as well as the ordinary form, a convex surface acting as though it were blackened. In conclusion, he exhibited a photometric four-vaned radiometer, in which the fly was attached to a small magnetic needle, and this might be so checked by an external magnet that the strongest light would be incapable of causing the needle and vanes to make a half rotation. If the circumference of the globe be graduated, and the apparatus be brought within the influence of a source of light, the angle to which the needle is deflected will be a direct measure of the intensity of the light, and Mr. Crookes showed that by a simple arrangement such an instrument might be rendered self-recording.

Prof. Dewar exhibited a simple electrometer which he has designed, founded on the discovery of Leipman that the capillary constant is not really independent of the temperature or the condition of the surface, but is a function of the electromotive force. If a capillary tube be immersed in mercury, and dilute sulphuric acid be placed in the tube above the mercury, and a current from a Daniel's cell be so passed through the liquids that the mercury forms the negative pole, the column will be depressed to an extent dependent on the diameter of the tube. In making an electrometer Prof. Dewar has increased the sensitiveness by connecting two vessels of mercury by means of a horizontal glass tube filled with the metal, except that it contains a bubble of dilute acid. The tube must have an internal diameter of 2 millimetres, and it is essential that it be perfectly clean, uniform in diameter, and horizontal. The instruments exhibited were constructed by Messrs. Tisley & Spiller, and Prof. Dewar showed that it is possible by means of them to measure an electromotive force equal to $\frac{1}{10000}$th of a Daniel's cell; forces capable of decomposing water must be measured by causing two currents to act against each other. The index bubble is brought to zero by uniting the mercury cups by a wire. The apparatus is very convenient, as it requires no preparation, and is extremely simple in its action. He then showed an instrument, arranged by Mr. Tisley, for producing a current by the dropping of mercury from a small orifice into dilute sulphuric acid. If the vessels containing the mercury and the sulphuric acid be connected by a wire a current is found to traverse it, and Prof. Dewar explained how the electrolysis of water might be effected by this means. He then exhibited a delicate manometer suitable for measuring very slight variations of pressure, and he illustrated the use of it for proving Laplace's law that the internal pressure, multiplied by the diameter of a soap-bubble, is constant. It consists of a U-tube, one arm of which is about 15 inches long, and is bent horizontally, and levelled with great care. If the shorter arm be connected with a tube on which a bubble has been blown, and the diameter of the bubble be varied, the position of the extremity of the alcohol column will be found to vary in accordance with the above law.

CROOKES' FORCE.—During the last twelve months Mr. G. T. Stoney, F.R.S., and Mr. R. J. Moss have conjointly been investigating the behaviour of that force manifested in radiometers known as Crookes' force, and they have laid before the Royal Society some of the results so far obtained. If, as has been asserted, the pressure which is exerted on the blackened-pith surfaces reacts on the side of the glass envelope, then in like way a transparent disc, delicately suspended close to a stationary disc of blackened pith, ought to move away from the pith, and, therefore, towards the light when the pith is illuminated. An arrangement, described in their paper, was devised to test this. As soon as the vacuum commenced to be formed, the glass disc was repelled from the pith, and the repulsion was more violent as the vacuum became more perfect. The establishment of this fact with regard to this mysterious force the authors put forward without any expression of doubt. With regard to the influence of variations in the tension of the residual gas, and the variations in distance between the reacting surfaces, the authors state some results, but reserve discussion till further observations have been made.

PHYSICAL SOCIETY.

From the Telegraphic Journal.

77

At the meeting of the Physical Society on Jan. 16th Mr. Crookes described some of the most recent results he has obtained in his experiments on the radiometer, and exhibited many beautiful forms of the apparatus, most of which have been devised with a view to decide on the correct theory of the instrument. He commenced by describing the arrangement he has used for some time past in studying the resistance offered by air and other gases to the rotation of a mica disc. From the normal pressure to the best vacuum which can be obtained by the ordinary air-pump the resistance remains nearly constant, and the experiments have been carried on in vacua of remarkable perfectness, the highest exhaustion obtained being represented by one millimetre on a scale of ten miles, a point which was attained by means of a Sprengel pump with improvements by Mr. Grimingham, and measured by a McLeod gauge. Mr. Crookes concludes that in a perfect vacuum a mica plate would not continue to oscillate for ever, a fact probably due to the viscosity of the glass fibre employed. About 15 different forms of the radiometer were exhibited, and their inventor has satisfied himself that the theory of their action proposed by Mr. G. Johnstone Stoney is the only one capable of completely accounting for their action, and he considers it to be in all probability the correct one. As, on the molecular movement theory, the rotation is due to a throwing off of particles from the blackened surface of the mica, it follows that, if a piece of transparent mica be attached to each fly in front of the blackened surface, the rotation will take place in the opposite direction, and this proved on experiment to be the case. As these facts can be explained on the "molecular movement" or the "evaporation and condensation" theory, Mr. Crookes arranged a radiometer having four transparent mica vanes, and mounted in a rather large bulb. At the side of the bulb in a verticle plane, a plate of mica, blackened on one side, is so fixed that the vanes can pass, and when light shines on this fixed plate, the fly is found to rotate, a fact which in itself disproves the latter theory. In conclusion, he exhibited a photometric four-vaned radiometer, in which the fly was attached to a small magnetic needle, and this might be so checked by an external magnet, that the strongest light would be incapable of causing the needle and vanes to make a half rotation. If the circumference of the globe be graduated and the apparatus be brought within the influence of a source of light, the angle to which the needle is deflected will be a direct measure of the intensity of the light.

Radiometer.—A comparison has recently been made by Dr. Buff between the indications of the thermomultiplier and the radiometer. The two instruments were placed side by side in the cone of light admitted through an aperture of a board from a gas lamp, which could easily be regulated and kept constant for some minutes. There was a glass disk in front of the thermopile. In the galvanometer deflections of the needle were proportional to the deflecting force up to 21°. On tabulating deflections and numbers of rotations, it appears that their product is very nearly a constant number, warranting the inference that *the velocity of rotation of the little wheel is inversely proportional to the heat action of the penetrating rays.* This confirms the view that the turning of the radiometer is due to an action of heat rays which penetrate the glass. "If the radiometer," says Dr. Buff, "is incapable of measuring a mechanical force of light, it none the less wears its present name with full right. It is a special form of thermometer, only exclusively for heat rays of high refrangibility, whose heating force is proportional to the velocity of rotation of the wheel."

PHYSICAL SOCIETY.

Professor G. C. FOSTER, F.R.S., President in the chair.

Stratification of the Electric Discharge in Vacuum Tubes.—Mr. Spottiswoode exhibited some experiments and described his attempts to produce the effects as obtained by Mr. Gassiot and Mr. De la Rue, with batteries of several thousand cells by means of the induction coil. He showed the different forms of striæ produced in several different gases, and mentioned that the side towards the negative is always sharply defined, and that towards the positive gradually shades off into darkness. Mr. Spottiswoode has examined them by means of a rotating mirror, the mercury break being worked by the axis of the mirror so that the one only varies with the other. It was thus clearly ascertainable whether a band was progressing towards either pole or remaining stationary, or was intermittent, according as the line observed in the mirror was inclined or horizontal or broken. He considers that the ordinary break prolongs the sparks, so as, in some cases, to give rise to the ill-defined nature of the striæ, and he showed two forms of contact breaker adapted to these experiments. In the first the breaking was effected by a steel rod caused to vibrate by an electro-magnet, the number of these vibrations being determined by the musical note produced. In the apparatus now usually employed, however, a brass wheel is caused to rotate with great rapidity, the tops of the teeth are covered with platinum, the spaces between them being filled in with ebony. It was shown that if the current be made and broken by a wire resting on the rim of this wheel, the bands may be caused to move in one direction or the other, or remain stationary, according to the velocity of rotation of the wheel. A very ingenious arrangement, invented by Mr. Spottiswoode's assistant, Mr. Ward, was employed for introducing resistance into the secondary circuit, and thereby adjusting the strength of the current to suit the velocity of rotation of the wheel. It consisted of a spiral column of mercury surmounted by a vessel containing a badly conducting liquid, and by raising or lowering a cup connected with the base by means of an india-rubber tube, the amount of mercury present in the column is increased or decreased, the resistance offered by the column of constant length of course varying in the inverse proportion.

it had flowered profusely, I could not find a single normal fruit, and subterranean ones were extremely scarce.

According to Delpino the changing colours of certain flowers would serve to show to the visiting insects the proper moment for effecting the fertilisation of these flowers. We have here a Lantana the flowers of which last three days, being yellow on the first, orange on the second, purple on the third day. This plant is visited by various butterflies. As far as I have seen the purple flowers are never touched. Some species inserted their proboscis both into yellow and into orange flowers (*Danais erippus*, *Pieris aripa*), others, as far as I have hitherto observed, exclusively into the yellow flowers of the first day (*Heliconius apseudes*, *Colaenis julia*, *Eurema leuce*. This is, I think, a rather interesting case. If the flowers fell off at the end of the first day the inflorescence would be much less conspicuous; if they did not change their colour much time would be lost by the butterflies inserting their proboscis in already fertilised flowers.

In another Lantana the flowers have the colour of lilac, the entrance of the tube is yellow surrounded by a white circle; there yellow and white markings disappear on the second day.

Mr. Leggett's statements about *Pontederia cordata* appear to me rather strange, and I fear that there is some mistake. In all the five species of the family which I know the flowers are so short-lived, lasting only one day, that a change in the length of the style is not very probable. In the long-styled form of our highland Pontederia the style has its full length long before the flowers open. In my garden this Pontedaria is visited by some species of Augochlora collecting the pollen of the longest and mid-length stamens; they are too large to enter the tube of the corolla, and have too short a proboscis to reach the honey; they can only fertilise the long-styled and mid-styled forms, but not the short-styled.

Among the secondary sexual characters of insects the meaning of which is not understood, you mention ("Descent of Man," vol. i., p. 345) the different neuration in the wings of the two sexes of some butterflies. In all the cases which I know this difference in neuration is connected with, and probably caused by, the development in the males of spots of peculiarly-formed scales, pencils, or other contrivances which exhale odours, agreeable no doubt to their females. This is the case in the genera Mechanitis, Dircenna, in some species of Thecla, &c.

FRITZ MÜLLER

Blumenau, St. Catharina, Brazil, October 19

The Radiometer and its Lessons

PROF. OSBORNE REYNOLDS'S letter in NATURE (vol. xvii. p. 26) has directed attention prominently to the circumstance that two hypotheses have been submitted to the scientific world as explanations of the force and motions which Mr. Crookes had shown to exist—one by Prof. Osborne Reynolds, the other by myself.

Prof. Osborne Reynolds's explanation is based on the fact that when a disc with vertical sides is heated on one side and exposed to a gas, a convection current sets in, which draws a continuous supply of cold gas into contact with the hot surface of the disc. As this cold gas reaches the disc it is expanded, and thus its centre of gravity is thrown further from the disc. Accordingly, the disc, if freely suspended, will move in the opposite direction so as to keep the centre of gravity of the gas and disc in the same vertical line as before, and, if not freely suspended, will suffer a pressure tending to make it move in that direction. If I have understood Prof. Reynolds aright, this is both a correct and full description of his explanation as last presented.

My explanation, on the other hand, is based on *molecular* motions which go on in the gas without causing any molar motion, and is independent of convection currents. Prof. Reynolds is therefore, I conceive, fully justified in denying that my theory has supplied any deficiency in his explanation. As he points out, the two explanations are incompatible; if either is correct, the other is wholly wrong.

It is easy to apply comparative tests to the rival hypotheses by making a selection from Mr. Crookes's incomparable experiments, from the experiments by Mr. Moss and myself, and from instances of compressed Crookes's layers in the open atmosphere; but it is not easy to make the choice so as to bring the abundant evidence within the compass of a letter.

These tests might take various forms, of which perhaps the most direct is to ascertain whether the force is affected by variations in the convection current, as required by Prof. Reynolds's hypothesis, or is independent of convection, but increased when the heater and cooler are brought nearer together, as required by mine.

To test this Mr. Crookes mounted a radiometer in a receiver consisting of two unequal bulbs connected by a large tube. The movable portion could be transferred from one bulb to the other through the tube. In the small bulb the convection current is most impeded, and at the same time the heater and cooler are closest together. Mr. Crookes found that the motion of the radiometer was more rapid in the small bulb than in the large one, in conformity with my theory, and in opposition to Prof. Reynolds's. The same is the uniform drift of a vast number of other experiments by Mr. Crookes, and of those by Mr. Moss and myself, from which it appears that whenever the heater and cooler are made to approach there is an increase in the force, and that the force is not appreciably affected by variations of the convection current, or by its suppression.

This may also be proved, and quite conclusively, by observations not requiring apparatus. Drops in the spheroidal state and the drops which are often seen floating on the surface of volatile liquids, as, for example, the drops which run about on the surface of the sea in certain states of the weather when water drips from an oar, are supported by Crookes's layers of air intervening between them and the liquid beneath. Similarly a red-hot copper plate will float on water, supported on a Crookes's layer, and many other instances of a like kind might be adduced. In such cases, where the film of air is thin and for the most part horizontal, it is manifest that there is no opportunity for those convection currents to arise which are required by Prof. Reynolds's hypothesis, while in all of them there are the peculiar molecular motions of my theory.

The absence of convection currents which could produce an appreciable effect may also be proved in those radiometers of which the arms whisk round at a very rapid speed, and in many other cases that would take too much space to describe here.

Again, a tangential force which may be rendered considerable is an immediate consequence of my theory, but has no place as a consequence of Prof. Reynolds's. Now its presence has been verified by Mr. Moss and myself, and by Mr. Crookes in an exquisitely beautiful apparatus suggested for this purpose by Prof. Stokes, as well as, in a less degree, in all Mr. Crookes's apparatus with curved or crumpled discs.

Hence Prof. Osborne Reynolds's hypothesis is not the explanation of Crookes's stress. It alleges a cause which is in certain cases a *vera causa*, but not *the* cause of what is to be explained. So far as I can form a judgment, its merit was collateral, and not intrinsic. It was the first attempt at a reduction of the observed phenomena to known physical laws. Though not accounting for them, it was sufficiently plausible to attract the attention of Prof. Reynolds and other physicists. It thereby had the important effect of suggesting Dr. Schuster's most valuable experiment, which was the first that established the cardinal fact that the forces within a radiometer case are balanced.

The conclusion to which we are thus led by a purely *experimental* inquiry is supported by an examination of the chief *theoretic* assertions of Prof. Osborne Reynolds's letter, viz., 1. That an essential part of my explanation "is contrary to the law of the diffusion of heat in gases;" and 2. "That the force arising from the communication of heat from a surface to adjacent gas of any particular kind depends only on one thing, the rate at which heat is communicated, and to this it is proportional."

Both of these statements have been set down by Prof. Osborne Reynolds in error; the first from not observing that the ordinary laws for the propagation of heat through a gas do not apply to compressed Crookes's layers; and the second from a misapprehension of the actual agency at work in radiometers and other similar apparatus. I will proceed to establish these two positions.

1. So long as a gas is in its ordinary state the distribution of the velocities of the molecules is the same in all directions, and when heat is imparted to the gas it does not disturb this uniformity of structure. The heat simply increases the mean velocity, and the actual velocities continue to be distributed about

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CAREY FOSTER

EXPERIMENTS WITH THE RADIOMETER

I.

ABSTRACTS of my earlier papers on "Repulsion Resulting from Radiation" having appeared in NATURE, it has been suggested that an account of my later researches, which place the subject in such a different light, may also prove of interest.

It has already been shown that if the air is expelled from a large bulb containing a suspended bar of pith, and a lighted candle is placed about 2 inches from the globe, the pith bar commences to oscillate to and fro, the swing gradually increasing in amplitude until the dead centre is passed over, when several complete revolutions are made. The torsion of the suspended fibre now offers resistance to the revolutions, and the bar commences to turn in the opposite direction. It has been found, however, that very little movement takes place until the vacuum is so good as to be almost beyond the powers of an ordinary air-pump to produce, and that, as the vacuum gets more nearly absolute, so the force increases in power. The most obvious explanation therefore is, that the repulsive action is due to radiation; but at a very early stage of my investigation I found that the best vacuum I had succeeded in producing might contain enough matter to offer resistance to motion, and in describing an experiment in a paper sent to the Royal Society on February 5, 1876, I said that the impression conveyed to my mind was that the torsion beam was swinging in a viscous fluid, and the repulsion caused by radiation was indirectly due to a difference of thermometric heat between the black and white surfaces of the moving body, and that it might be due to a secondary action on the residual gas.

I have recently succeeded in producing such a complete exhaustion that I have not only reached the point of maximum effect, but gone so far beyond it that repulsion nearly ceases, and the results I have thus obtained seem to show conclusively that the true explanation of the action of the radiometer is that given by Mr. Johnstone Stoney, according to which the repulsion is due to the internal movements of the molecules of the residual gas. When the mean length of path between successive collisions of the molecules is small compared with the dimensions of the vessel, the molecules, rebounding from the heated surface, and therefore moving with an extra velocity, help to keep back the more slowly moving molecules which are advancing towards the heated surface; it thus happens that though the individual kicks against the heated surface are increased in strength in consequence of the heating, yet the number of molecules struck is diminished in the same proportion, so that there is equilibrium on the two sides of the discs, even though the temperature of the faces are unequal. But when the exhaustion is carried to so high a point that the molecules are sufficiently few, and the mean length of path between their successive collisions is comparable with the dimensions of the vessel, the swiftly-moving, rebounding molecules spend their forces in part or in whole on the sides of the vessel; and the onward crowding, more slowly-moving molecules are not kept back as before, so that the number which strike the warmer face approaches to, and in the limit equals, the number which strike the back cooler face; and as the individual impacts are stronger on the warmer than on the cooler face, pressure is produced, causing the warmer face to retreat.

Before referring at length to the experiments which led to my adopting the above theory, I will describe some effects of dark heat, &c., on the radiometer. In a paper I sent to the Royal Society on January 5, 1876, and which is now being published in the *Philosophical Transactions* of the Royal Society, about seventeen pages are occupied with the description of my experiments with various forms of this instrument. In the present paper I propose only to refer to a few typical experiments made during the year 1875.

To show the action of dark heat on the radiometer, a candle was placed at such a distance from the instrument that the arms would make one revolution a minute. A small glass flask of boiling water was then placed half-an-inch from the bulb. The revolutions instantly stopped, two of the arms setting equidistant from the hot-water flask. The flask of water was removed. As the portion of the bulb which had been heated by the hot water cooled, the white surface gradually crept nearer and nearer to it, the superior repulsion of the candle on the black discs urging the arms round, and acting in opposition to the repulsion of the hot glass to the white disc. At last the force of the light drove the white disc with difficulty past the hot spot of glass. Rotation then commenced, but for some revolutions there appeared to be a difficulty in the white discs passing the spot of glass which had been warmed by the hot water; and the flask of boiling water being replaced in its position half-an-inch from the bulb of the radiometer, the rotation immediately stopped.

The instrument having become cool, the candle was again placed in position, so that it produced one revolution in a minute. The finger was then pressed against the side of the bulb, and as the spot of glass got warm, the white surface experienced more and more difficulty in getting past it, until at last one refused to pass, and the arms came to rest.

The instrument was again allowed to cool, and the revolutions recommenced at the usual speed (the laboratory in which this was tried was somewhat cold). I then came from a warm room, and stood a foot from the radiometer, watching it. In about a minute the radiant heat from my body had warmed the side of the bulb nearest to me sufficiently to cause an appreciable difficulty in the movement, and soon the revolutions stopped. The same effect has been observed if the radiometer is brought into a very warm room and placed near a cold window. If the daylight is feeble, the instrument not very sensitive, or an observer stands near the instrument, an appreciable sticking is observed as the white discs come near that part of the bulb which is the warmest.

These experiments show that many precautions are necessary to guard against the interfering action of unequal heating of the radiometer when it is being used for accurate measurements.

Having found such an antagonistic action of dark heat, I tried the action of ice. This is equivalent to warming the opposite side of the instrument. A lump of ice was brought within half an inch of the bulb on the opposite side to the candle. The revolutions got slower, until at last the movement stopped altogether, one arm pointing direct to the ice, and being apparently held there by a powerful attractive force. Bringing the candle nearer caused the arms to oscillate a little, and when it was almost close to the bulb the force of the light overcame the action of the ice, and the arms revolved again, but irregularly, and with jerks, the discs moving quickly to the ice and leaving it with difficulty. In this action of ice no preference was noticed for either the black or white surface.

A very delicate radiometer, in 2-inch bulb, was placed in a sufficient light to allow it to be seen distinctly, but not enough to cause it to move. I then came out of a warm room and stood near it. In a few seconds it began to move slowly round in the negative direction, *i.e.* the black discs advanced instead of retreated. On moving away from the instrument the rotation gradually stopped. I again approached it, and held one hand an inch from the bulb. Rotation soon commenced, but still in the reverse way. These experiments were frequently repeated and always with the same results.

When the instrument was at rest I came quickly to it, and gently breathed on the bulb. There was a slight movement in the normal direction, but this stopped directly, and the arms then revolved the reverse way for more than a minute, performing three or four complete revolutions.

A glass shade four inches in diameter was held over a gas-flame till the air inside was warm, and the inner surface dim with steam. It was then inverted over the radiometer. Rotation commenced the reverse way, and kept up for several minutes. The glass shade was then dried inside, and heated uniformly before a fire until it had a temperature of about 50° C. It was then inverted over the radiometer. Reverse rotation instantly commenced, and kept up with some vigour for more than five minutes, diminishing in speed until the shade had cooled down to the temperature of the surrounding air.

The same experiment was repeated, and whilst the arms were in full negative rotation, a lighted candle was slowly brought near it. When three feet off the negative rotation slackened. When the candle was about two feet off the arms became still, and when nearer than two feet the instrument rotated normally, the antagonism between the action of the hot shade and the lighted candle was perfect; by moving the candle to and fro it was easy to cause the radiometer to move in one direction or the other, or to become still.

I now tried the action of a radiometer the moving parts of which were made of a good conductor of heat, such as a metal, instead of pith, which is a bad conductor of heat. I selected thin rolled brass as the material wherewith to make the arms and discs of a radiometer. The parts were all fastened together with hard solder, and no cement or organic matter was used, so that if necessary the instrument could be submitted to a high temperature without injury. The moving portion weighed 13·1 grains. One side of the discs was silvered and polished, the other side being coated with lampblack. The apparatus was exhausted with a charcoal reservoir attached. A candle 1½ inch from the bulb caused it to revolve about once a second, the black surface being repelled in the normal manner.

Standing in a rather dark cold room, it was covered with a warm glass shade, and it immediately began to revolve the negative way, but very slowly. A few drops of ether poured on the bulb caused the arms to move rather rapidly the normal way. A hot shade put over whilst it was thus moving caused it to stop, and then begin moving the reverse way. A small non-luminous gas flame was held vertically beneath the apparatus, so that hot air should ascend and wrap round the bulb on all sides. The arms now revolved the reverse way.

The brass radiometer being somewhat heavy, one was made of aluminium, the moving parts being hard soldered as before. A siphon-gauge was attached, and the apparatus connected direct on to the pump by a spiral, no charcoal tube being used. One side of the wings was bright aluminium, and the other was lampblacked. When exhausted the arms revolved very quickly to a candle a few inches off, the black being repelled. On removing the candle the arms stopped and immediately commenced revolving the reverse way, keeping up rotation for more than ten minutes, and being little inferior in speed to what it was when the candle shone on it. The whole of the bulb was heated with a Bunsen burner; whilst it was getting hot the aluminium arms revolved rapidly in the normal direction, but as soon as the source of heat was removed and cooling commenced, rotation set up in the reverse way, and continued with great energy till the whole thing was cold. It appeared as if the reverse movement during the cooling was equal in energy to the normal movement as it was being heated.

A little ether was poured on the bulb of a very sensitive pith radiometer as it was standing still in a faint light. The evaporation of the ether caused a chilling of the instrument and a rapid abstraction of heat from the arms. They commenced to move in the normal direction and

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ON REPULSION RESULTING FROM RADIATION.—PART IV.*

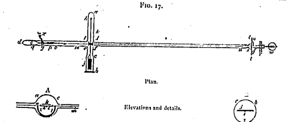
By WILLIAM CROOKES, F.R.S., &c.

(Concluded from p. 56.)

The Measurement of Force.

209. I have long endeavoured to devise some means of measuring the amount of force exerted by radiation, from a standard candle for instance at a foot off, on a measured surface of matter. The data given in pars. 199 and 200 are sufficient to enable the amount of force acting on the pith disks to be calculated indirectly; but I wished to have a means of measuring the force by as direct a method as we have of getting the weight of a ponderable body. I wanted an apparatus which will give me, at once, the pressure in grains which a ray of light exerts on a surface on which it may fall. Such an apparatus is shown in fig. 17.

Fig. 17.



Plan.

Elevations and details.

Vertical section of cross tube at the centre.

Vertical section of cross tube at the end containing the pith.

The principle of the construction is that of the torsion-balance first described by W. Ritchie, F.R.S., in 1830.† $a\,b$ is a glass tube 13·5 inches long, 1 inch wide as far as $a\,c$, and 1·2 inch wide at $c\,b$. It is closed at the end a, and ground flat and polished at the end b, so as to be capable of being closed by a plate of glass cemented on. $d\,e$ and $f\,g$ are two narrower tubes sealed into $a\,b$, as shown, the part $d\,e$ being 17 inches long, and $f\,g$ 38 inches long. $d\,e$ is $\frac{1}{2}$ an inch in diameter, and is closed at the end; $f\,g$ is a $\frac{1}{4}$ of an inch diameter. $h\,i$ is a thin glass beam, having a glass weight at the end h, and a flat surface of lampblacked pith (j) at the end i. The pith (j) exposes exactly 2 square inches of surface. It is prevented from curling up in the vacuum by cutting it partly through at intervals, as shown. k is a silvered mirror, cemented on to the centre of the glass beam; $l\,l$ are two knife-edges of glass, finely ground and polished; $m\,n$ is a very fine fibre of glass cemented to the beam ($h\,i$) beneath the mirror (k). The end (n) of the glass torsion-fibre is attached to the solid stopper (r), which is carefully ground and polished into the contracted part of the tube (s). The other end of the torsion-fibre (m) is cemented to a filament of silk ($m\,o$); this silk is attached to one end of a steel spring (p), which is held firmly at the other end by the solid rod (q) cemented to the glass tube ($d\,e$). The torsion-fibre ($m\,n$) passes over the knife-edges ($l\,l$), which thus support the beam. The tension of the spring (p) is so adjusted that the glass fibre shall remain stretched under a constant pull of about 100 grains. $t\,t$ is a circular card cemented to the end of the tube (g) and divided into 360 degrees. On the stopper (r) is fixed a pointer (u), which revolves with it, and marks the degrees through which it has turned. The complete revolutions are recorded on a "counter" (w). Motion is given to r by a torsion-handle (v). The apparatus is connected to the pump by the spiral (x), which works in a stopper tap (y) most ingeniously devised by my friend and assistant Mr. C. H. Gimingham, so as to enable the instrument to be disconnected from the pump and attached to it again without interfering with the exhaustion.*

The stopper (r) is very accurately ground and polished in the tube at s, as long a surface as possible being in contact. It should be lubricated by setting fire to a piece of plain india-rubber, and allowing the melted drops to fall on the contact surfaces. This is a nearly perfect lubricant, allowing very free movement and preventing any access of air.

210. The torsion-fibre must be selected with great care. Ten threads were drawn (103) and were suspended from a horizontal beam. Weights were then gradually hung on to the lower ends. Only two were found strong enough, the others having broken before 450 grains had been added. The one selected stood 450 grains without breaking. Its diameter is less than 0·001 inch.

The torsion of the glass fibre was taken by the method given in par. 186. With the weight of 15·46 grains hanging on to it half an oscillation took 30 seconds.

A fellow thread, selected of as nearly as possible the same strength and tension, and having a weight of about 100 grains at the end, broke when it was twisted 36 times. The actual thread used in the balance has been tested up to 30 turns without breaking.

211. A flat oblong piece of soft iron, weighing accurately 0·01 grain, is put loose into the cross tube under the pith surface (see z, fig. 17, vertical section of cross tube). This weight can be picked up by a horseshoe magnet outside the tube, and dropped on any part of the pith. A mark is made at the exact centre of the pith surface, and by moving the magnet about, it is easy to place the iron weight accurately on this mark.

212. A silvered glass mirror is supported at an angle of 45° over the pith surface, and so that the centre of the mirror is 2 inches from the pith when the beam is in

* A Paper communicated to the Royal Society, February 5, 1876. From the *Philosophical Transactions of the Royal Society of London*, vol. clxvi., part 2.

† *Phil. Trans.*, vol. 120 (for 1830), p. 215.

* I have asked Mr. Gimingham to send a description of this [illegible] and some useful improvements he has introduced in the mercu[illegible] pump, to the Royal Society.

LETTERS TO THE EDITOR

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.

The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to ensure the appearance even of communications containing interesting and novel facts.]

The Radiometer and its Lessons

HAVING been prevented from attending the recent meeting of the British Association by the necessity of devoting my entire vacation to mental and bodily renovation after the sad family losses I had sustained, I have only become aware within the last few days that my article in the April number of the *Nineteenth Century*, entitled "The Radiometer and its Lessons," had been there spoken of by Prof. G. Carey Foster, in his address as President of Section A, as showing an "unmistakable tendency, *either intentionally or unintentionally*, to depreciate Mr. Crookes's merits, and to make it appear that he had put a wrong interpretation upon his own results," which statement is said by your reporter to have "elicited great applause."

Of Mr. Crookes's own reply in the July number of the same periodical, entitled "More Lessons from the Radiometer," I took no notice; partly because my mind was at the time fully occupied by sad cares and urgent duties, and partly because I thought that his assertions (1) that he had not theorised on the subject at all, (2) that he had not attributed the rotation of the radiometer to the direct impetus of light, and (3) that he had never claimed the discovery of a new force or a new mode of force, were so well known in the scientific world to be inconsistent with fact, that I need not trouble myself to refute them.

Prof. Carey Foster, however, speaking with authority as President of the Physical section of the British Association, has given it as his judicial opinion that what I have written on this subject shows an unmistakable tendency to depreciate Mr. Crookes's merits, and to misrepresent his opinions; and he has further "unmistakably" suggested (as it appears to me) that this *may* have been done with deliberate intention, instead of being done in good faith under the influence of an unintentional bias. As it is impossible for me to allow such an imputation from such a quarter to pass unnoticed, I might fairly challenge Prof. Carey Foster to justify language which I must presume him to have used with all due consideration of its obvious meaning, and of *his* and *my* relative positions. But as he explicitly disavows the more serious part of this imputation, I have now only to ask to be allowed to show, in the columns of the journal which has not only recorded the accusation, but has pointedly directed attention to it,—*first*, that I have not, *even unintentionally*, "depreciated Mr. Crookes's merits" as the inventor of the Radiometer; and *secondly*, that Mr. Crookes really did in the first instance put that "wrong interpretation upon his own results" which I attributed to him. Had Prof. Carey Foster complied with the request I privately made him, that he should specify the passages which (in his opinion) justify his charge, I should have been able to reply to it much more briefly. But by declining thus to particularise, he obliges me to traverse the whole ground covered by his general accusation.

That I was not influenced, when writing on the Radiometer, by any *animus* arising from my personal antagonism to Mr. Crookes on another subject, will appear, I think, from the following extracts from the two lectures which I delivered at the London Institution (by special request) on Mesmerism, Spiritualism, &c., before Christmas, and which were published in *Fraser's Magazine* at the commencement of the present year:—

"The recent history of Mr. Crookes's most admirable invention, the Radiometer, is pregnant with lessons on this point. When this was first exhibited to the admiring gaze of the large body of scientific men assembled at the *soirée* of the Royal Society, there was probably no one who was not ready to believe with its inventor that the driving-round of its vanes was effected by the direct mechanical aid of that mode of Radiant Force which we call Light; and the eminent Physicists in whose judgment the greatest confidence was placed, seemed to have no doubt that this mechanical agency was something outside Optics properly so called, and was, in fact, if not a new Force in nature, a new *modus operandi* of a force previously known under another form. There was here, then, a perfect readiness to admit a novelty which seemed so unmistakably demonstrated, though transcending all previous experience. But after some little time the question was raised, whether the effect was not really due to an intermediate action of that *mode* of Radiant Force which we call *heat*, upon the attenuated vapour of which it was impossible entirely to get rid; and the result of a most careful and elaborate experimental inquiry, in which nature has been put to the question in every conceivable mode, has been to make it (I believe) almost if not quite certain, that the first view was incorrect, and that Heat is the real moving power, acting under peculiar conditions, but in no new mode."—*Lectures on Mesmerism and Spiritualism*, p. 8.

"I hold the warning given by the history of this inquiry, in regard to the duty of the scientific man to exhaust every possible mode of accounting for new and strange phenomena, before attributing it to any previously unknown agency, to be one of the most valuable lessons afforded by Mr. Crookes's discoveries.

"Now I maintain that it requires exactly the same kind of specially trained ability to elicit the truth in regard to the phenomena we are now considering, as has been exerted in the researches made by the instrumentality of the Spectroscope and the Radiometer. And I cannot but believe that if Mr. Crookes had been prepared by a special training in the bodily and mental constitution, abnormal as well as normal, of the Human instruments of the Spiritualistic inquiries, and had devoted to them the ability, skill, perseverance, and freedom from prepossession, which he has shown in his Physical investigations, he would have arrived at conclusions more akin to those of the great body of scientific men whom I believe to share my own convictions on this subject."—*Op. cit.*, p. 70.

No one, I think, can fail to see that in speaking of Mr. Crookes's "most admirable invention," and in giving him the fullest credit for the "ability, skill, perseverance, and freedom from prepossession," with which he had carried on his investigations in regard to it, I eulogised him as warmly as if I had never come into collision with him. It must also be apparent to any reader of these lectures, that I did not impute to him any blame for having originally fallen into an error shared at the time by the "eminent Physicists in whose judgment the greatest confidence was placed;" and that my reason for bringing forwards the subject was to enforce the lesson, that "no new principle of action has any claim to scientific acceptance, save after an exhaustive inquiry as to the extent to which the phenomena can be accounted for, either certainly or probably, by agencies already known."

Circumstances to which I shall presently advert having made me feel it desirable that this "lesson" should be yet more fully and emphatically set forth, I applied myself to a careful reperusal of Mr. Crookes's papers in the *Proceedings* of the Royal Society, with the most earnest desire to present a true history of the whole inquiry; and I availed myself of the opportunity kindly afforded me by the editor of the *Nineteenth Century*, to place before the public what I believed to be a fair statement of the case, with the lessons it conveyed.

Commencing with a description of the phenomena presented by the Radiometer when it was first exhibited by Mr. Crookes at the *soirée* of the Royal Society, I thus continued:—

"It is scarcely surprising, then, that a general impression should at once have prevailed that a capital discovery had been made—that of the *direct mechanical action of light*; which, though not indicating the existence of a new force in nature, showed that the most universally diffused of all forces, next to gravitation, has a *mode of action* which was previously not merely unknown, but altogether unsuspected. And this impression was not confined to those who had only a general acquaintance with Physical Optics; for it was shared by the greatest masters of that department of science, who had followed the course of the experimental researches on which Mr. Crookes had been for some time engaged, and of which this discovery was the culmination."—*Nineteenth Century*, April, 1877, p. 243.

I then went on to give, from Mr. Crookes's papers, a history of the investigations which had led him up to the Radiometer; and showed (p. 249) that at that stage of the inquiry, the argument for the *directness of radiant repulsion*, deducible from what was then supposed to be a fact—the increase of the rapidity of the rotation in proportion to the perfection of the vacuum—"seemed alike valid and cogent."

I next sketched the history of the opposite view originally propounded by Prof. Osborne Reynolds, supported by Dr. Schuster's experiment, and finally established by Mr. Crookes's own later researches, which have culminated in the doctrine of

"heat reaction" now generally accepted. In reference to Mr. Crookes's own part in these subsequent inquiries, I say later on (p. 254), that "no sooner was adequate ground shown for calling in question his interpretation of the phenomena, and a *vera causa* found in an agency already known, than Mr. Crookes evinced the spirit of the true philosopher in varying his experiments in every conceivable mode, so as to test the validity of his original interpretation." And again in the next page I speak of his "carrying out this beautiful inquiry in a manner and spirit worthy of all admiration."—What higher praise *could* be given to a scientific investigator?

Having brought the history to its conclusion, I thus proceed:—

"Before adverting to the lessons which this remarkable history seems to me to convey, I would point out that this change of interpretation of the facts discovered by Mr. Crookes, does not in the least diminish either the interest of the facts themselves or the merit of his discovery. Nor is the value of his Radiometer in any degree lowered by the demonstration that it does not (as Mr. Crookes at first supposed) afford an absolute mechanical measure of radiant energy under any of its aspects. What (according to present views) it really does measure, is the amount of 'heat reaction' producible in gaseous atmospheres of different kinds and of different degrees of attenuation. And such a precise method of measurement appears more likely than any other mode of investigation, to furnish a test of that kinetic theory of gases, the recent development of which by Prof. Clerk-Maxwell is regarded by competent judges as constituting (if it should receive such verification) the most important advance ever made in molecular physics. Most deservedly, therefore, did Mr. Crookes receive from the Royal Society the award of one of its chief distinctions." (*Loc. cit.*, p. 251.)

To this I may add that I personally congratulated Mr. Crookes most cordially on that occasion, and expressed to him the deep interest with which I had followed his researches throughout. And though I had next to show that Mr. Crookes has another side to his mind, which makes Mr. Crookes the "spiritualist" almost a different person from Mr. Crookes the "physicist," I carefully guarded what I had to say on this point in the following words:—

"I would not be thought for one moment to disparage Mr. Crookes's merits as the inventor of the Radiometer, by now bringing into contrast with the admirable series of scientific investigations which led up to that invention, what I cannot but regard as his thoroughly unscientific course in relation to another doctrine of which he has put himself prominently forward as the champion."

I cannot but surmise that Prof. Carey Foster must have read my paper rather carelessly, and have applied to Mr. Crookes, the inventor of the Radiometer, the depreciatory remarks I felt called upon to make in regard to Mr. Crookes, the supporter of a system, a large proportion of which even Mr. D. D. Home has recently denounced as "a seething mass of folly and imposture."[1] If Prof. Carey Foster knew as much as I do of the mischief which *this* Mr. Crookes has done, especially in the United States, on the one hand to his own reputation and to that of British science,[2] and on the other to public morality, by the facility with which he has lent himself to the support of frauds as wicked as those by which fortune-tellers delude ignorant and credulous servant-girls, he would not wonder that I should feel called upon to show that the high scientific ability of Mr. Crookes, the Physicist, neither prevents him from believing in his own day-dreams, nor renders him a match for the cunning of the clever female cheats who play upon his Spiritualistic "prepossessions."

I now pass to the second part of my defence; and shall show that for "making it appear that Mr. Crookes had put a wrong interpretation upon his own results," I can adduce adequate justification from his own published statements.

Of the "repulsion accompanying radiation" shown in his early experiments by the swinging-round of the pith bar, Mr. Crookes said, in 1874 (*Phil. Mag.*, vol. xlviii., p. 94), "*My own impression is that it is directly due to the impact of the waves*

[1] See his "Lights and Shadows of Spiritualism," containing an unsparing exposure of its "delusions," its "absurdities," and its "trickeries."

[2] On the strength of a private letter from Mr. Crookes, which has been published (in *fac simile*) in the American newspapers, a certain Mrs. or Miss Eva Fay announced her "spiritualistic" performances as "endorsed by Prof. Crookes and other Fellows of the Royal Society." The particulars of the complete public exposure of this woman's disgraceful frauds, showing that Mr. Crookes's *scientific tests* are no more worthy of trust than the late Prof. Hare's *experimental demonstration of the immortality of the soul*, will appear in the forthcoming number of *Fraser's Magazine*.

46

The Radiometer and its Lessons

As I now learn for the first time what are the grounds on which Prof G. C. Foster based his inculpation of me, I may ask for a *very* few last words. I fully admit that in giving a sketch of the history of the Radiometer, I *intended* to attribute to Mr. Crookes that he had in the first instance put a wrong interpretation upon his own results; because I believed that this was a simple fact, well known to everybody who had followed the history of the inquiry. And Prof. Carey Foster has not called in question the correctness of my statement of the general impression which prevailed among scientific men, alike when Mr. Crookes first exhibited his radiometer at the *soirée* of the Royal

Society, and when its phenomena were discussed at the subsequent meeting. Having followed that discussion with the greatest interest, I cannot now recall one word that was not in harmony with the "direct impact" doctrine, or that suggested the idea of "heat reaction" through residual gas. If the question had been then asked, whether the rotation would continue to take place in an *open* vacuum (were such possible), or in a *perfect* vacuum,—so as to eliminate all "reaction," through residual gas, between the vanes and the containing flask,—I believe that the general, if not the unanimous, verdict would have been in the affirmative. Certainly I heard nothing from Mr. Crookes on the other side, he having previously spoken of the dependence of the "Repulsion resulting from Radiation on the presence of residual gas as 'impossible to conceive.'"

It is clear, then, that in referring to this then prevalent view, I no more wished to put Mr. Crookes in the wrong, than I wished to put in the wrong my very excellent friends among the other eminent Physicists who shared it; the special purpose of this part of my paper being to bring out, as strongly as I could, *the thoroughly scientific and philosophical method in which Mr. Crookes afterwards worked himself right.* If this is not expressed in as much detail as Prof. G. C. Foster would have approved, it surely afforded no adequate ground for his going out of his way to charge me with having "depreciated Mr. Crookes's merits." Yet this is the *only* ground that I can find in the whole of Prof. Carey Foster's statement, for what I could not but regard as a very grave imputation.

On Mr. Crookes's reply I shall make but a single remark, with reference to his perfectly correct citation of the latter part of my conversation with him, on the occasion of his receiving the Royal Medal. If I had not found, after the publication of my Lectures (in which I said nothing but what was respectful to Mr. Crookes), that he had himself been "digging up the hatchet" which I was quite disposed to keep buried, by giving his public attestation to the "spiritualistic" genuineness of what had been proved to be a most barefaced imposture, I should not have again brought his name into the controversy. But I felt that his greatly increased reputation as a Scientific man would do an increasing injury to what I honestly believed to be the cause of reason and common sense, not only in this country but still more in the United States.

Since the death of Prof. Hare, not a single scientific man of note (so far as I am aware) has there joined the Spiritualistic ranks; but the names of the "eminent British scientists," Messrs. Crookes and Wallace, are a "tower of strength" to the various orders of "mediums"—rapping mediums, writing mediums, drawing mediums, materialising mediums, test mediums, photographic mediums, trance mediums, healing mediums, and the like—*whose names form many columns* of the "Boston Trades' Directory." And the now notorious impostor, Eva Fay, has been able to appeal to the "endorsement" given to her by the "scientific tests" applied to her by "Prof. Crookes and other Fellows of the Royal Society," which had been published (I now find) by Mr. Crookes himself in the *Spiritualist* in March, 1875. Within two months of that date, as Mr. Maskelyne has publicly stated, an offer was made him (I have myself seen copies of the letters) by Eva Fay's manager, that for an adequate sum of money the "medium" should expose the whole affair, scientific tests and all, "*complicating at least six big guns, the F.R.S. people*," as she was not properly supported by the Spiritualists.

I have therefore felt it incumbent on me to show that in dealing with this subject Messrs. Crookes and Wallace have followed methods which are thoroughly *un*-scientific; and have been led by their "prepossession" to accept with implicit faith a number of statements which ought to be rejected as completely untrustworthy.

My call to take such a part—which I would most gladly lay aside for the scientific investigations which afford me the purest and most undisturbed enjoyment—seems to me the same as is made upon every member of the Profession to which I have the honour to belong, that he should do his utmost to cure or to mitigate *bodily* disease. The training I originally received, and the theoretical and experimental studies of forty years, have given me what I honestly believe (whether rightly or wrongly) to be a rather unusual power of dealing with this subject. Since the appearance of my Lectures I have received a large number of public assurances that they are doing good service in preventing the spread of a noxious *mental* epidemic in this country; and I have been privately informed of several instances, in which persons who had been "bitten" by this malady, have owed their recovery to my treatment. Looking to the danger which threatens us from the United States, of an importation of a real spiritualistic *mania*, far more injurious to our *mental* welfare, than that of the Colorado beetle will be to our *material* interests, I should be untrue to my own convictions of duty if I did not do what in me lies to prevent it. That I do not take an exaggerated view of the danger, will be obvious to any reader of Mr. Home's book. I know too well that I thus expose myself to severe obloquy, which (as I am not peculiarly thick-skinned) will be very unpleasant to myself, and unfortunately still more so to some who are nearly connected with me. But I am content to brave all, if I can believe that my *exposé* will be of the least service either to individuals or to society at large.

W. B. CARPENTER

THE high scientific position which Prof. Foster holds, as well as the decided manner in which his letter was written, must lead the otherwise unbiassed reader to the conclusion that not only has a satisfactory explanation of the action in question been found and generally adopted, but that this explanation turns upon certain considerations, and particularly on the mean length of the path of the gaseous molecules as influenced by the degree of rarefaction.

I feel my position, therefore, particularly unfortunate in having, for the sake of truth, to show that the explanation which Prof. Foster has adopted, and supposes others to have adopted, is, if judged by the statements in his letter, inconsistent with well-established laws.

Prof. Foster gives me credit for having originated the fundamental idea of the explanation, but states that my "explanation was theoretically incomplete; in particular it did not show clearly why so high a degree of rarefaction should be necessary for the production of the phenomenon in question;" and then he proceeds to explain how this asserted deficiency was supplied by other thinkers, who showed that "the increase, resulting from rarefaction, in the mean length of the path of the gaseous molecules, would favour the action."

It is this supposed completion of my explanation that is erroneous. It is contrary to the law of the diffusion of heat in gases that "the increase, resulting from rarefaction, in the mean length of the path of the gaseous molecules would favour the action," and so far from supplying any deficiency in my explanation it is incompatible with it. The only result from such an increase is to diminish the action—a result which rises into importance only when the rarefaction is carried so far that the mean length of the path of a molecule becomes comparable with the dimensions of the inclosing vessel.

In my first paper I gave a definite proof, which has nowhere been questioned, that according to the kinetic theory the force arising from the communication of heat from a surface to adjacent gas of any particular kind depends only on one thing, the rate at which heat is communicated, and to this it is proportional. If therefore the increased rarefaction increased the force it must increase the rate at which heat is communicated, but according to the law established by Prof. Maxwell the rate at which heat is communicated is independent of the density of the gas, whence it follows that the increase in the mean length of the path of the gaseous molecules, resulting from rarefaction, cannot favour the action which remains approximately constant until the gas becomes so rare that the law of diffusion no longer holds, after which it may easily be shown the communication of heat, and hence the action in question, diminishes but never increases.

The fact that in the radiometer the force caused by the communication of heat only causes motion when the surrounding gas becomes extremely rare is, as I pointed out in my first papers, fully explained by the action of what I have called convection currents, which action depends on the weight and density of the gas. The gas adjacent to the hot surface is hotter than that which is more remote, and hence the former rises forming an ascending column, to supply which the gas is drawn in laterally on all sides, and tends to carry the surface forward with it. With the same difference of temperature and surrounding circumstances the speed of these convection currents is the same whatever may be the density of the gas, and hence the force which they exert on the surface is proportional to the density of the gas.

This force is opposite in direction to that arising from the communication of heat to the gas, and since the former diminishes with the density while the latter is constant, there must be some density for which they balance, and below which the constant force will predominate, while above this point the convection currents will carry the surface with them. The fact that, starting from low densities, the motion of the vanes in the radiometer does not only diminish as the density increases, but is actually reversed at higher densities, requires explanation, and no other than this has yet been offered.

I have gone into the subject at considerable length, as I felt bound, when venturing to differ from so high an authority as Prof. Foster, to state my reasons. There is, however, nothing in what I have said here which I have not said elsewhere, in the same or other words; and however incomplete in theory the explanation given in my first papers may be, I can only say that it included all the facts known to me at the time these were written; it has led me to predict many of the experimental results which have since been obtained, and I have not been able to find one fact with which it is not in accordance, nor has it been, so far as I am aware, controverted in any particular.

OSBORNE REYNOLDS

47

insects, and then, after noticing the Chermes that attacks that very strong food the larch, we come to a full description of *Phylloxera vastatrix*. The Hemiptera are shortly mentioned, and then the Myriopoda. There is a good picture of Geophilus clinging around its great prey, a large earthworm, and also of a Polydesmus. Amongst the Scorpions the long-armed Phrynus and Gonoleptes, and amongst the Spiders a long Tetragnatha and the extraordinary-bellied Gasteracantha, form admirable illustrations. A short chapter on Pycnogonum and Nymphon concludes this really wonderful volume.

P. M. D.

OUR BOOK SHELF

Heat. By B. Loewy (Lardner's Handbook of Natural Philosophy. Crosby Lockwood and Co., 1877.)

THIS, though not a bulky book, is a sort of miniature Encyclopædia of the subject. So far as we have read it it seems to have all the faults of the original (?) work to which Lardner's name was prefixed, with the important exception of the inaccuracies. These have been to a great extent removed, and the work has been brought up to date, but there is still the woeful want of order, or indeed of any guiding principle whatever which distinguished the former editions. It is a very curious mixture of good and bad, and cannot be called, in any sense, attractive to the reader. Numerous tables of experimental data are given, but they are in many cases carried to a number of places of figures quite beyond the present power of experimental science. Two, or perhaps three of the figures in the earlier places of each number are probably correct; the others give a show of minute accuracy which may altogether deceive the beginner. The treatment of the theoretical part is very meagre, but in the experimental part many curious facts not usually known are given. The book may be useful as a work of reference to those who are not in possession of Balfour Stewart's treatise, but we cannot say more in its favour.

Ferns, British and Foreign. The History, Organography, Classification, and Enumeration of the Species of Garden Ferns, with a Treatise on their Cultivation. By John Smith, A.L.S., Ex-Curator of the Royal Gardens, Kew. New and Enlarged Edition. (London: Hardwicke and Bogue, 1877.)

THAT Mr. Smith's "Ferns, British and Foreign" should have reached a new edition in a comparatively short time is no small tribute to its value as a book of reference for amateurs and fern cultivators. The chief portion of this very neatly got up work is occupied by an enumeration of cultivated ferns. The different genera, as understood by the author, who was one of the foremost pteridologists of his day, are described and figured, while a list of the cultivated forms, with synonyms and range of geographical distribution, follow under each genus, no attempt being made to give a diagnosis of the species. The scope of the work is therefore entirely different from that of the "Synopsis Filicum" of Hooker and Baker. The classification adopted is that propounded by Mr. Smith in his early publication on ferns, an arrangement not much used by modern writers. An appendix of recently-introduced ferns is given. These have been collected and arranged under their respective genera and tribes, as their names have from time to time been noticed in the horticultural journals and in nurserymen's catalogues. The list has thus no pretensions to be a critical one. The most interesting part of the book is the history of the introduction of exotic ferns, a subject about which, probably, no man living knows more than Mr. Smith. This is followed by an explanation of terms used in describing ferns, perhaps the least satisfactory part of the whole volume, as many of the terms are more or less obsolete, or only used in the book now before us. In this section nothing is said about the recent researches into the nature of the prothallus, construction of the reproductive organs, and morphological nature of the sporangia. The last part of the work is occupied by an essay on the cultivation of ferns, reprinted without alteration from the first edition, but giving the results of long experience of the successful cultivation of all groups of ferns. As a work of reference and guide to the cultivation, this book will most undoubtedly be of great service to the fern-growing public.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to ensure the appearance even of communications containing interesting and novel facts.]

The Radiometer and its Lessons

I HAVE little doubt that Prof. Osborne Reynolds is much more competent than I am to say what is or is not consistent with the kinetic theory of gases, but I hardly think that he gives evidence of this in his letter to last week's NATURE (p. 27). Unless my ignorance of the matter is more complete than I am aware of, the law that the rate of communication of heat to a gas is independent of the density, applies only when the space occupied by the gas is so great, or the variations of density so small, that these variations do not alter the temperatures of those portions of the gas which are at each instant respectively receiving and giving out heat. This condition cannot, I imagine, be fulfilled in the radiometer, where it seems to me inevitable that an action of the kind to which Mr. Johnstone Stoney called attention must take place.

G. CAREY FOSTER

P.S.—Since writing my previous letter to NATURE, a fortnight ago, I have read a paper by Mr. R. Finkener, in *Poggendorff's Annalen* (vol. clviii. pp. 572–595). This paper contains, besides a theoretical investigation of the motion of the radiometer founded on the kinetic theory of gases, an experimental proof that the action becomes much less when an extremely high degree of rarefaction is reached. The paper itself is not dated, but, as the Part of the *Annalen* which contains it was "closed" on July 31, 1876, the experiments described in it cannot have been much, if at all, subsequent to those (communicated to the Royal Society, June 13, 1876) which led Mr. Crookes to a like result.

G. C. F.

UNTIL I read Dr. Carpenter's letter in your issue of the 8th inst., it had never occurred to me that his "special purpose" was to bring out strongly my "thoroughly scientific and philosophical method!" This is an act of disinterested kindness which recalls to me the exquisite truth of Dean Swift's remark, "No enemy can match a friend."

Dr. Carpenter's only reply to my letter which appeared in your issue of the 1st inst. is contained in the following passage:—"If I had not found," he says, "after the publication of my Lectures, that he had himself been 'digging up the hatchet,' which I was quite disposed to keep buried, by giving his public attestation to the 'spiritualistic' genuineness of what had been proved to be a most barefaced imposture, I should not have again brought his name into the controversy."

Further on Dr. Carpenter paraphrases passages from his article in *Fraser's Magazine* for this month, in which he goes more into detail touching this "public attestation," of which in his eyes I stand accused.

"Eva Fay," he says, "returned to the United States, carrying with her a letter from Mr. Crookes, which set forth that since doubts had been thrown on the Spiritualistic nature of her 'manifestations,' and since he in common with other Fellows of the Royal Society had satisfied himself of their genuineness by 'scientific tests,' he willingly gave her the benefit of his attestation. This letter was published in *facsimile* in American newspapers."

My answer to this calumny shall be brief.

It is untrue that I dug up the hatchet—Dr. Carpenter's

48

Dec 77

Uses of Crooke's Mill.

CONTINUED FROM PAGE 341.

Photographers may also derive great benefit from the use of Crooke's mill in their dark rooms, where they use an orange-colored glass to admit daylight. They will notice a certain slow velocity of the instrument when exposed to this light; having ascertained by experiment, once for all, what the safe velocity is, beyond which the light is so strong that his plates become foggy or his sensitized paper injured, he may take care in the future to diminish the light as soon as the instrument revolves beyond this velocity by a too strong sun or day light penetrating the yellow glass. Suppose he finds that with 12 revolutions per minute the light has effect, he will look out that when the instrument revolves with a velocity beyond 10, to draw his curtain.

In meteorological observations everything is at present accurately recorded—temperature, atmospheric pressure, rain-fall, force of wind, etc.; but the only thing thus far roughly guessed at is the amount of light prevailing. No doubt this light is as influential upon animal and vegetable life as any of the other agencies, and for the progress of science and its useful application to agriculture and sanitary regulations, it should be as accurately recorded as the other observations.

The instrument in question now gives a direct measure, quite different from a mere rough estimate thus far followed. It is simply placed on a high building or mountain, and connected by telegraph wires to a central observatory, where then an exact account can be kept of the proportion of sun-light received, and compared with similar observations in various latitudes and different hights above the level of the sea.

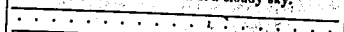
It is evident that such observations are closely related to those of temperature. The latter depends greatly on the amount of rays which a locality receives from the sun, and also on atmospheric currents of different temperatures which pass over it, and of ocean currents of warm or cold water which pass in its neighborhood. Thermometrical observations alone do not enable us to discriminate between these different causes; but the radiometer will enable us to distinguish how much of the annual temperature of a place is due to direct solar radiation, and how much to winds and ocean currents.

The transmission of the velocity of revolution by telegraph wire may be arranged by making one of the axes a steel magnet, or suspending such a one to one of the vanes; another magnet in the form of a bar or compass-needle is placed outside, delicately suspended on its center, and by every revolution of the instrument it is moved by the magnet carried on one of the vanes, and revolving with them. This motion of the outside compass-needle makes and breaks contacts, and so sends alternate currents, one for every revolution, which, by means of a Morse telegraph, makes dots upon a ribbon of paper regularly moved by clock-work. The distance of the dots will of course be proportional to the number of revolutions; they will be far apart when there is a little light, and closer together in proportion as the light is stronger.

If this instrument is not sensitive enough to be started by light alone, which is very likely to be the case, when the magnets manifest their attraction forcibly, it may be started from headquarters by means of a battery current acting on a small electro-magnet placed outside the instrument; a single contact will manifest a sudden attraction to the movable magnet and start a motion in the same, which may give it an impetus which will be kept up by the influence of the light. The record thus kept may be represented as follows:

Record of a weak illumination at daybreak.

Record of illumination of a cloudy sky.



Record of illumination of sunshine in the early morning.

Record of illumination by sunlight at noon.

The law that the intensity of light is in an inverse ratio to the square of the distance may be also recorded by the method just described. Place a candle 4 inches from the instrument, and if the dots are then say ½ an inch apart, place the candle at 5⅔ inches, and they will be 1 inch apart; at 8 inches they will be 2 inches apart; at 10 inches they will be 3¼ inches apart. Now these distances of the dots—½, 1, 2, and 3¼—are in a ratio to the squares of the distances, 4, 5⅔, 8, and 10, which are 16, 32, 64, and 100, or dividing all these by 32 we obtain ½, 1, 2, and 3¼, proving that the instrument acts according to the law.

CERTAIN MOVEMENTS OF RADIOMETERS[1]

NEARLY two years ago Mr. Crookes was so good as to present me with two of his beautiful radiometers of different constructions, the discs of one being made of pith, and those of the other of roasted mica, in each case blackened with lampblack on one face. With these I was enabled to make some experiments, having relation to their apparently anomalous movements under certain circumstances, which were very interesting to myself, although the facts are only such as have already presented themselves to Mr. Crookes, either in the actual form in which I witnessed them, or in one closely analogous, and have mostly been described by him. Although it will be necessary for me to describe the actual experiments, which have all been repeated over and over again so as to make sure of the results, I do not bring forward the facts as new. My object is rather to endeavour to co-ordinate them, and point to the conclusions to which they appear to lead.

I do not pretend that these conclusions are established; I am well aware that they need to be further confronted with observation; but as I have not leisure to engage in a series of experiments which would demand the expenditure of a good deal of time, and have lately been urged by a friend to publish my views, I venture to lay them before the Royal Society, in hopes that they may be of some use, even if only in the way of stimulating inquiry.

In describing my experiments I will designate that direction of rotation in which the white face precedes as positive, and the reverse as negative. It will be remembered that, under ordinary circumstances, radiation towards either radiometer produces positive rotation.

1. If a glass tumbler be heated to the temperature of boiling water, and inverted over the mica radiometer, there is little or no *immediate* motion of the fly, but quickly a *negative* rotation sets in, feeble at first, but rapidly becoming lively, and presently dying away.

2. If after the fly has come to rest the hot tumbler be removed, a *positive* rotation soon sets in, which becomes pretty lively[2] and then gradually dies away as the apparatus cools.

3. If the tumbler be heated to a somewhat higher temperature, on first inverting it over the radiometer there is a *slight positive* rotation, commencing with the promptitude usual in the case of a feeble luminous radiation, but quickly succeeded by the negative rotation already described. If the tumbler be heated still more highly, the initial positive rotation is stronger, and lasts longer, and the subsequent negative rotation is tardy and feeble.

4. If the pith radiometer be treated as in § 1, the result is the same, with the remarkable difference that the rotation is positive instead of negative; it is also less lively.

[1] Paper read at the Royal Society, December 20, by Prof. G. G. Stokes, Sec. R.S.

49

perature of the interior surface of the fly will be less attracted, or, which is the same, more repelled. Hence, whether the inner surface of the bulb be cooler or hotter than the fly, a reversal in the direction of rotation while the fly is being heated, indicates a reversal in the order of absorbing power of
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5. But if the tumbler be removed when the fly has come to rest, it remains at rest, or nearly so.

6. If the tumbler be more strongly heated, positive rotation begins as promptly as with light. In this case the tumbler must not be left long over the radiometer, for fear the vacuum should be spoiled by the evolution of gas from the pith.

7. If the tumbler be heated by holding it over the spout of a kettle from which steam is issuing, and held there till the condensation of water has approximately ceased, and be then inverted over the pith radiometer, the bulb is immediately bedewed, and a *negative* rotation is almost immediately set up, though sometimes, just at the very first moment, there is a trace of positive rotation. The negative rotation is lively, but not lasting; and after fifteen seconds or so, is exchanged for a positive rotation, which is not lively, but lasts longer.

8. If the tumbler be lifted when the negative rotation has ceased, and the dewed surface be strongly blown upon, a lively but brief positive rotation is set up.

9. To produce positive rotation by blowing it is not *essential* that the bulb be wet. If it be merely warm, and the circumstances are such that the fly is at rest for the moment, or nearly so, blowing produces positive rotation, though much less strongly than when the bulb is wet.

10. If the tumbler be heated as in § 7, and inverted over the mica radiometer, the rotation is positive, as when the tumbler is dry.

11. If the tumbler or a cup be smoked inside (to facilitate radiation), heated to a little beyond the temperature of boiling water, and inverted over the pith radiometer, a positive rotation is produced; and if, when this has ceased, which takes place in a couple of minutes or so, the heated vessel be removed, a negative, though not lively, rotation is produced as the apparatus cools.

12. These results do not seem difficult to co-ordinate so far as to reduce them to their proximate cause.

As regards the small quantity, if any, of heat radiated directly across the glass of the bulb, the action of which was experimentally distinguishable by its promptitude, both radiometers behaved in the ordinary way.

13. As regards the mica radiometer, when the bulb gets heated and radiates towards the fly the fly is impelled in the negative direction *as if* the white pearly mica were black and the lampblack were white. And there is nothing opposed to what we know in supposing that such is *really* their relative order of darkness as regards the heat of low refrangibility absorbed and radiated by the glass; for the researches of Melloni and others have shown that lampblack is, if not absolutely white, at any rate very far from black as regards heat of low refrangibility. On the other hand, glass and mica are both silicates, not so very dissimilar in chemical composition, and it would not therefore be very wonderful, but rather the reverse, if there were a general similarity in their mode of absorption of radiant heat, so that the heat most freely radiated by glass and accordingly abounding in the radiation from *thin* glass such as that of the bulb, were greedily absorbed by mica. The explanation of the reversal of the action when heat and cold were interchanged is too well known to require mention.

14. With the pith radiometer, when the bulb as a whole is heated, and radiates towards the fly, the impulse is positive, though less strong than in the case of the mica (§ 4); and when the bulb as a whole is cooler than the fly the impulse is negative (§ 11).

But to explain all the phenomena we must dissect the total radiation from or towards the bulb. When I first noticed the negative rotation produced by a heated wet tumbler, I was disposed to attribute it to radiation from the water, which possibly the glass of the bulb might be thin enough to let pass; but when I found that hot water in a glass vessel outside, even though the glass of it were thin, produced no sensible effect, and that blowing on the heated bulb when it was dry produced a similar effect to blowing on it when dewed, though of much less amount, I perceived that the moisture acted, not by direct radiation from it, and in consequence of a difference of quality between the radiations from glass and water, but by causing a rapid *superficial* heating of the bulb; and, similarly, the blowing on the dewed surface acted by causing a rapid superficial cooling. When the dry tumbler radiates to the bulb, the radiation is absorbed at various depths; the absorption is most copious, it is true, at the outer strata, but still the change of temperature is not by any means so much confined to the immediate surface as when we have to deal with the latent heat of vapour condensed on it, or obtained from it by rapid evaporation.

Hence, thin as is the glass of the bulb (about 0·02 in. thick), we must still, in imagination, divide it into an outer and inner stratum, and examine the effects of these separately. The heat radiated by either stratum depends only on its temperature, but the radiation from the outer, on its way to the fly, is sifted by passing through the inner, and the portion for which glass is most excessively opaque is in great part stopped. It appears from the observed results that the residue acts decidedly negatively, while when the bulb is pretty uniformly heated there is positive action. We may infer that if it were possible to heat the inner stratum alone it would manifest a very decided positive action.

15. In the struggle between the opposing actions of the outer and inner strata we see the explanation of the strange behaviour of the pith radiometer. In the experiment of § 7 the outer stratum at first shows its negative action, but quickly the inner also gets heated, partly by conduction from the outer, partly by direct radiation from the tumbler, and then the inner prevails. In the experiment of § 5 the whole bulb cools, partly by radiation, partly by convection, while the fly remains warmer; and the slightly greater coolness of the outer than of the inner stratum makes up for the superiority of the inner when the two are equally cool, so that the antagonistic actions nearly balance, and slight causes, such as greater or less agitation of the air, suffice to make the balance incline one way or other. That the inner stratum *would* prevail if the two were about equally cooled may be inferred from the behaviour of the radiometer when the bulb is pretty uniformly heated (§§ 4, 11), or shown more directly by cooling the bulb with snow, when a negative rotation may be obtained.

16. The complete definition of a radiation would involve the expression of the intensity of each component of it as a function of some quantity serving to define the quality of the component, such as its refractive index in a standard medium, or its wave-length, or the squared reciprocal of the wave-length.[1] The experimental determination of the character, as thus defined, of a radiation consisting of invisible heat-rays is beset with difficulties, at least in the case of heat of extremely low refrangibility; and in general we can do little more than speak in a rough way of the radiation as being of such or such a kind. It is obvious that the behaviour of radiometers by itself alone affords no indication of the refrangibilities of the kinds of heat with which we have to deal; nevertheless, by combining what we know of the behaviour of bodies in respect to radiations in general (especially luminous radiations, which are the most easily studied) with what we observe as to the motions of radiometers, we may arrive at some probable conclusions.

17. We may evidently *conceive* a series of ethereal vibrations of any periodic time, however great, to be incident on a homogeneous medium such as glass, and inquire in what manner the rate of absorption would change with the period; though whether we can actually *produce* ethereal vibrations of a very long period is another question, seeing that we can only act on the ether by the intervention of matter, and are limited to such periods of vibration as matter can assume when vibrating molecularly, in a manner communicable to the ether, and not as a continuous mass, in the manner of the vibrations which produce sound. We may inquire whether, on continually increasing the period of vibration, the glass (or other medium) would ultimately become and remain very opaque, or whether, after passing through a range of opacity, it would become transparent again, on still further increasing the period of the incident vibrations.

18. This is a question the experimental answer to which, as it seems to me, could only be given, in so far as it could be given at all, as a result of a long series of experiments, of a kind that Melloni has barely touched on. A variety of considerations, which I could not explain in short compass, lead me to regard the second alternative as the more probable, namely, that, on increasing the periodic time, homogeneous substances in general (perhaps even metals, though this is doubtful) become at last transparent, or at least comparatively so. The limit of opacity, in all probability, varies from one substance to another; and the lower it is, the lower would be the lowest refrangibility of the radiation which the same substance is capable of emitting.

19. In what immediately follows I shall suppose accordingly that glass is strongly absorbing through a certain range of low

[1] A map of the spectrum, constructed with the squared reciprocals of the wave-lengths for abscissæ, would be referred to a natural standard, no less than that of Angström, which is constructed according to wave-lengths; while it would have the great advantage of admitting of ready comparison with refraction spectra, the kind almost always used.

50

The Radiometer and its Lessons

78

WITH reference to the controversy between Mr. Stoney and Mr. Osborne Reynolds about the laws of the conduction of heat in gases, it seems desirable to call the latter gentleman's attention to the fact that neither Clausius' nor Clerk Maxwell's investigations, as published in the *Philosophical Magazine*, affect the controversy between them.

The latter, in his papers in the *Philosophical Magazine*, vol. xxxv., lays particular stress upon the fact that he supposes the motions of the molecules to be uniformly distributed in every direction. He says, however, on page 188: "When one gas is diffusing into another, *or when heat is being conducted through a gas*, the distribution of velocities will be different in the positive and negative directions instead of being symmetrical, as in the case we have considered." From this theory of the uniform distribution of velocities he deduces the formula (29), (31), and (32), as he numbers them, and to which he subsequently refers. On page 214 he gets an equation (143) which represents the transference of heat through the medium, and says: "The second term contains quantities of four dimensions in $\xi\,\eta\,\zeta$, *whose value will depend upon the distribution of velocity* among the molecules. *If* the distribution of velocity is that which we have proved to exist when the system has no external forces acting on it, and when it has arrived at its final state we shall have by equations (29), (31), (32) . . ." certain results from which he deduces his equation for the conduction of heat in gases.

When he says "has arrived at its final state" it is evident from his reference to the equations that he means the state of a gas in which neither diffusion nor conduction of heat nor currents of any kind are going on. It will thus be seen that his final result is only a first approximation and could not possibly be expected to hold within distances comparable with the mean length of the path of a molecule between two encounters.

Clausius in his paper as translated in the *Philosophical Magazine* for June, 1862, does suppose a distribution of velocity among the molecules of such a kind that the velocity and number of molecules moving in the positive and negative directions is different, but assumes the mean between them to be the same as the number moving in a direction normal to the direction of the transference of heat. This is evident from the fact that what he practically does is to assume that the number of molecules moving in a direction making an angle θ with the direction of transference of heat can be expressed by a formula of the form—

$$n = n_0 (1 + e \cos \theta),$$

for he neglects e^2 throughout his investigation. In this form it is evident that n_0 is the number when $\theta = \frac{\pi}{2}$ and is the mean of the values $n_1 = n_0 (1 + e)$ and $n_2 = n_0 (1 - e)$, which represent the numbers going towards and from the points of high temperature. From the fact that e^2 enters into the investigation at all it is evident that this is only an approximation to the true distribution. In accordance with this Mr. Stoney has shown conclusively that in a compressed Crookes's layer the number of molecules moving parallel to the direction of the transference of heat is greater than the number of those moving in any direction normal to it, so that the expression Clausius derived from his assumption cannot be considered as expressing the whole state of affairs.

It is remarkable that to this order the expression for the pressure on *any* plane is the same, but Clausius gives another term in his expression for the pressure on a plane normal to the direction of transference of heat to which he attaches, indeed, only an indefinite coefficient because it is of the order e^2, and he was purposely neglecting quantities of that order. He might have prophesied, however, from the existence of such a term that at distances comparable with e a force would be manifested such as Mr. Crookes has since discovered. Now this e is by definition a quantity of the order of the length of the mean path between successive encounters, and hence these terms, varying with e^2 would become of importance at distances comparable with the length of this mean path.

I believe, then, that I have shown that neither Clausius nor Clerk Maxwell have considered the case in dispute between Mr. Stoney and Mr. Osborne Reynolds, and that as far as their investigations bear upon it they tend very much to strengthen Mr. Stoney's case. I have also shown that Clausius was on the point of anticipating both Crookes's force and Mr. Stoney's explanation of it.

GEO. FRAS. FITZGERALD

Trinity College, Dublin

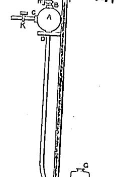
GEISSLER AIR-PUMP.

[17360.]—Of all the air-pumps, the Geissler mercury pump is, without doubt, the most easily

Eng Mechanic

constructed by the inexperienced amateur. No piston to make, no metal work to do. With such a pump as that we will describe, a first-class vacuum is got, and very delicate experiments may be performed. We have dispensed with the usual gear work and three-way taps, and have made a very simple form of the apparatus. The glass globe A has three openings, viz., the neck at D, and two openings at B and C. This globe, in our machine, has 2½in. diameter. It may be bought at any chemical apparatus warehouse. The openings at band C are fitted with indiarubber "corks," each having a hole. Thus we fit at B a brass funnel, with stopcock, and at C a glass tube,

Eng Mechanic May 28/80



having also a stopcock. On to the neck D we fix an indiarubber tube D E, about one yard long, which communicates with the mercury bottle by the lower tubulure F. This tube should be made of good and thick rubber, in order to withstand the weight of the mercury. In our machine, we have made it double, in order to avoid accidents, as it is very unpleasant to have to hunt about for 8lb. of mercury spilled over the floor of a room.

The apparatus is worked as follows:—The flask or tube to be emptied of air is connected with the lateral tube C K. The stopcock K is closed, H is opened, the mercury bottle F G is lifted, until the mercury, after having filled the globe A, comes up into the funnel. The stopcock H is then closed, and the mercury bottle put down on the baseboard M N. The mercury then leaves the globe A in a state of vacuity, and descends a short way in the tube D E (the difference of the level in the tube and in the bottle is equal to the barometric pressure at that moment). We then open K, and hear the air rush from the flask we exhaust into A. This operation must be repeated several times. It takes, of course, longer to perform than a stroke of the piston of an ordinary air-pump; still, we do not think it too tiresome, and are very satisfied with our new machine. Those who are good hands at glass-working can dispense with the indiarubber cocks, and blow the funnel and stopcock tube directly on to the glass globe.

The globe A will cost about 1s. 6d.; the stopcock funnel, 3s.; the stopcock-tube, 3s.; the mercury bottle 1s.; and about 28 shillingsworth of mercury (say 7lb.) will be required. The mercury can, of course, be taken out of the apparatus, when wanted, and used for a gas-trough.

Paris, May 8.

C. Detaille.
E. Diguet.

51

The Radiometer and its Lessons

PROF. OSBORNE REYNOLDS arranges his last letter (NATURE, vol. xvii. p. 220) under four numbered heads, and in the reply which I appear called on to make I will follow this division.

1. In the first section he says, "There is nothing in my earlier papers that is 'admittedly erroneous.' If there is error in these papers I am not aware of it." This is strange. In his first paper (*Proceedings*, Royal Society, vol. xxii. p. 40) Prof. Reynolds declares its object to be "to point out and to describe experiments to prove that these effects (the motions observed by Mr. Crookes) are the results of evaporation and condensation." Now they are not the results of evaporation and condensation: and it might have been seen, *ab initio*, that evaporation and condensation could have had nothing to do with them; for evaporation and condensation can only produce a temporary force, ceasing so soon as the distillation is complete, and cannot therefore be any part of the cause of a persistent force such as that detected by Mr. Crookes, which lasts for any length of time during which the heat is applied. In the same paper Prof. Reynolds further says, "The reason why Mr. Crookes did not obtain the same results within a less perfect vacuum [than that of the Sprengel pump], was because he had then too large a proportion of air, or non-condensing gas, mixed with the vapour, which was also not in a state of saturation." All this is manifest error. But this is not all, for *the whole of the theory* of those papers is erroneous; neither condensable vapour nor residual gas acts in the way described by Prof. Osborne Reynolds. In investigating the force arising from evaporation and condensation, he has overlooked the circumstance that the evaporation from the disc will keep back part of the vapour which would otherwise have reached it, and in investigating the effect of condensation he tacitly assumes that it does keep it back. Now in both cases the reverse of the assumption is what takes place, and he actually arrives at the absurd result that "if the opposite sides of a pith ball in vapour were in such different conditions [*i.e.*, one surface evaporating, the other condensing] the ball would be forced towards the colder side" (p. 403). His conclusion amounts to this: that the recoil of a cannon would be doubled if it were struck from behind by a missile at the same moment that it discharges an equal mass with equal velocity forwards! If he had not made these mistakes he would have got out only the forces which result from "the perceptible motion of the vapour," which he states "would be insensible" (p. 403), along with alterations in the general tension of the vapour *which would act equally on both sides of the disc*. Those errors vitiate the whole of his mathematical reasoning, so that the value for *f* which he gets, is not, as he supposes, "the force arising from evaporation," and his law connecting it with the heat falls to the ground. I have all along supposed, from Prof. Reynolds's having long ceased to mention his theory of evaporation and condensation, that he was aware of some of its errors.

The same error vitiates his reasoning in reference to the action of residual gas. If the error is corrected, and if, as he assumes, the gas coming up to the disc had been unpolarised (*i.e.* had brought to the disc equal numbers of molecules, and with equal velocities from all directions in front), his investigation *would only have given him an increase in the general pressure of the gas*, acting, as I pointed out in paragraph 5 of my first paper (*Phil. Mag.*, March, 1876, p. 179), equally on the front and back of the disc, except during the almost inappreciable instant of adjustment. *Prof. Osborne Reynolds therefore wholly missed the source of the persistent force with which Mr. Crookes's experiments deal.*

2. Prof. Osborne Reynolds next says that his second paper "does not conclude with his own expression of opinion that residual gas is not the cause of the force observed by Mr. Crookes." In reply I have only to quote the concluding words of that paper (*Phil. Mag.*, November, 1874, p. 391). After passing under review the two agencies (condensable vapour and residual gas), which he supposes are to be considered, he decides in favour of the former in the following words: "hence in such cases [*i.e.*, under the conditions which he supposed to prevail in Mr. Crookes's experiments] it seems to me that the effects must be due to the forces of condensation."

3. In the next section of his letter Prof. Reynolds states that Clausius and Maxwell "established the law that the only condition of thermal equilibrium in a gas is that of uniform temperature." I am not aware that they have ever established this law. The converse of it is obviously true, and has often been used, and the law itself has sometimes been assumed, but has never, so far as I know, been proved. I am, however, disposed to concur with those who think that it is probably true, and the conclusion in my paper on penetration (which is the reverse of that attributed to me by Prof. Reynolds) is in conformity with it. My conclusion is expressed in the following words (*Phil. Mag.*, December, 1877, § 4):—"Hence there must, in the cases that really arise, be some escape of heat which may be small but cannot vanish." And, I may remark, there will, according to my view, be two other sources of escape of heat, viz., conduction by diffusion, which was excluded from my investigation; and conduction by radiation, which was excluded both from Clausius's investigation (*Phil. Mag.*, June, 1862, p. 422, footnote) and from mine.

Prof. Osborne Reynolds a second time objects to my having excluded conduction when investigating the penetration of heat. As he attaches weight to authority he will perhaps be reconciled to my doing so, by the example of Clausius, as cited above, and by his justification of it in the following words (*loc. cit.*):—"In any case, however, it is allowable to consider separately each of these two ways in which heat moves."

Before passing from this subject I wish to take the opportunity of stating that Dr. Schuster's letter (NATURE, vol. xvii. p. 143) has satisfied me that I have hitherto erred in my estimate of the relative efficiency of penetration and conduction as agents for conveying heat. I am now convinced that penetration is usually feeble compared with conduction, and, in the figures representing De la Prevostaye and Desains' experiments, is to be sought in those portions of the curves which slope steeply downwards. The second part of my paper on penetration, that in which I apply the theory to experiment, will accordingly require considerable modification; and some of the statements which I made in my papers on Crookes's force will need amendment. The corrections that are required do not, however, affect any of the material parts of my theories of Crookes's force and of penetration, which depend essentially on the fact that there is a layer in the gas extending to a limited distance from a heater or cooler, throughout which the effects of the discontinuity in the gaseous motions at the surface will be felt, and that within that layer the stresses and the communication of heat follow special laws.

4. I have to express my great satisfaction at the explicit admission made by Prof. Osborne Reynolds in the fourth section of his letter, in the following sentences:—"There is one statement in Mr. Stoney's letter which is not erroneous. He says, 'I cannot find anywhere in Prof. Osborne Reynolds's writings an explanation of the thing to be explained, viz., that the stress in a Crookes's layer is different in one direction from what it is at right angles to that direction.' I [Prof. Osborne Reynolds] do not at all admit that this is 'the thing to be explained,' and I am quite sure that Mr. Stoney would find no explanation of it in my writings." This admission disposes finally of all controversy as to priority between us.

I need hardly, after this admission, follow Prof. Osborne Reynolds through the rest of his letter. His supposed invariable law "that the [Crookes's] force always tends to drive the vanes or bodies in the direction of their colder faces," does not seem to be true. A familar exception occurs when a spheroidal drop is supported over a platinum dish. The Crookes's force acting upon the platinum dish is equal to the weight of the drop, and acts downwards, *i.e.* in the direction of the *hottest* surface of the dish.

In applying his hypothetical case of a heater and cooler, A and B, within an envelope of intermediate temperature, to prove that "the force that causes the motion in the bodies cannot be due" to the stresses of my theory, he has overlooked the very obvious circumstance that the envelope, as well as B, is a cooler in reference to A, and the envelope, as well as A, is a heater in reference to B.

Prof. Reynolds observes that I have not defined polarisation. I described the kind of polarisation that exists in radiometers in my first two papers, and I will give a formal definition of the term as applied generally to gases in an article which I am preparing, and which I hope will be admitted into the pages of NATURE, giving as clear an account of my theory as I can, compatibly with brevity and the omission of mathematics.

The way in which Prof. Reynolds has excluded polarisation from his explanation is by assuming that the state of the gas close to the heated disc may be adequately represented by unpolarised gas of one temperature coming up to the disk, and unpolarised gas of another temperature leaving it, *i.e.*, by mole-

Law of the Absorption of Radiation through Bodies and on its Application in Quantitative Spectral Analysis (Second Part).—G. Govi.—Theoretic considerations, confirmed by experiment, have demonstrated to physicists that a mono-chromatic radiation, *i.e.*, one of a single wave-length, is extinguished by absorption, so that we have $I_1 = Ik^x$, I representing the intensity of the incident radiation; I_1, that of the same radiation after its passage through a thickness, x, of the absorbent medium. The magnitude k, called the coefficient of absorption, and which is always fractional, expresses the intensity of the light which has traversed the unity of the thickness of the medium. This reaction enables us to calculate the value of k for any wave-length soever as soon as we know the ratio of the two intensities $\frac{I_1}{I}$ for a thickness x of the medium traversed. When the coefficients k_1 are once known nothing is easier than to apply them for tracing the curves of equal chromatic absorption, whether for a refraction spectrum or for the normal spectrum. For this it is sufficient to calculate x, giving to $\frac{I_1}{I}$ a constant value for all the different points of the spectrum, and employing for each point the corresponding coefficient of absorption. We may thus obtain as many points as we wish of the curve which corresponds to any intensity whatever, and construct by equidistant sections or by curves what may be called the surface of chromatic absorption in any given medium. Such researches cannot be made with an ordinary spectroscope, but a "photometer-analyser" must be applied, that is to say, an instrument by which the different simple radiations which form part of a complex radiation may be measured photometrically. If the principle of the photometer-analyser is once known, nothing is easier than to imagine for such an instrument very different arrangements which may almost equally well answer the end in view. It is sufficient to imagine a kind of spectroscope, the slit of which is divided into two parts longitudinally, and receives different radiations upon each half. If i is requisite to study absorption we leave one half of the slit free, and place before the other half a stratum of known thickness of the absorbent medium we wish to examine. The light coming from the two halves of the slit is decomposed by a prism into two spectra, which are in juxtaposition for their entire length, and one of which only has been modified by absorption. If we then endeavour to equalise these two spectra successively (by modifications of the slit, by polarising apparatus, or otherwise), at a very large number of points corresponding to determined wave-lengths, we obtain the measure of the intensity of the different radiations absorbed. When these intensities are once obtained we may deduce from them directly the coefficients of absorption corresponding to each radiation, and the form of the surface of chromatic absorption in the body which is under examination. If we have some coefficients of absorption of a substance dissolved in known quantity in a medium either non-absorbent, or having an absorbing power feeble and already measured, it is easy to determine the quantity of this same substance in another solution. It is merely requisite to take a stratum of the solution of known depth, and place it before the slit of the analytic photometer, measuring then the intensity of the radiations transmitted to know at once to what depth of the normal solution the same intensities would correspond, and consequently what is the quantity of the absorbent matter contained in the solution to be determined. Spectral analysis thus becomes a true method of quantitative analysis, and its applications are at once greatly extended. It must not be forgotten that this new method of analysis requires that we should be able to study all the radiations emitted or transmitted by different bodies. If we wish to confine ourselves to the study of the visible radiations, the utility of the method would be greatly reduced. But we substitute for the eye another organ, such as, *e.g.*, a thermo-electric battery, immediately substances which appear to absorb nothing in the luminous spectrum may manifest their presence in the ultra-red portion of the spectrum, and the means to determine their quantity is presented. A solution of aluminic sulphate is a case in point, and by the aid of the galvanometer the proportion of the salt contained in different solutions may be determined. The same will happen with the ultra-violet radiations, the intensity of which may be measured by the eye, by the aid of uranium glass, or of sulphate of quinine. If it is true, as a large number of observations appear to demonstrate sufficiently, that the luminous spectral lines of incandescent gases, or the dark lines which the same gases may determine by absorption in continuous spectra, are merely isolated and more intense summits of spectral curves of emission or absorption, quite similar to the curves of shade which absorbent solids and liquids produce, and if it is true that these lines may multiply and especially increase in breadth and intensity the condensation and the elevation of temperature of the bodies whence they spring, we comprehend that the determination of the luminous intensity at different points of a spectrum may serve to recognise the temperature and the density of the substance which emits or absorbs them, that is to say, to determine its quantity in a limited portion of space, provided that we have beforehand established the relation which connects the nature of the radiations emitted with the density and the temperature of the body under examination. Thus, then, by assimilating the phenomena of the emission- and absorption-spectra of gaseous bodies to those presented by the absorption-spectra of solids and liquids it does not appear impossible that we may succeed in obtaining quantitative analyses of bodies examined, even when such bodies escape ordinary methods of observation by reason of their tenuity or their remoteness. The "photometer-analyser" may still render other services to science. By applying it in the quantitative and qualitative analysis of the colours proper to different bodies we may hope to place the classification of colours upon an absolutely accurate basis.

THE CHEMICAL NEWS.

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DISCOVERERS AND ?

"Sic vos non vobis mellificatis apes."

It has more than once fallen to our lot to vindicate the claims of original discoverers in the pages of this journal. It sometimes happens that the same discovery is made by two men quite independently of each other. In such cases, although both may deserve equal credit, he who can prove priority of publication is acknowledged to be entitled to the honour attending the discovery.

It also sometimes happens that a discoverer, after his results have been not only published, but fully discussed in the scientific journals, finds them re-discovered, and laid before some illustrious society as an entire novelty, without the slightest reference to his labours. We have even known the "conveyer," as in the case of thallium, to accuse the original discoverer of appropriation.

It is not many years since we drew the attention of our readers to the fact of the well-known process of Parkes for the volumetric determination of copper being claimed by M. de la Follye as an improvement of his own upon the sulphide of sodium process of Pelouze, and, strange to relate, Pelouze himself actually described it as such in a memoir read before the Academy of Sciences. So far as we know—we shall be glad to be corrected if we are wrong—this claim has never been withdrawn, notwithstanding the indignant protests of German as well as English chemists. Now it is not to be expected that one man will surrender his claim until priority of discovery has been clearly established by another; but let this once be done, and he who desires to act honourably will at once concede to his rival the honour due to him. To act otherwise is dishonourable in the highest degree; nor is it, in our opinion, less dishonourable for one scientific man to endeavour to injure, or detract from, the reputation of another. We can understand feelings of national pride, and jealousy of national interests, leading men to leave no stone unturned in their endeavour to claim priority of discovery for a fellow-countryman, but we utterly fail to comprehend the motive which prompts a man to shift the credit of a discovery or an invention from a fellow-countryman to a foreigner. At the risk of being accused of obtrusiveness and egotism we feel bound to ask if this has not been the course pursued by Prof. Osborne Reynolds in his several notices of the Radiometer at the Manchester Literary and Philosophical Society. Prof. Osborne Reynolds we have always regarded as a man of singular ability, a physicist who, by earnest study and close application, has attained to an honourable position in the scientific world. His opinion on subjects connected with mechanical and physical science deservedly commands attention, and it is because we entertain these views of his scientific attainments that we think it necessary to point out what would seem to be a studied injustice unworthy of his present position.

The facts of the case are simple. In December, 1873, the first part of a paper "On Attraction and Repulsion Resulting from Radiation" was read before the Royal Society. The experiments therein described led to the construction of an instrument, which is now well known as Crookes's Radiometer, which was first exhibited at the *Soirée* of the Royal Society on the 7th April, 1875. In December, 1875, our attention was directed to an advertisement in *Nature*, in which Mr. Browning announced that he had been appointed sole agent for a new Radiometer made by Herr Geissler. We at once called on Mr. Browning, and he saw that the advertisement gave undue credit to Herr Geissler, and readily made the necessary alteration.

In January, 1876, it was announced by the Secretaries of the Manchester Literary and Philosophical Society (Prof. Osborne Reynolds and Mr. Baxendell) that at the next meeting Prof. Osborne Reynolds would exhibit and explain Crookes's Radiometer. In the report of the meeting on the 25th January, however, the instrument is described as "Geissler's light-mill." On the 17th February it is announced by circular that at a meeting of the Society on the 22nd inst. Prof. Reynolds will show some further illustrations with reference to the action of "Geissler's light-mills."

Any person unacquainted with the circumstances might infer from the above programme that the "light-mill" was a new and independent discovery of Herr Geissler; yet all the time it is simply the radiometer which has been exhibited before the Royal Society and the Royal Institution. Herr Geissler certainly makes radiometers so as to bear transportation, according to a suggestion given him by the inventor through Prof. Zöllner. The latter distinguished physicist, in an autograph letter, declares—"As regards the name of the instrument, 'Crookes's Radiometer' is the only suitable appellation, expressing at once the merit of the discoverer and the nature of the matter." It is no disparagement to the unimpeachable skill of Herr Geissler to say that the instrument should bear the name of its inventor rather than of its maker.

It is, to say the least, an unfortunate coincidence that the gentleman who has thought fit to employ this novel nomenclature has, with reference to the discovery in question, scarcely shown the candour and courtesy usual in physical and chemical discussions. After the reading of the first paper at the Royal Society Prof. Osborne Reynolds, in a letter to the editor of *Nature*, and in a paper which was read before the Royal Society on June 18, 1875, gave it as his opinion that the results we had obtained were in part due to evaporation and condensation, and that they afforded a direct proof of the truth of the kinetic theory of gases. Both in a letter to *Nature*, and in a lecture delivered before the Physical Society on the 20th of June, we brought forward what we conceived to be reasonable arguments against this supposed explanation. We stated that our impression was that the repulsion caused by radiation was directly due to impact upon the surface of the moving mass, and not secondarily through the intervention of air currents, electricity, or evaporation and condensation, but that we did not wish to insist upon any theory of our own, our object being to ascertain facts, varying the conditions of each experiment, so as to find out what are the necessary and what the accidental accompaniments of the phenomena. By working steadily in this manner, letting each group of experiments point out the direction for the next group, and following up as closely as possible, not only the main line of research, but also the little bye-lanes which often lead to the most valuable results, after a time the facts will group themselves together and tell their own tale. The conditions under which the phenomena invariably occur will give the laws, and the theory will follow without much difficulty.

At the meeting of the British Association in August last, Prof. Reynolds said* "he thought that some energy was given to the moving body which enabled it to propel itself. He did not desire to throw any slight upon the work of Mr. Crookes, *but the latter should not produce facts to subvert preconceived notions of the nature of things*, and deprecate explanations being given in accordance with principles previously well established."

Whether or not in what we have stated above we can fairly be charged with deprecating *explanations* given in accordance with principles previously well established, we leave to the judgment of our readers.

Since our earlier researches we have vastly improved the apparatus, and carried out numerous experiments, the results of which are embodied in three subsequent papers

* *Bristol Daily Post*, September 1, 1875.

54

Repulsion Resulting from Radiation.—W. Crookes.—Presented by M. Th. du Moncel.—For several years I have been pursuing my researches on the repulsive force resulting from radiation transmitted through rarefied gases. The apparatus I used consisted of a torsion balance, in which the beam for carrying the experimental disks is a straw suspended by a very fine glass fibre. Six disks, each differing from each other, are suspended from one end of this beam, and they are balanced at the other end by a suitable counterpoise. A standard candle, placed at a fixed distance from the balance, supplied the radiation, and the displacements produced by this radiation were increased on a graduated scale by a ray of light reflected from a mirror. A screen was so arranged that the light might fall on any disk selected for experiment without the others being affected. Finally, a standard lampblacked disk was placed in the apparatus in order that the results might be compared. All the apparatus was carefully sealed and attached to a mercury pump capable of carrying the exhaustion to any desired point. My experiments have extended over one hundred different substances, and I have measured the effect produced by them, not only under the influence of simple radiation from a luminous source, but also by removing the invisible heat rays by the interposition of a water screen. In this manner I found that each substance exercises a more or less distinct action on the absorption of rays. Thus most white powders powerfully absorb the invisible heat rays, while they are almost without action on the luminous rays.

On the contrary, the black powders powerfully absorb the luminous rays and only slightly absorb the obscure heat rays whatever their intensity may be. The different metals present great differences in their action. Iron, for instance, chiefly absorbs the invisible heat rays, while gold is principally acted on by the luminous rays. The substances I have experimented with may be divided into two classes: 1st. Those whose action is increased by the interposition of water screens with regard to the effect produced on the standard disk; 2nd. Those in which the contrary is the case. Amongst the former may be mentioned copper tungstate, saffranin, precipitated selenium, and copper oxalate; these are more affected by light than by invisible heat. Amongst class 2 may be mentioned chromic oxide, persulphocyanogen, zinc oxide, barium sulphate, and calcium carbonate; these are acted upon more by the ultra-red rays than by the luminous rays. Remarkable effects may be obtained by combining the substances in these two categories on the disk of the radiometer. Thus, if we alternately coat these disks, which we will suppose to be made of pith, with chromic oxide and precipitated selenium, the radiometer will be seen to turn in one direction when it is exposed to the light of a candle, and the contrary way when a water screen is interposed before the luminous source. A similar radiometer, the vanes of which are coated with saffranin and hydrated zinc oxide, does not move at all when it is directly exposed to the flame of a candle, but will be set in motion as soon as a water screen is interposed. In a note which I have had the honour of presenting to the Academy of Sciences I have shown that when the exhaustion of a radiometer is carried beyond a certain limit its sensibility gradually diminishes until it became absolutely null. I have entered more deeply into this question, and have come to the conclusion: 1st. That there is a gradual increase in the sensitiveness of the radiometer until the pressure has attained 50 millionths of an atmosphere (0·038 millim.); 2nd. That beyond this limit to 30 millionths of an atmosphere (0·013 millim.) it remains stationary; 3rd. Further still, it sinks rapidly until at 1 millionth (0·00076 millim.); 4th. That at 0·2 millionth of an atmosphere (0·00015 millim.) the radiometer refuses to turn even when five candles are put near it. To examine the effects of molecular pressure produced directly by heat upon a radiometer I arranged, besides the system of vanes suspended horizontally, a ring of platinum which could be rendered incandescent by an electric current. The vanes were of transparent mica, and were inclined to each other like the sails of a windmill, and above these vanes was a mica disk, which turned on a separate pivot. The normal direction of this disk was naturally inverse to that of the system of vanes. The following are the results I obtained:—(1.) When the apparatus is full of air at the normal pressure of 760 m.m., and the platinum ring was incandescent, the direction of the rotation of the vanes and disk was *positive*, that is to say, that which would be produced by a current of air coming from the platinum ring: this effect must be attributed to the ascending current of hot air. (2.) At a pressure of 80 millims. the disk did not turn. The vanes turned slowly in the positive direction. (3.) At 19 millims. no movement was produced either by the disk or by the vanes. (4.) At 14 millims. the disk remained stationary, but the vanes began to turn gently in the negative direction, that is to say, in a way inverse to their first direction. (5.) At 1 millim. the disk turned in a continuous manner in the positive direction, whilst the vanes turned rather fast in a negative direction. (6.) At 0·224 millim. the speed of the disk or the vanes was the same, and their rotative movement was the same. Below the pressure the speed of the rotation of the vanes diminished gradually, whilst the speed of the disk increased, and at a pressure of 0·107 millim. the disk turned rapidly in the positive direction, whilst the vanes were motionless. (7.) With a more perfect exhaustion still, at 0·098 millim. a sudden change was seen. The vanes which had been

stationary then began to turn in the positive direction at a speed of 100 revolutions per minute, whilst the disks turned as before, positively, but with less speed. It is probable that the speed of this disk was diminished in consequence of the rapid movement of the vanes in the opposite direction.* (8.) When the exhaustion was carried beyond 0·098 millim. the speed of the two disks and of the vanes increased till it exceeded 600 revolutions per minute, and it did not seem to diminish with the highest rarefaction, which was at 0·0001 millim. According to the most recent determinations the number of molecules contained in a cubic centimetre of air at the ordinary pressure is probably something like 1,000,000,000,000,000,000,000 (one thousand trillions); consequently, at an exhaustion of 0·0001 millim., 100,000,000,000,000 are still left. This number is sufficiently large to justify the hypothesis—That when the molecules are set in vibration by a white-hot platinum wire they are still capable of exercising an enormous mechanical effect.

Comptes Rendus Hebdomadaires des Seances de l'Academie des Sciences, tome lxxxi., No. 2, July 12, 1875.

Magneto-Chemical Phenomena Produced in a Medium of Rarefied Gases in Geissler's Tubes Illuminated by means of Induction Currents.—M. J. Chautard.—(Third part.) In all the simple bodies of the chlorine group, and in all their derivative compounds, gaseous or volatile, which have been examined, the action of the magnet is instantaneous, and is shown—not merely by a change in the tint of the tube—but, above all, by a more complete illumination of the rays which display a wonderful brilliancy, and are sometimes split up. The wave lengths of each ray will form the subject of a future communication. The substances examined, beside chlorine, bromine, and iodine, are the chloride, bromide, and fluoride of silicium, the fluoride of boron, hydrochloric acid, antimony chloride, bismuth chloride, mercurous chloride, and stannous and stannic chlorides. The lights of sulphur and of selenium are completely extinguished in the moment when the magnet is set in action, and it is the same with that of tubes of chlorine, bromine, and iodine if the strength of the coil is suitable. The lustre of the light of oxygen, always pale, undergoes no very sensible change. It is the same with the compounds of carbon, such as carbonic acid and oxide, proto- and bi-carbide of hydrogen. The fine bands of the nitrogen spectrum are merely modified in the red and orange portion. These colours are almost entirely extinguished, or, at least, are replaced by a very uniform tint, in which there is no trace of "chanelling." The bands of the more refrangible portion remain unaltered. The rays of hydrogen preserve the same appearance; yet, on employing an electro-magnet of sufficient strength, we see appear at the moment when it is set in action a very brilliant yellow ray, which is merely that of sodium derived from the glass. This ray vanishes as soon as the circuit is broken, and reappears if the magnetisation is resumed. Protochloride of tin, dry and crystalline, but bihydrated, presents a most remarkable phenomenon of dissociation under the influence of the magnet. In its normal state the spectrum is pale, and presents some of the green rays of chlorine; but as the magnet is set in action we see two of the characteristic rays of hydrogen, the red and the blue, which remain as long as the magnetisation lasts, and disappears when it ceases.

55

In connection with the recent rapid progress in electric lighting it is interesting to recall the fact that Otto Von Guericke (1602-1688), burgomaster of Magdeburg, and inventor of the air-pump, was the first who produced light by electricity. He did so by simply pressing his hands against a globe of sulphur, which was set in rapid rotation about one of its diameters. The effect he describes as being similar to the glow of sugar when bruised in the dark. The spark was obtained more distinctly a short time afterwards by Dr. Wall, by rubbing a piece of amber with a woollen cloth. He, with others, believed that in such cases the light was the cause of the electric state. The advance from these germinal observations to the electric light as now used—*e.g.*, in our lighthouses—is remarkable.

REPULSION RESULTING FROM RADIATION.

78

By W. Crookes.

[Presented to the French Academy by M. Th. du Moncel.]

For several years I have been pursuing my researches on the repulsive force resulting from radiation transmitted through rarefied gases. The apparatus I used consisted of a torsion balance, in which the beam for carrying the experimental disks is a straw suspended by a very fine glass fiber. Six disks, each differing from each other, are suspended from one end of this beam, and they are balanced at the other end by a suitable counterpoise. A standard candle, placed at a fixed distance from the balance, supplied the radiation, and the displacements produced by this radiation were increased on a graduated scale by a ray of light reflected from a mirror. A screen was so arranged that the light might fall on any disk selected for experiment without the others being affected. Finally, a standard lampblacked disk was placed in the apparatus in order that the results might be compared. All the apparatus was carefully sealed and attached to a mercury pump capable of carrying the exhaustion to any desired point. My experiments have extended over one hundred different substances, and I have measured the effect produced by them, not only under the influence of simple radiation from a luminous source, but also by removing the invisible heat rays by the interposition of a water-screen. In this manner I found that each substance exercises a more or less distinct action on the absorption of rays. Thus most white powders powerfully absorb the invisible heat rays, while they are almost without action on the luminous rays. On the contrary, the black powders powerfully absorb the luminous rays and only slightly absorb the obscure heat rays, whatever their intensity may be. The different metals present great differences in their action. Iron, for instance, chiefly absorbs the invisible heat rays, while gold is principally acted on by the luminous rays. The substances I have experimented with may be divided into two classes: 1st. Those whose action is increased by the interposition of water-screens with regard to the effect produced on the standard disk; 2d. Those in which the contrary is the case. Among the former may be mentioned copper tungstate, saffranin, precipitated selenium, and copper oxalate; these are more affected by light than by invisible heat. Among class 2 may be mentioned chromic oxide, persulphocyanogen, zinc oxide, barium sulphate, and calcium carbonate; these are acted upon more by the ultra-red rays than by the luminous rays. Remarkable effects may be obtained by combining the substances in these two categories on the disk of the radiometer. Thus, if we alternately coat these disks, which we will suppose to be made of pith, with chromic oxide and precipitated selenium, the radiometer will be seen to turn in one direction when it is exposed to the light of a candle, and the contrary way when a water screen is interposed before the luminous source. A similar radiometer, the vanes of which are coated with saffranin and hydrated zinc oxide, does not move at all when it is directly exposed to the flame of a candle, but will be set in motion as soon as a water-screen is interposed. In a note which I have had the honor of presenting to the Academy of Sciences, I have shown that when the exhaustion of a radiometer is carried beyond a certain limit its sensibility gradually diminishes until it becomes absolutely null. I have entered more deeply into this question, and have come to the conclusion: 1st. That there is a gradual increase in the sensitiveness of the radiometer until the pressure has attained 50 millionths of an atmosphere (0·038 millim.); 2d. That beyond this limit to 30 millionths of an atmosphere (0·013 millim.) it remains stationary; 3d. Further still, it sinks rapidly until at 1 millionth (0·00076 millim.); 4th. That at 0·2 millionth of an atmosphere (0·00015 millim.) the radiometer refuses to turn even when five candles are put near it. To examine the effects of molecular pressure produced directly by heat upon a radiometer I arranged, besides the system of vanes suspended horizontally, a ring of platinum which could be rendered incandescent by an electric current. The vanes were of transparent mica, and were inclined to each other like the sails of a windmill, and above these vanes was a mica disk, which turned on a separate pivot. The normal direction of this disk was naturally inverse to that of the system of vanes. The following are the results I obtained: (1.) When the apparatus is full of air at the normal pressure of 760 m.m., and the platinum ring was incandescent, the direction of the rotation of the vanes and disk was *positive*, that is to say, that which would be produced by a current of air coming from the platinum ring: this effect must be attributed to the ascending current of hot air. (2.) At a pressure of 80 millims. the disk did not turn. The vanes turned slowly in the positive direction. (3.) At 19 millims. no movement was produced either by the disk or by the vanes. (4.) At 14 millims. the disk remained stationary, but the vanes began to turn gently in the negative direction, that is to say, in a way inverse to their first direction. (5.) At 1 millim. the disk turned in a continuous manner in the positive direction, while the vanes turned rather fast in a negative direction. (6.) At 0·224 millim. the speed of the disk or the vanes was the same, and their rotative movement was the same. 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According to the most recent determinations the number of molecules contained in a cubic centimeter of air at the ordinary pressure is probably something like 1,000,000,000,000,000,000,000 (one thousand trillions); consequently, at an exhaustion of 0·0001 millim., 100,000,000,000,000 are still left. This number is sufficiently large to justify the hypothesis that when the molecules are set in vibration by a white-hot platinum wire they are still capable of exercising an enormous mechanical effect.

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BOSTON, MAY 1, 1876. Obcr

A NEW MOTIVE POWER.

THE mechanical action of the radiation of light and heat, although noticed by several observers during the past half-century, has not until recently been made the subject of careful study and experiment. To Dr. William Crookes, of London, the distinguished chemist, belongs the honor of first [illegible]ting by delicate mechanical contr[illegible]ces [illegible]istence of a power in radiant light [illegible] opens up new fields for thought and investigation. This discovery and the experiments of Dr. Crookes have produced an amount of interest in the world of science but little [illegible] awakened by the splendid researche[illegible] and Kirchhoff, w[illegible] spectroscop[illegible]08. The experiments [illegible] Crookes beg[illegible] three years ago, and the first paper upon [illegible] subject w[illegible]ted to the Royal Society in May, 1873, but it was not until 1875 that the new-found fact, the mechanical effect of radiation in a vacuum, was announced to the world.

The researches of Dr. Crookes are regarded as so new and wonderful that the President of the Mathe[illegible]ical and Physical Section of the British Association last summer stated that "they were among the most interesting in the whole range of physical science." He claims to [illegible] proved that there is exerted by the sun's rays a direct mechanical action; that when light bodies are delicately poised in a vacuum under [illegible] adjustments, they are moved or *repelled* [illegible] of light, natural or artificial. This [illegible] to be indep[illegible] elec-[illegible]ir, and [illegible] radiant [illegible] appa[illegible] invented by Dr. [illegible] establish this view has been quite [illegible] produced in this country, and Profes-[illegible] pe[illegible]rimen[illegible] with the "radiome[illegible] the results of which are presented i[illegible] interes[illegible]ticle published in the *Ad[illegible]ser*, of [illegible] April 3d. The radiometer [illegible] described by Dr. Crookes has been made in this country, so far as we know, only by Mr. Demuth, of Cambridge, a very skilful glass-blower. After Mr. Demuth succeeded in making the delicate little instrument, and had produced a dozen or two which have been widely distributed, he was taken sick of pneumonia, and died. [illegible] undoubtedly he would have succeeded in making instruments much more perfect than any of those now in the hands of experimenters. Mr. Demuth's radiometer consists of a little wheel, which revolves inside of a glass bulb from which the [illegible] been exhausted. When placed in the sunlight, or near a gas-light or candle, the little arms, to which are [illegible] thin disks of mica, having one surface blackened, revolve with great rapidity upon the delicate needle-point forming the axis on which they are poised.

Professor Cooke differs from Dr. Crookes in his interpretation of the cause of the movements produced, and attributes them to molecular action in the attenuated atmosphere within the bulb. In his view it is the action of heat rather than of light, and in this he is sustained by the views of Professor Dewar, of Scotland, Herr Neesen, of Germany and several other experimenters of note. Professor Cooke's paper, to which allusion has been made, is exceedingly interesting, and we regret that we have not space to copy it entire.

From some perhaps imperfect experiments with the radiometer, we are led to conclude that the movements occur only under the combined action of light and heat. We do not find that dark heat, like that from st[illegible] or hot air, produces the rep[illegible] or movements in a vacuum near perfection. Neither does light, when the calorific rays are cut off. Dr. Crookes's apparatus is undoubtedly much more perfect and sensitive than any which has been produced here. If it were possible to obtain an absolute vacuum inside the radiometer bulb, the difference of views among scientific men as regards the cause of the motion could be settled at once. If Professor Cooke's views are correct, the disk would be motionless; if, on the other hand, the motion is due to light-energy alone, the movements would increase in velocity, and the discoverer's views would be sustained. Professor Dewar's vacuum, like that obtained by Dr. Crookes, was nearly perfect,—so perfect as to [illegible] passage of the induction spark. After the pump refused to reduce the tension of the gas, the residue was removed, and the vacuum further perfected by the absorbent power of charcoal. But all this care and labor fell short of producing a *perfect* vacuum, and w[illegible] this the decisive experiment cannot be [illegible]. The results thus far of Dr. Crookes's patient labor, ingenuity, and scientific skill are worthy of the abundant applause he has received. The medal of the Royal Society was bestowed for the discovery, the highest honor which the most learned body in England can confer.

It is a curious circumstance that this honor is conferred upon one who a short time ago presented papers to the Royal Society describing important experiments and discoveries in another class of phenomena, which were refused reception and even examination by the *savants*. Dr. Crookes devoted *three years* of careful study and experiment to the class of phenomena called "Spiritual," and he brought to the labor the same indefatigable perseverance, the same skill in devising mechanical appliances, the same scientific learning, the same clear, cool, analytical powers of mind, displayed in his researches upon the mechanical action of light, but his labors were ridiculed and rejected without examination. We have carefully read Dr. Crookes's papers upon the "psychic force," or "spiritualism," or whatever the class of phenomena may be called, which have appeared in the London *Quarterly Journal of Science*, and we unhesitatingly say that in our view they do not rightfully belong to the class of "rejected papers" to which they

June 76 Obcr

whole of it in the form of carbonate, it is perfectly useless for them to think that that paint can possess a covering power to be compared with that of a genuine article.

ANNUAL CONVERSAZIONE OF THE ROYAL SOCIETY, LONDON.

THE recent Conversazione of the Royal Society, held at Burlington House, well kept up the high character of the now long series of receptions which the Royal Society has given to its friends. The libraries were literally filled with objects of high scientific interest, and the period of three hours, during which the conversazione lasted, were all too short for the study which they deserved, especially as on such occasions that study must necessarily be so largely interrupted by friendly greetings and conversation.

RADIOMETERS.

Mr. Crookes, F.R.S., occupying his usual corner of the librarian's room, exhibited a splendid collection of radiometers and specimens of his new modification of them, to which he has given the name of the Otheoscope, or propulsion indicator. This instrument differs from the radiometer in the fact that the propelling power is caused by the radiation from blackened stationary disks or vanes fixed at a suitable angle in the neighborhood of the movable fly and within the exhausted envelope. The vanes of the fly, unlike those of the radiometer, are alike on both sides, and the action is precisely like what it would be if the fixed vanes were emitting jets of air and blowing the fly round after the manner either of a Robinson's anemometer or of a smoke-jack. In one of these instruments a four-armed fly with vanes made of mica rendered opaque by roasting is supported on a central pivot like the fly of a radiometer, and within the glass envelope rigidly attached to its sides are three vertical plates of clear mica set at an angle somewhat oblique to the axis. When a candle is approached the molecular disturbance caused by radiation from the oblique plates impinge on the fly and causes it to rotate. In another form a horizontal disk of roasted mica is balanced at its center on a vertical point, and below it is a fixed circle of inclined aluminum vanes of the form of the wheel of a smoke-jack. Upon approaching a candle to this instrument the upper disk moves with great velocity, being driven by the molecular forces caused by radiation acting obliquely to the under surface of the upper disk. Mr. Crookes also showed an instrument which is the converse of the last. In this case the fly is composed of inclined planes of aluminum similar to the fixed vanes in the instrument last described, and below it is fixed a blackened disk of mica. When a source of radiation is approached molecular disturbance takes place due to the radiation from this disk, but as the angles of incidence of the vanes of the fly are inclined to the direction of this molecular disturbance, motion is given to the fly and it rotates at great speed.

Of radiometers Mr. Crookes showed some very interesting specimens, illustrating very remarkably the theory of the radiometer propounded by Dr. Johnstone Stoney. In one example a radiometer of the usual construction, that is to say, having its vanes blackened on one side only, has attached at a short distance from and parallel to the black surface of each vane a large disk of clear mica. When a candle is brought near this radiometer the fly rotates in the abnormal direction, that is to say, with its black surfaces toward the light. This reversal of motion is caused by the reflection, [fr]om the clear mica plates, of the molecular disturbance set [u]p by radiation from the black surface. In corroboration of [th]is hypothesis Mr. Crookes showed another instrument in [w]hich each vane carried two large disks, one on each side. [I]n this case the molecular disturbance, prevented from being [re]flected backwards by the second equal-sized disk, can only [es]cape in planes symmetrical with the diameters of the fly, [an]d consequently no motion is produced on the approach of [a] lamp.

In another new form of experimental radiometer the vanes [o]f the fly are of aluminum, bright on both sides and cup-[sh]aped, similar to those in Dr. Robinson's anemometer, but [no]t so deep. Unlike the anemometer, however, the vanes [ro]tate with the concave surface forward. The radiation [fr]om a standard candle placed 3¼ in. from this instrument, [an]d falling equally on both convex and concave surfaces, [ca]used the vanes to rotate at a speed of about 18 revolutions [p]er minute. When a screen was placed between the candle [an]d the instrument in such a position as to allow it to shine [o]nly on the convex surfaces, the vanes rotated in the same [d]irection as before, but at the reduced speed of 8 revolutions [p]er minute; the screen was then shifted so as to screen the [c]onvex surfaces, allowing the radiation to fall only on the [c]oncave surface, the rotation continued as before, but at a [s]peed of 8¼ revolutions per minute. Mr. Crookes arranged [t]his experiment to show that the repelling influence of radiation on the convex surface is about equal to its attracting influence on the concave surface, and that the double velocity at which the vanes move when both surfaces are exposed to the radiating force is the result of the sum of these two influences. As a sequel to this experiment, Mr. Crookes showed an interesting pair of radiometers similar in construction to that last described, but having in one instrument the concave surface blackened, and in the other the convex. In the former the usual action of radiation is reversed, the bright convex surface being repelled and the black concave surface attracted. In the latter, as might be expected from a consideration of the two experiments, the rotation was in the usual direction and very rapid. In the former the two conditions of the vanes, viz., the curvature of surface and the blackening of one side, are acting against one another, the surface form having the large influence; and in the latter the two conditions by which the vanes are rendered sensitive to the mechanical influence of radiation or acting together, and the speed is consequently increased.

All these instruments are marvels of constructive skill, and have been made by Mr. C. H. Gimingham, who has been associated with Mr. Crookes in this research from the first. Two instruments especially ought to be mentioned as examples of extraordinary delicacy of manipulation. One was an eight-armed radiometer rotating at a great velocity upon a horizontal axis, which was supported by two glass cups so delicately adjusted by fusion of their glass supports as to nip the fine needle-points of the horizontal spindle, so as to prevent the latter dropping from its central position, and yet so free from friction that the light of a single candle caused it to "run away." The other instrument consisted, first, of a radiometer having four large rectangular vanes; each of these vanes carried above it a secondary, tiny four-armed radiometer, which consequently had a sort of "lunar" motion, rotating on its own pivot, which in its turn was carried round by the larger radiometer. Above the central fly was again

58

Boston Journal of Chemistry.

ELECTRIC DISCHARGE IN TUBES CONTAINING RAREFIED GASES.

July 78

By MM. Warren de la Rue and Hugo W. Müller.

The discharge in a tube of rarefied gas does not differ from that which takes place in air or other gases at the atmospheric pressure. It is not a current in the ordinary sense of the term, but a disruptive discharge, the gaseous molecules effecting a transport of electrization. The gases probably receive two impulsions in opposite directions, that from the negative electrode being the more continuous. There are sometimes formed metallic spots upon the tubes, which leave a permanent trace of the intervals comprised between the strata.

59

ELECTRIC DISCHARGE IN GASES[1]

II.

The form of point most favourable to the production of the arc has been minutely investigated by the authors. By turning wires in a lathe to various outlines they arrived experimentally at the best point; this was then placed under the microscope and drawn by means of the camera lucida; from the study of the drawing it was ascertained that the longest spark was procured when the point assumed a form resembling a paraboloid; the curved out

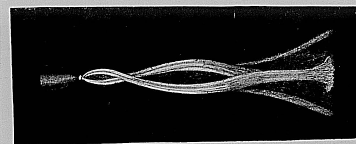

Fig. 8.—"Streamers."

line, which corresponded to that found experimentally, was one in which each succeeding ordinate was in the ratio of the square root of the odd numbers 1, 3, 5, &c., the sectional areas being consequently in the ratio of the odd numbers.

The curves in the diagram (p. 528) show the distances at which, with a given potential, the arc is formed between such a point and a disc, and between two such points respectively. The results recorded in the case of the point and disc are those obtained by electrifying the point to the sign (positive or negative) which gave the greatest length; for it was found that with low potentials the distance at

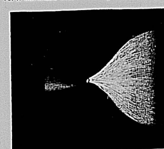

Fig. 9.—"Glow."

which the arc forms is greater when the point is *negative*, that between 3,000 and 5,000 volts it is the same whether the point be positive or negative, but that with potentials higher than 5,000 volts it is greater when the point is *positive*.

The actual formation of the arc, when a point and disc or two points are employed as terminals, is preceded by a luminous discharge (streamers and glow), presenting phenomena of an interesting character; an extremely minute quantity of electricity passes as compared to that

Fig. 10.—"Streamers and Glow."

when the arc is formed, but still it is sufficient when

[1] Continued from p. 528.

60

Geissler's Tubes.

THE tubes manufactured by Geissler in Bonn, Germany, for showing the flow of electricity in rarefied air, gases, and vapors, have lately obtained a regular foothold in all collections of philosophical apparatus and the experimental lectures in physics. They consist simply of tubes of thin glass of various forms, sealed at the ends, and perforated there with platinum wires, soldered in the glass. There is no metal better adapted for this purpose, because its expansion by heat is very nearly equal to that of glass, so that in heating and cooling there is no unequal expansion and contraction, and therefore the main cause of the cracking of the glass in the process of manufacturing the tubes is avoided.

Fig. 1 represents three different forms of these tubes;

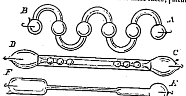

Fig. 1.—Geissler's Tubes.

E F is the most common. In this form the glass is contracted in the middle, so as to compel the electrical discharge to pass through a narrow space and thus be concentrated or condensed to a very luminous narrow line, especially adapted for observation by the spectroscope. C D is a more complex arrangement, in which small perforated globes of uranium glass have been inserted into the tube; this glass becomes very florescent by the electrical discharge, and adds greatly to the beauty of the luminous phenomenon. A B is still another form, in which a series of glass globes are connected by means of semi-circular tubes, which gives a very pretty appearance to the luminous electric current. The figures show plainly the platinum wires at the extremities, and it is only necessary to connect the projecting ends of one of these wires with a source of electricity and the other with the ground, to observe the brilliant phenomena referred to.

The pressure of the air, gas, or vapor in these tubes is very small, not exceeding one-fiftieth of an inch, and this is obtained by first exhausting the air with a good air-pump, then admitting the gas or vapor, and lastly exhausting again until the required low pressure is obtained. The latter is a very delicate point, because when the exhaustion is insufficient, the electric current receives too much resistance, and does not pass freely enough, while when on the contrary an absolute exhaustion of all gas or vapor is accomplished, the inner space of the tube becomes an absolute non-conductor and absolutely refuses the passage of any electricity, however powerful it may be. In fact, the experiments with these tubes have revealed to us the important and startling truth (referred to in another part of this number) that the vacuum is an absolute non-conductor.

Sometimes the discharge of the electric current through the rarefied gas or vapor, shows cross striæ of different shapes, colors, and lusters, depending upon the nature of the gas, the dimensions of the tube, and the degree of rarefication.

Now when A B, Fig. 1, is filled with rarefied hydrogen gas, the striæ will be white in the bulb and red in the narrow tubes. Carbonic acid will show a greenish stratification; nitrogen, an orange-yellow; while the spectroscope peculiar lines in each gas or vapor characteristic of its nature, and giving the direct means to recognize one from the other. It is also to be remarked that the lines revealed by the spectroscope differ for different temperatures, and that those produced by electric currents coincide with those obtained by the highest possible temperature, very different from the lower degree of heat obtained by a simple flame.

Fig. 2 represents a large set of Geissler tubes attached to a rotating disk. The stand A supports a wooden disk B, revolved by a handle; a string running over its circumference runs also over a small disk—not seen in the figure—and communicates to this and to its axis a very rapid revolving motion. This axis carries the triangular disk to which the tubes are attached, while the electric current passes from one to the other, and at the end is connected with two distinct and mutually isolated parts of the axis, so that while the disk is in rapid rotation the electric current may be as easily passed through the tubes as when the disk is in repose. This communication is made from the stand D F by successive sparks, which intermittent illumination, combined with the rotatory movement, makes this one of the most interesting and showy exhibi-

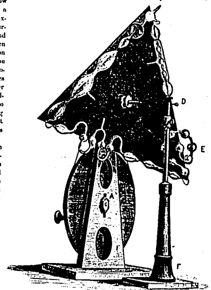

Fig. 2.—Geissler Tubes Attached to a Rotating Disk.

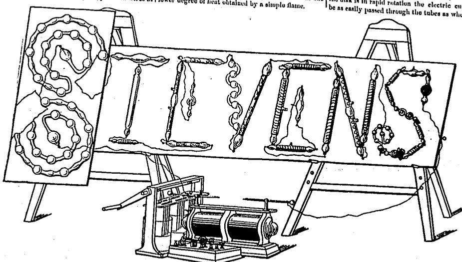

Fig. 3.—Display of Colossal Geissler Tubes, Connected with Ruhmkorf Coil and Battery.

61

…cture-room, and the most bril…
…to of electric experiments.
… of colossal Geissler tubes, ar…
…orton of the Stevens Institute,
…s founder. They are seen con…
…Ruhmkorf coil of that institute
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ON THE THERMAL PHENOMENA PRODUCED BY THE PASSAGE OF ELECTRICITY THROUGH RAREFIED GASES[1] 1878

A PORTION of the experiments described in this paper were made before the publication of Wiedemann's experiments on the same subject. The authors state that if they had known of the work of the German physicist they would probably not have undertaken the investigation, but they have continued the experiments and think them worthy of description as the methods employed differ from those of Wiedemann.

The apparatus used consisted of ordinary Geissler tubes, the electrodes being in wide tubes connected by a narrow one. A large Ruhmkorff's coil with a secondary wire 100,000 metres in length was set in action by two large Bunsen cells, and the current was made and broken by a Foucault's interrupter. In order to measure the induced current a reflecting galvanometer was employed, being placed at such a distance from the coil that the effect of the electro-magnet on the needle was very small; this slight deviation was, however, applied as a correction in all the readings. It was first proved that the current induced on completing the primary circuit was incapable of passing through the Geissler tube, for the galvanometer needle was equally deflected whether placed in the secondary circuit or not, indicating that the movement of the needle was due solely to the direct action of the magnet of the coil; on the contrary, when the primary circuit was broken, a considerable deflection of the needle occurred when the galvanometer was in the secondary circuit, and a slight one, but in the opposite direction, when the needle was influenced by the magnetism of the coil alone.

Tubes containing chlorine, carbonic anhydride, and hydrogen, were employed in the experiments, the electrodes being soldered to the wires from the coil by means of Wood's fusible alloy. The narrow part of the tube was placed in a copper cylinder containing water, or preferably mercury, in which a delicate thermometer was immersed, the deflection of the galvanometer was read every thirty seconds, and the thermometer every minute. When the current indicated by the galvanometer was greatest the increase of temperature was most rapid, but the important fact shown by these experiments is that in every case the rise of temperature divided by the deflection is a constant. Unfortunately the different constants are not comparable, as the experiments were not made with the same tube containing the different gases at known pressures, but with different tubes of nearly the same sizes; but the pressures of the gases are not given.

Some experiments were undertaken to determine the heating effects in the neighbourhood of the electrodes. For this purpose the upper end of a Geissler tube containing chlorine was placed in the calorimeter, the latter surrounding the part of the tube containing the platinum wire. When the electrode was negative about eight times more heat was developed than when it was positive. As the quantity of heat produced when the electrode was positive was very small the relation between the deflection of the galvanometer and the rise of temperature was not so regular in the different experiments as in the other case; and when the electrode was negative it was observed that the quantity of heat increased a little more rapidly than the deflection. More accurate results were obtained by immersing the lower end of the tube in the calorimeter; under these circumstances the quantity of heat collected when the electrode was negative was 22·8 times as great as in the experiments in which it was positive, and while the deflection of the galvanometer varied from 100 to 640, the rise of temperature divided by the deflections increased from 100 to 120 only.

It being suspected that the different effects at the two electrodes might be due to a cause similar to the Peltier effect in solid conductors, an attempt was made to discover if the positive electrode is cooled during the passage of the electricity. There appeared to be a very slight diminution of temperature at the commencement of the experiment, but it was soon marked by the conduction of heat from other parts of the tube.

The calorimeter was next placed on the wide part of the Geissler tube, but not surrounding the electrode, which was 16·5 mm. from the calorimeter. In this case, also, a larger quantity of heat was developed near the negative electrode than near the positive, but the ratio was only 4·9. When a portion of the narrow part of the tube was placed in the calorimeter, that near the negative electrode was slightly more heated than the other portion. When a tube containing hydrogen was used similar results were obtained, but the difference between the quantities of heat at the two ends was very much less than in the case of chlorine.

The next series of experiments was made to determine the effect of different diameters of tube. For this purpose a U-tube containing air of the pressure of two mm. was used, one limb of the tube having a sectional area of 36·3 square mm., the other 12·6 square mm., both limbs being surrounded by calorimeters. The quantity of heat developed in the narrow tube was only very slightly greater than in the other, the ratio being about 1·1. By using another tube with the areas of 116·9 square mm. and 4·5 a similar result was found, but in this case the ratio was not greater than 1·2.

[1] By Dr. Naccari and M. Bellati (vol. iv. ser. v., degli *Atti del R. Instituto veneto de Science, Lettere ed Arti*).

ON THE ILLUMINATION OF LINES OF MOLECULAR PRESSURE, AND THE TRAJECTORY OF MOLECULES.

Jan 29

By WILLIAM CROOKES, F.R.S., V.P.C.S.

Induction Spark through Rarefied Gases. Dark Space round the Negative Pole.

THE author has examined the dark space which appears round the negative pole of an ordinary vacuum tube when the spark from an induction coil is passed through it. He describes many experiments with different kinds of poles, a varying intensity of spark, and different gases, and arrives at the following propositions.

Illumination of Lines of Molecular Pressure.

a. Setting up an intense molecular vibration in a disc of metal by electrical means causes a molecular disturbance to proceed from the surface of the disc to the surrounding gas. When the gas is dense, the disturbance only extends a short distance from the metal, and, as rarefaction proceeds, the layer of molecular disturbance increases in thickness. In air at a pressure of ·078 millimetres this molecular disturbance extends for at least 8 millimetres from the surface of the disc, forming an oblate spheroid round it.

b. The diameter of this dark space varies with the exhaustion; with the kind of gas in which it is produced; with the temperature of the negative pole; and, in a slight degree, with the intensity of the spark. For the same degree of exhaustion it is greatest in hydrogen and least in carbonic acid, as compared with air.

c The shape and size of this dark space do not vary with the distance separating the poles; or, except very slightly, with alteration of battery power; or with intensity of spark. When the power is great the brilliancy of the rest of the tube overpowers the space, and renders it difficult to observe; but, on careful scrutiny, it is seen to be there unchanged in size. With a very faint spark the space is still present, unaltered in dimensions, although scarcely visible; and if the power is still further diminished, it fades out altogether, without change of shape.

The author describes numerous experiments, devised to ascertain if this visible layer of molecular disturbance is identical with the invisible layer of molecular pressure or stress, the investigation of which has occupied him for some years.

The Electrical Radiometer.

One of these experiments is as follows:—An ordinary radiometer is made, with aluminium discs for vanes, each disc having a film of mica close to one side. Instead of a glass cup, the fly is supported by a hard steel cup, and the needle point on which it works is connected by means of a wire with a platinum terminal sealed into the glass. At the top of the radiometer bulb a second terminal is sealed in. The radiometer can therefore be connected with an induction coil, and the moveable fly be made the negative pole.

Passing over the phenomena observed at low exhaustions, it is found that, when connected with the coil, a halo of a velvety violet light forms on the metallic side of the vanes, the mica side remaining dark throughout these experiments. As the pressure diminishes, a dark space is seen to separate the violet halo from the metal. At a pressure of half a millimetre this dark space extends to the glass, and positive rotation commences.

On continuing the exhaustion, the dark space further widens out and appears to flatten itself against the glass, the rotation now being very rapid.

When aluminium cups are used, instead of discs backed with mica, for the vanes of a radiometer, similar appearances are seen. The velvety violet halo forms over each side of the cup. On increasing the exhaustion the dark space widens out, retaining as much as possible the shape of the cup. The bright margin to the dark space becomes concentrated at the concave side of the cup to a luminous focus, and widens out at the convex side. On further exhaustion, the dark space on the convex side touches the glass, when positive rotation commences, becoming very rapid as the dark space further increases in size, and becomes flattened against the glass.

Convergence of Molecular Rays to a Focus.

The subject next investigated is the convergence of the lines of force to a focus, as observed with the aluminium cup. As this could not be investigated when in rapid rotation, an instrument was made, having the cup-shaped negative pole fixed, instead of moveable. On exhausting, the convergence of the lines of force to a focus at the concave side was well observed. When the dark space is very much larger than the cup, it forms an irregular ellipsoid drawn in towards the focal point. Inside the luminous boundary a focus of dark violet light can be seen converging, and as the rays diverge on the other side of the focus they can be seen spreading beyond the margin of the dark space; the whole appearance is strikingly similar to the rays of the sun reflected from a concave mirror through a foggy atmosphere.

Green Phosphorescent Light of Molecular Impact.

At very high exhaustions the dark space becomes so large that it fills the tube. Careful scrutiny still shows the presence of the dark violet focus, and the part of the glass receiving the rays diverging from this focus shows a sharply defined spot of greenish yellow light. On still further exhaustion, and especially if the cup is made positive, the whole bulb becomes beautifully illuminated with greenish yellow phosphorescent light.

This greenish yellow phosphorescence, characteristic of high exhaustions, is frequently spoken of in the paper. It must be remembered, however, that the particular colour is due to the special kind of soft German glass used. Other kinds of glass phosphoresce of a different colour. The phosphorescence only takes place under the influence of the negative pole. At an exhaustion of four millionths of an atmosphere,* no light other than this is seen in the apparatus. At ·9 M the phosphorescence is about at its maximum. When the exhaustion reaches ·15 M the spark has a

* M signifies the millionth of an atmosphere.

difficulty in passing, and the green light only appears occasionally in flashes. At ·06 M the vacuum is almost non-conductive, and a spark can only be forced through by increasing the intensity of the coil, and well insulating the tube and wires leading to it. Beyond that exhaustion nothing has been observed.

Focus of Molecular Force.

In an apparatus specially constructed for observing the position of the focus, the author found that the focal point of the green phosphorescent light was at the centre of curvature, showing that the molecules causing it are projected in a direction normal to the surface of the pole. Before reaching the best exhaustion for the green light, another focus of blue-violet light is observed; this varies in position, getting further from the pole as the exhaustion increases. In the apparatus described, at an exhaustion of 19·3 M these two foci are seen simultaneously, the green being at the centre of curvature, whilst the blue focus is nearly twice the distance off.

Nature of the Green Phosphorescent Light.

The author adduces the following characteristics of the green phosphorescent light, distinguishing it from the ordinary light observed in vacuum-tubes at lower exhaustions:—

a The green focus cannot be seen in the space of the tube, but only where the projection causing it strikes the glass.

b The position of the positive pole in the tube makes scarcely any difference to the direction and intensity of the lines of force which produce the green light. The positive pole may be placed in the tube either at the extremity opposite the negative pole, it may be below it, or by its side.

c The spectrum of the green light is a continuous one, most of the red and the higher blue rays being absent; whilst the spectrum of the light observed in the tube at lower exhaustions is characteristic of the residual gas. No difference can be detected by spectrum examination in the green light, whether the gas whose residue it is has been nitrogen, hydrogen, or carbonic acid.

d The green phosphoresence commences at a different exhaustion in different gases.

e. Viscosity of a gas is almost as persistent a characteristic of individuality as its spectrum appearance. The author refers to a preliminary note and a diagram* of the variation of viscosity of air, hydrogen, and other gases at exhaustions between 240 M and ·1 M. From these and other unpublished results, the author finds that the viscosity of a gas suffers very little diminution between atmospheric pressure and an exhaustion at which the green phosphorescence can be detected. When, however, the spectral and other characteristics of the gas begin to disappear, the viscosity also commences to decline, and at an exhaustion at which the green phosphorescence is most brilliant, the viscosity has rapidly sunk to an insignificant amount.

f. The green phosphorescence will not turn a corner in the slightest degree, but radiates from the negative pole in straight lines, casting strong and sharply defined shadows of anything which happens to be in its path. On the other hand, the ordinary luminous phenomena of vacuum tubes will pass along any amount of curves and angles.

Projection of Molecular Shadows.

The author next proceeds to examine the phenomena of shadows cast by the green light. The best and sharpest shadows are cast by flat discs and not by narrow pointed poles; no green light whatever is seen in the shadow, however thin or whatever substance be the material casting it.

From these and other experiments, fully described in the paper, the author ventures to advance the theory that the induction spark actually illuminates the lines of molecular pressure caused by the electrical excitement of the negative pole. The thickness of the dark space is the measure of the mean length of the path between successive collisions of the molecules. The extra velocity with which the molecules rebound from the excited negative pole keep back the more slowly moving molecules which are advancing towards the pole. The fight occurs at the boundary of the dark space, where the luminous margin bears witness to the energy of the collisions of the molecules.

When the exhaustion is sufficiently high for the mean length of path between successive collisions to be greater than the distance between the fly and the glass, the swiftly moving rebounding molecules spend their force, in part or in whole, on the sides of the vessel, and the production of light is the consequence of this sudden arrest of velocity. The light actually proceeds from the glass, and is caused by fluorescence or phosphorescence on its surface. No light is caused by a mica or quartz screen, and the more fluorescent the material the better the luminosity. The author considers that the greenish yellow light is caused by the direct impact of the molecules on the surface of the glass. The shadows are not optical, but are molecular shadows, only they are revealed by an ordinary illuminating effect. The sharpness of the shadow when projected from a wide pole proves them to be molecular.

Phosphorescence of Thin Films.

An experiment is next described in which a film of uranium glass, sufficiently thin to show colours of thin plates, is placed in front of a thick plate of the same glass; the whole being enclosed in a tube with terminals, and exhausted to a few millionths of an atmosphere. With this apparatus the following observations are recorded:—

a. The uranium film, being next to the negative pole, casts a strong shadow on the plate.

b. On making contact with the coil, the thin film flashes out suddenly all over its surface with a yellowish phosphorescence, which, however, instantly disappears. The uncovered part of the plate does not become phosphorescent quite suddenly, but the phosphorescence is permanent as long as the coil is kept at work.

c. With an excessively faint spark the film remains more luminous than the plate, but on making the spark more intense, the luminosity of the film sinks and that of the uncovered part of the plate increases.

d. If a single intense spark be suddenly sent through the tube, the film becomes very luminous whilst the plate remains dark.

These experiments are conclusive against the phosphorescence being caused by the radiation of phosphorogenic ultra-violet light from a thin layer of arrested molecules at the surface of the glass, for were this the cause, the film could under no circumstances be superior to the plate.

The momentary phosphorescence of the film, and its rapid fading out, prove more than this. The molecular bombardment is too much for the thin film. It responds to it at first, but immediately gets heated by the impacts, and then ceases to be luminous. The plate, however, being thick, stands the hammering without getting hot enough to lose its power of phosphorescing.

* "Proc. Roy. Soc," Nov. 16, 1876, vol. xxv., p. 305.

Mechanical Action of Projected Molecules.

It was noticed that when the coil was first turned on, the thin film was driven back at the moment of becoming phosphorescent, showing that an actual material blow was given by the molecules. Experiments are next described in which this mechanical action is rendered more evident. A small rotating fly, capable of being moved about in any part of an exhausted bulb, is used as an indicator, and by appropriate means the molecular shadow of an aluminium plate is projected along the bulb. When entirely in, or entirely out of the shadow, the indicator scarcely moved, but when immersed so that one-half was exposed to molecular impact the fly rotated with extreme velocity.

Magnetic Deflection of Lines of Molecular Force.

With this apparatus another phenomenon was investigated. It is found that the stream of molecules, whose impact on the glass causes the evolution of light, is very sensitive to magnetic influence, and by bringing one pole of an electro-magnet or even of a small permanent magnet near, the shadow can be twisted to the right or to the left.

The little indicator was placed entirely within the molecular shadow, no movement being produced. An adjacent electro-magnet being now excited, the shadow was twisted half off the indicator, which immediately rotated with great speed.

The Trajectory of Molecules.

The amount of deflection of the stream of molecules forming a shadow is in proportion to the magnetic power employed.

The trajectory of the molecules forming the shadow when under magnetic influence is curved, the action of the magnet is to twist the trajectory of the molecules round in a direction at an angle to their free path, and to a greater extent, as they are nearer the magnet. The direction of twist being that of the electric current passing round the eletro-magnet.

Laws of Magnetic Deflection.

An apparatus was constructed so that the deflection of a spot of light was used instead of that of a shadow; a horseshoe magnet being placed underneath the negative pole to deflect the trajectory. The action of the north pole being to give the line of molecules a spiral twist one way, and that of the south pole being to twist it the other way, the two poles side by side cause the line to move in a straight line up or down along a plane at right angles to the plane of the magnet and a line joining its poles.

The ray of molecules does not obey Ampère's law, as it would were it a perfectly flexible conductor, joining the negative and the positive pole. The molecules are projected from the negative, but the position of the positive pole, whether in front, at the side, or even behind the negative pole, has no influence on their subsequent behaviour, either in causing phosphorescence, producing mechanical effects, or in their magnetic deflection. The magnet only gives their line of path a spiral twist, greater or less according to its power, but diminishing as the molecules get further off.

Numerous experiments were tried in this apparatus with different gases, and with the magnet in and out of position, and the following conclusions are arrived at:—

Working with exhausted air it was found that the spot of green phosphorescence on the screen was visible at an exhaustion of 102·6 M when the mean free path of the molecules, measured by the thickness of the dark space round the negative pole was only 12 millims. Hence, it follows, that a sufficient number of molecules to cause green phosphorescence on the screen are projected the whole distance from the pole to the screen or 102 millims, without being stopped by collisions.

Alteration of Molecular Velocity.

If we suppose the magnet to be permanently in position, and thus to exert a uniform downward pull on the molecules, it is seen that their trajectory is much curved at low exhaustions, and gets flatter as the exhaustion increases. A flatter trajectory corresponds to a higher velocity. This may arise from one of two causes; either the initial impulse given by the negative pole is stronger, or the resisting medium is rarer. The latter is probably the true cause. The molecules which produce a green phosphorescence must be looked upon as in a different state to those which are arrested by frequent collisions. The latter impede the velocity of the free molecules and allow longer time for magnetism to act on them; for, although the deflecting force of magnetism might be expected to increase with the velocity of the molecules, Professor Stokes has pointed out that it would have to increase as the square of the velocity, in order that the deflection should be as great at high as at low velocities.

Comparing the free molecules to cannon balls, the magnetic pull to the earth's gravitation, and the electrical excitation of the negative pole to the explosion of the powder in the gun, the trajectory will be flat when no gravitation acts, and gets curved under the influence of gravitation; it is now also much curved when the ball passes through a dense resisting medium, it is less curved when resisting medium gets rarer; and, as already shown, intensifying the induction spark, equivalent to increasing the charge of powder, gives greater initial velocity, and, therefore, flattens the trajectory. The parallelism is still closer if we compare the evolution of light seen when the shot strikes the target, with the phosphorescence caused in the glass screen by molecular impacts.

Focus of Heat of Molecular Impact.

The author finally describes an apparatus in which he shows that great heat is evolved when the concentrated focus of rays from a nearly hemispherical aluminium cup is deflected sideways by a magnet on to the walls of the glass tube. By using a somewhat larger hemisphere and allowing the negative focus to fall on a strip of platinum foil, the heat rose to the melting point of platinum.

An Ultra-gaseous State of Matter.

The paper concludes with some theoretical speculations on the state in which the matter exists in these highly exhausted vesels. The modern idea of the gaseous state is based upon the supposition that a given space contains millions of millions of molecules in rapid motion in all directions, each having millions of encounters in a second. In such a case, the length of the mean free path of the molecules is excessively small as compared with the dimensions of the vessel, and the properties which constitute the ordinary gaseous state of matter, and which depend upon constant collisons, are observed. But by great rarefaction the free path may be made so long that the hits in a second are negligible in comparison to the misses, and the average molecule is allowed to obey its own motions or laws without interference; and if the mean free path is comparable to the dimensions of the vessel, the properties which constitute gaseity are reduced to a minimum, and the matter becomes exalted to an ultra-gaseous state, in which the new and very decided properties now under investigation come into play.

Rays of Molecular Light.

In speaking of a ray of molecular light, the author

has been guided more by conciseness of expression than by a wish to advance a novel theory. It is considered, however, that the comparison, under these special circumstances, is strictly correct, and that he is as well entitled to speak of a ray of molecular or emissive light when its presence is only detected by the light evolved when it falls on a suitable screen, as he is to speak of a sunbeam in a darkened room as a ray of vibratory or ordinary light when its presence is only to be seen by int[...] in its path. In both cases the [...] ray of light, a[...] applied to the [...] apply the e[...] emissive light[...] between the [...] The light by[...] course, undul[...]

The phen[...] physical scie[...] exists in a f[...] of light hold[...] move in a s[...] and with whi[...] periment fro[...]

When the glass bulb was strongly heated by a spirit flame the leaves suddenly discharged and fell together.

Another bulb (fig. 2) was prepared, containing a plate of mica *a*, which could be suddenly placed between the gold leaves *b b*. The plate of mica was longer and wider than the gold leaves, and was connected with a small piece of iron wire, capable of moving up and

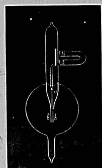
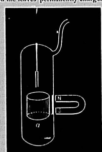


FIG. 2.

down a tube sealed into the top of the bulb. By means of an outside magnet the mica plate could thus be lowered between the gold leaves or raised out of their way, as desired. The tube was exhausted in about the millionth of an atmosphere, the mica plate being held quite above the leaves. One side of the bulb was then heated, and the leaves permanently charged by means



instead of a mica plate coming between the leaves, a mica cylinder *a*, was made capable of being raised and lowered outside the divergent leaves. I was not able to get entirely concordant results with this, owing to the friction of the mica developing electricity on the inner surface of the glass tube; but in all cases, when the cylinder was raised until it covered the electrified

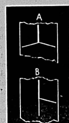
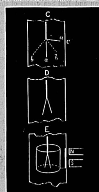


FIG. 4A.

leaves, it had the effect of diminishing the angle which they formed with each other.

The following experiments were also tried. The leaves being separated about 160°, as at fig. 4A, one side of the tube was slightly heated by a spirit flame. The leaf on that side fell to a vertical position, and remained so when all was cold, the other leaf sticking out as before, as at B. This seems to show that the divergence of the leaves in this case was not so much



ON ELECTRICAL INSULATION IN HIGH VACUA.

By WILLIAM CROOKES, F.R.S.

THE experiments here described were tried nearly two years ago. They were suggested by some observations I was then making on the passage of an induction

with a lamp, the leaf was repelled down, but not so readily as the other had been, and when the tube got cold, it rose to nearly its former position. This was repeated several times with uniform results. When the leaf was repelled down, the vertical leaf also moved away, so as to keep the same angle between them. This shows that the leaves themselves were also charged.

Fig. 4, C, shows the two positions of the leaves, *a a* before applying heat to the side *c* of the tube, and *b b* after heating the glass at *c*.

The tube was now heated on both sides, causing the leaves to come nearer together, as shown at fig. 4, D. While the glass was warm the cylinder was raised so that it surrounded the leaves; this caused them to get a little closer together, and they kept in this position, shown at E, till the whole apparatus was quite cold.

After remaining thus for some time, the cylinder was lowered, when the leaves widened out and took up the position shown at *b b*, fig. 4, C. The leaves did not return to the position *a a*, showing that now their divergence was owing to their own mutual repulsion, and not to an attraction of one or other to the electrified glass.

In December, 1877, I totally immersed one of these exhausted glass bulbs in a vessel of water; the gold leaves having previously been charged, and standing at an angle of 112° from one another, as at fig. 5. The

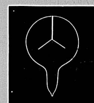


FIG 5.

water was connected electrically with "earth," and the whole was set aside in a cabinet on the 1st of January, 1878.

At the present time, after having remained in this condition for thirteen months, the leaves form exactly the same angle with one another which they did when they were first put in the cabinet.

After this experience I think we may consider that at an exhaustion of a millionth of an atmosphere, air is an absolute non-conductor of statical electricity. It is, therefore, legitimate to conclude that the vacuum of interstellar space offers equal obstruction to the discharge of electrified bodies, without necessarily interfering with their mutual repulsion if similarly electrified. It is possible that in these facts an explanation may be found of some obscure celestial phenomena.

EXPERIMENTAL RESEARCHES ON THE REPULSION RESULTING FROM RADIATION[1]

II.

HAVING completed the experimental investigation of the amount of repulsion produced by radiation on disks of various kinds, and coated with different substances, I turned my attention to the amount of repulsion produced when polarised light is allowed to fall on a plate of tourmaline suspended in vacuo in a torsion balance. It was originally thought that a slice of tourmaline, being black to a ray of light polarised in one plane, and white to a ray polarised in the other plane, would be repelled when the incident light was quenched by it, and not affected when the incident light passed through it. Experiments, however, prove that this action does not exist in any

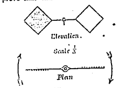


FIG. 4.

appreciable degree, the repulsion resulting from radiation being almost entirely a surface action, whilst the action of a tourmaline on a ray of polarised light is one in which thickness is necessary.

I next examined the effect of shape in influencing the amount and direction of repulsion. These experiments were for the most part tried with the apparatus shown in Fig. 3 (p. 513, part I.). Through the open top access can readily be obtained, and disks, plates, &c., can be quickly tested by being fixed to the extremities of a pair of aluminium arms, with a glass cap in the centre, rotating on the needle-point. Plates, 12 millims. square, cut from thin aluminium foil, were mounted diamond-wise on arms, and supported on the needle-point inside the bulb. The plates were lampblacked on sides facing

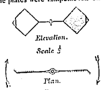


FIG. 5.

opposite ways, and the apparatus was well exhausted. The vanes behaved like an ordinary metal radiometer in respect to light and radiant heat. Fig. 4 shows the elevation and plan of the fly, the dotted side representing the one which was lampblacked. The arrows show the direction of positive rotation when exposed to the light of a standard candle 3·5 inches off. The outer corners of the aluminium plates were now turned up at an angle of 45°, 4 millims. of the two sides being turned up, leaving 8 millims. flat, as shown in Fig. 5. They were lampblacked on the inside, as shown in the figure by dots. A lighted candle 3·5 inches off caused very slow and feeble positive rotation. On shading the light from the black side, the bright side was repelled, causing positive rotation; and on shading the light from the bright side the black was repelled, causing negative rotation.[1] The positive repulsion was, however, rather stronger than the negative repulsion, so that, when both sides were illuminated, the force was only that due to the difference of these repulsions.

A hot glass shade is a convenient means of heating the bulb, by immersing it in a hot-air bath, without the liability of introducing action of rays other than those emitted by hot glass. On inverting a hot glass shade over the bulb in the above experiment, negative rotation was produced which changed to positive on cooling. Both these rotations were stronger than that given by the candle. The experiment was varied (1) by 6 millims. of the sides being turned up instead of 4; (2) by folding the plates across the vertical diagonal and then across their horizontal diagonal; (3) by attaching flat

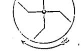


FIG. 6.

plates to the arms at an angle of 45°, blacking them on the insides away from the bulb, and repeating the experiment with plates blacked on the outsides. The results obtained show that when flat plates are taken blacked on alternate sides, the rotation is normal or positive, *i.e.*, the black side is repelled. When the outer corners of each plate is turned up so as to keep the blacked surface on the concave side, the positive rotation is either diminished, stopped, or converted into negative rotation, according to the amount of surface of the plate which has been turned up. The favourable presentation of the surface of the vanes to the inside of the bulb has more influence on the movement than has the colour of the surface. Radiometers constructed with silver flake vanes set at an angle

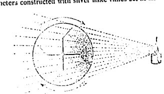


FIG. 7.

of 45° and blacked on the outside prove the most sensitive for light hitherto constructed.

I now endeavoured to clear up many anomalous results which had attended the application of heat either by hot shades or by hot water to radiometers. There was an antagonistic action between the effect of shape and that of colour of surface, the two actions sometimes acting together and sometimes in opposition.

Five radiometers were made exactly alike in size of bulb, shape of vanes, and degree of exhaustion, only differing in the material of which the vanes were composed. No. 1 was made of mica, 0·003 inch in thickness; No. 2, of mica, 0·0005 inch in thickness; No. 3, of pith,

[1] Continued from p. 514.

[1] I call the rotation *positive* when the black or driving side is repelled, and *negative* when the side which under ordinary circumstances would be the driving side, moves towards the light.

from a hot pole of the bulb will strike the *inner* surface of the sloping vanes, and driving them before it, will cause a rotation which appears *negative* to an observer, although it is really *positive* to the direction of pressure. Fig. 11 sufficiently illustrates this mode of action. The heat is supposed to be applied near the centre, and the molecular pressure, radiating on all sides, presses the vanes chiefly on the inner surfaces. The anomalous results obtained when the radiometers were heated with hot glass shades or hot water are thus accounted for. Polar heating gives *negative*, and equatorial *positive*, rotation, and when both are applied together by immersion in hot water, the direction of motion is governed by the stronger of these two forces.

In my description of Fig. 7 (p. 534) I showed that the glass heated by the ultra-red rays became hot, and acted on the driving surface, generating molecular pressure, and causing the sloping vanes to turn in the positive direction. At the same time the vanes get warm and become themselves sources of molecular pressure. The amount of molecular pressure thus generated depends on the capacity of the material of the vanes to absorb heat. Thin mica will hold very little, thick mica will hold more, and aluminium will hold most. This extra capacity for heat causes more molecular pressure to proceed from the aluminium and thick mica, and generates a proportionate amount of driving power on the surfaces of the vanes, turning them in the positive direction, and supplementing the action of the equatorial ring of hot glass.

The next subject of investigation was the action of radiation on cones, cylinders, and cup-shaped vanes. A pair of thin aluminium disks, cut half across the diameter, were bent into cones and mounted on two arms as a radiometer, the cones facing opposite ways. Several experiments were tried and repeated with cones of different material. The movement which appeared most anomalous was the attraction observed when a candle was allowed to shine on the hollow side of a cone or cup-shaped radiometer, the light being screened off the retreating side. Further experiments, however, showed that the effect of bending the plates, or of making cones of them, is to produce a more favourable presentation to the inner surface of the glass bulb. Radiation falls from the candle on the aluminium; some is reflected and lost, but a portion is absorbed, to be converted into thermometric heat or heat of temperature. Aluminium being a good conductor of heat, and the thickness of metal being insignificant, it becomes equally warm throughout, and a layer of molecular disturbance is formed on each surface of the metal. At a low exhaustion the thickness of this layer is not sufficient to reach from the metal cone to the side of the glass bulb; as the exhaustion increases, this layer extends further from the generating surface, until at a sufficiently high exhaustion the space between the side of the glass bulb and the adjacent portion of the metallic cone is bridged over, and pressure is exerted between the two surfaces. Fig. 12 shows how this pressure will act. The direction of pressure is indicated by dotted lines issuing from the metal cone. The more favourable presentation offered by the cone causes the pressure to be greatest between the glass bulb and the outside of the cone; the pressure from the inside of the cone and from the outside, away from the side of the glass, is dissipated without acting, but the pressure between the glass bulb and the side of the cone nearest to it is active; the cones, therefore, are pressed round in the direction of the arrows, and the motion has the appearance of *attraction*.

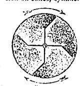


Fig. 10.

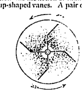


Fig. 11.

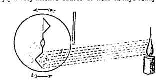


Fig. 12.

Cones being inconvenient in shape, I employed portions of cylinders wherewith to shape the vanes, and I ultimately found that cups were more easily affected by radiation than portions of cylinders, whilst they are more easily fashioned. I found that a four-armed cup-shaped aluminium radiometer, the cups being bright and 10 millims. in diameter, and the radius of the curvature being 6 millims., rotates in the light as well as a flat vaned instrument. I sealed one of these instruments on to the mercury pump. During exhaustion accurate observations were taken of the number of revolutions per minute caused by one or more standard candles 3 inches from the centre of the bulb. I also took observations of pressure, and the exhaustion was carried to a very high point. Fig. 13 shows the curve plotted from these observations, taking the rarefaction of the air in millionths of an atmosphere as abscissæ, and the number of revolutions a minute as ordinates. The curve traced through the dots representing observations illustrates the gradual increase of sensitiveness up to a certain point of rarefaction, and the sudden drop after that point is reached.

To still further investigate the action of dark heat on the vanes, I contrived an apparatus to which I could apply a very intense source of heat always ready in the same place, the heat not having to pass through glass, and being completely under control as to intensity and time of action. The instrument with which I performed the great number of these experiments is shown in Fig. 14. The cylinder is sealed at the top so as to permit of the highest possible exhaustion. It is drawn off narrow at the end, and a stem is sealed in to hold a needle-point. To the narrow end a fine tube is attached to connect the apparatus to the mercury-pump. Round the needle is placed a ring of fine platinum wire, *a a*, the ends of which are joined to thicker platinum wires passing through the glass. The fly consists of four square vanes of clear mica, *b b*, inclined at an angle of 45° to the horizontal plane and supported on light aluminium arms. Above the vanes is a flat disk of clear mica, *c c*, having a glass cap in its centre, and easily rotating on a needle-point. The vanes and the mica disk are supported independently of each other on separate needle points, which are held in glass rods, *d*, *d*, *d*. A current of electricity from two Grove's cells, turned on or off by a contact key, gives the power of making the wire ring, *a a*, red hot when desired.

The normal or positive movement of the disk is in the opposite direction to that of the vanes; thus, if the positive movement of the vanes is in the direction of the hands of a watch, the positive movement of the disk is in the opposite direction. With the apparatus full of air at the ordinary pressure (bar. = 761 millims.) the direction of rotation, both of the vanes and disk, is *positive* when the platinum wire is ignited. The speed of the vanes is 13·3 revolutions a minute, and that of the disk 1 a minute

EXPERIMENTAL RESEARCHES ON THE REPULSION RESULTING FROM RADIATION

IN previous papers[1] I have described my earlier experiments with the radiometer, and I then showed that the movement of this instrument was due to the presence of residual gas. I have since examined the repulsion exerted by a standard flame shining on pith and mica disks, coated with various powders, chemical precipitates, &c., and suspended *in vacuo* in a torsion apparatus, and I propose in this and succeeding papers to give an account of these experiments, and of the concluding researches on the repulsion resulting from radiation.

The apparatus I used to get quantitative measurements of the repulsion produced by radiation on various kinds of disks, and coated with different substances, is similar to one I have already described, but in order that the experiments may be better understood, it is shown in Fig. 1. I append the following description:—

ab is a horizontal glass tube containing the beam,

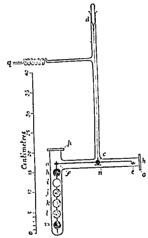


Fig. 1.

which, in this case, is made of straw, so as to secure lightness with absence of flexure under the comparatively heavy weights it sometimes has to bear; *cd* is a fine torsion fibre drawn from flint glass, to which the beam is suspended; it is cemented at *d* to a well-ground stopper, so as to admit of adjustment. When in position, cement, made by fusing together eight parts by weight of resin, and three parts of bees' wax, is run round the stopper. At *c*, the point of junction between the torsion-fibre and the straw beam, is a silvered glass mirror. At the end *e* of the beam, is a small pan to hold the weights counterpoising the disks, which are suspended to the other end. A flat stirrup of aluminium at *f* fits stiffly on the straw beam, and carries a flat glass fibre, *fg*, cemented to it so as to allow of no play, the straw beam, the aluminium hook, and the glass fibre being perfectly rigid. The experimental disks are fixed on the glass fibre by means of a touch of cement at the back. The vertical tube is arranged to hold six disks, the top one, *h*, being always the same standard lamp-blacked pith; the others, *i*, *j*, *k*, *l*, and *m*, being changed each time. A small magnet, *n*, attached to the central mirror, and controlled by a bar-magnet outside, gives the power of bringing the beam to zero, should it happen to get out of adjustment, without having to melt the cement and alter the angle of the torsion fibre by turning the stopper *d*. Plate glass caps at *o* and *p*, cemented to the ground edges of the tubes, give access to the interior; *o* allows the counterpoises to be adjusted in the pan, and *p* allows the aluminium stirrup to be unhooked, and the whole of the disks to be lifted out together. The apparatus is connected to the mercury pump by the arm and spiral *q*. The weights and dimensions of the various parts of the apparatus are as follows:—

Weight of straw beam, mirror, magnetic needle, aluminium stirrup, and flat glass fibre, &c.	7·25 grains.
Average weight of six plain mica disks ...	2·40 "
Average weight of six plain pith disks ...	0·59 "
Length of straw beam, from centre of counterpoising pan to centre of disks	17·0 centimetres.
Length of arm from centre of suspension to centre of pan	7·6 "
Length of arm from centre of suspension to centre of disks...	9·4 "
Glass torsion fibre—Length	23·0 "
" " Thickness	0·0013 inch.
Torsion with a glass weight hanging from it	½ oscillation in 15·75 seconds.

Fig. 2 shows the apparatus fitted up for experimentation. The disks are shown in position at *a*; a brick wall, *bc*, has holes pierced through it in two places, as shown, one hole, *d*, being opposite the centre mirror, and the other, *e*, opposite the disks. The aperture *d* is lined with card, lampblacked inside, and the interstices between it and the bricks are well plugged with cotton wool. A water cell at *d* prevents radiant heat from the lamp getting to the apparatus. Through the hole *e* pass six card tubes, lampblacked internally, 20 millims. diameter, and 23 centims. long. The tubes are firmly cemented to the wall, so that each shall be exactly central with its corresponding disk, and the outer end of each is closed with a cork. The space between the tubes and wall is well stuffed with cotton wool. The apparatus, being once fixed in position, is surrounded on all sides, as well as above and below, with cotton wool. Outside this is a row of glass bottles filled with water, and in front of all is a wooden screen. When protected in this manner, the inside of the apparatus is found to be free from disturbances caused by changes of temperature. When the disks have to be changed, air having been let in through the pump, access is easily obtained to the glass cap *p* (Fig. 1), and the cement being softened by heat, and the cap removed, the disks are lifted out together by seizing the aluminium stirrup with forceps. A fresh set of disks being introduced, the apparatus is again packed up and re-exhausted.

A lamp at *f* throws a narrow beam of light on the mirror of the apparatus, through the aperture *d*. The ray is reflected to the scale *g*, where its deflection from zero shows the angular movement of the torsion beam when one of the disks is repelled by radiation. The scale is 1½ metre from the reflecting mirror.

A standard candle (the kind employed in gas photometry, and defined by Act of Parliament as a "sperm candle of six to the pound, burning at the rate of 120 grs. per hour") is supported on a heavy stand, *h*, and can be raised or lowered by means of the sliding piece, *i*. Another sliding piece, *j*, carries a pointed wire projecting from it. The upright rod of the stand is graduated and numbered, so that when the sliding piece *j* is at mark 1,

[1] NATURE, vol. xv. pp. 224, 299.

74

THE ROYAL SOCIETY SOIRÉE, 1879.

THE conversazione which was given at Burlington House by the President and Council of the Royal Society on the evening of Wednesday, the 30th of April, was an exceedingly brilliant and successful one, and was in no way inferior to any that has gone before it, whether for the number of distinguished guests who availed themselves of the invitation, or for the importance and scientific interest of the objects collected for their pleasure and instruction.

As is usual on these occasions, Mr. William Crookes, F.R.S., contributed very largely to the success of the evening by his superb display of experimental illustrations of a branch of physical research which he has made his own quite as much as his celebrated investigations connected with Repulsion resulting from Radiation, which gave it birth. This new research, the investigation of certain phenomena connected with molecular physics in high vacua, Mr. Crookes first brought before the Royal Society in the month of December last, and it was treated in our article on the "Trajectory of Molecules" immediately after.* In that article we pointed out that Mr. Crookes's experiments tended to show that there exists in nature a fourth and higher condition of matter as much more ethereal than the gaseous condition as the gaseous state is higher than the liquid. Such experiments of Mr. Crookes as have produced the Radiometer, the Otheoscope, and the exceedingly beautiful series of experimental researches upon which he is still engaged, would have been impossible even to have been commenced before the days of the Sprengel pump, but Mr. C. H. Gimingham, by his great and important improvements in that instrument, has placed in the hands of the physicist an instrument by which vacua can be produced, compared with which the highest exhaustions effected by the old-fashioned air pump must be regarded almost as high pressures. The internal pressures of the gaseous residues within Mr. Crookes's apparatus are measured in millionths of an atmosphere, and in many of his more recent researches he has had to deal with vacua whose pressure is measured in small fractions of but one millionth of an atmosphere.

In the article to which we have already referred, we described Mr. Crookes's experiments which led to the discovery that the dark space around the negative pole within a vacuum tube, and separating it from the luminous nebulous glow, is a field of molecular activity which appears to bear a very close relationship to, if it is not identical with, the field of molecular disturbance in front of the vanes of a radiometer and by which its mechanical motion is produced. Fig. 1 represents a small apparatus in

Fig. 1

which this dark space is very beautifully shown. A A is a cylindrical vacuum tube having an aluminum wire sealed into each end at C C, and carrying across its middle diameter a circular disc B of aluminum, which is of slightly smaller diameter than the tube, and is connected by the wire shown in the sketch to the negative pole of an induction coil, the two wires C C both being connected to the positive pole. When this exhausted tube is placed in electrical communication with the induction coil, the tube is filled right and left of the disc B with a beautiful nebulous violet glow, with the exception of a space on each side of the disc shown at D D; this is the dark space around the negative pole, and its width from the disc increases as the exhaustion is continued, and if this be carried on sufficiently it will spread to the two ends of the tube, driving the luminous glow before it. When the negative pole is free to move like the vane of a radiometer and one of its faces is insulated by a film of mica, no motion takes place until the exhaustion is such that the dark space reaches the surrounding glass envelope or tube, and the moment that this occurs rotation commences. The electrical radiometer which we figured and described in the article above referred to,* embodies this principle and consists of a radiometer carrying flat aluminum vanes, each of which is covered on one face with a thin disc of mica; this fly is in metallic communication through its centre with an induction coil of which it forms the negative electrode. The positive electrode can be inserted in any other part of the bulb, its position in no way affecting the result. When the induction coil is placed in circuit with this apparatus the luminous glow gradually separates from the metallic surface of the vanes under exhaustion, leaving a dark space, which widens as the exhaustion is continued until the inner surface of the envelope or bulb is reached, when rotation of the fly immediately commences. This little instrument, which was shown by Mr. Crookes at the soirée, besides illustrating the very beautiful phenomena for which it was designed, exhibited some interesting optical effects; thus, whenever the number of vibrations of the contact-maker bore an exact proportion to the speed of rotation of the fly, it appeared to be standing perfectly still although really rotating at a high velocity, the number of vanes seen depending upon what the proportion was between the two speeds; these effects, which are familiar to those who have played with the colour top, especially when illuminated by electrical discharges, were especially strikingly illustrated in the instrument to which we refer, for the reason that the rotating object was at the same time the source of light by which it was itself illuminated. Similar effects were produced with a radiometer, the vanes of which were aluminum cups.

We have on a former occasion† referred to the very beautiful phosphorescent effects produced by molecular impact in tubes, in which the exhaustion is carried to high degree. With the ordinary soft German glass of which Mr. Crookes's tubes are generally constructed, this phosphorescence displays itself as a beautiful greenish yellow light spread over all those portions of the glass upon which the molecular stream impinges, and appears to be due to the sudden arrest of the gaseous molecules which are projected at a high velocity against the inner surface of the glass by a species of bombardment, their motion being suddenly arrested, and their energy being thereby coverted into luminous effects.

We have also pointed out that if any body, whether optically transparent or not, be interposed between the negative pole and the surface which is rendered phosphorescent by the molecular bombardment, a sharply-defined shadow of the object is cast upon the glass, that is to say, the interposed body acts as a shield or screen, arresting the streams of molecules projected in straight lines from the negative pole, and allowing only those portions of the glass to be subjected to molecular impact which are not screened from the negative pole by the object placed in the molecular path. This beautiful effect was illustrated by Mr. Crookes with the very simple

Fig. 2.

little apparatus shown in Fig. 2, in which A A is a pear-shaped vacuum tube or bulb having a flat aluminum disc B fixed at one end; in connexion with the negative electrode C of an induction coil is a Maltese cross cut out of thin aluminum foil fixed to a hinged support, so that it can be set up or laid down flat against the lower side of the tube, by slightly shaking the apparatus. For convenience this is made the positive electrode, but there is no other necessity for the cross C being electrically connected with the coil, as its only object is to present a screen or obstruction to the molecular streams projected from the disc B upon the end of the bulb. When this cross is lying flat at the bottom of the tube it offers no obstruction to the molecules in their path, and the larger end of the tube glows with the beautiful green "phosphorescent" light of molecular impact, but the moment that the cross is set up so as to stand in the path of the stream, a perfectly sharply-defined shadow is cast at D, producing a non-luminous transparent cross upon a green semi-opaque and luminous ground, indicating by its sharpness that the molecular streams are projected in perfectly straight lines, and in no way curve round an object or overlap one another. If, however, a magnet be brought near to the apparatus, these streams are deflected up or down, right or left, according to the position of the poles with respect to the tube, and in that case their paths become curved. This is shown by the shifting about of the shadow at the end of the tube, its position altering with every movement of the magnet, but its sharp definition remains the same. This magnetic deflection of the trajectory of molecules may be compared to the effect of gravitation upon the path of a cannon ball projected from a gun in a horizontal direction; if the action of gravitation were eliminated, the trajectory of the shot would be a horizontal straight line, but the action of gravitation combined with the constantly diminishing inertia of the ball, gives curvature to its trajectory.

As the molecular streams are projected fom the negative pole in straight lines which start in a direction normal to the surface of that pole, it is perfectly easy by giving to that pole a plane or a curved surface to concentrate the molecular streams to a focus, to cause them to diverge or to move in parallel straight lines, and Mr. Crookes has made a large number of experiments with cup-shaped poles by which effects of concentration are produced; one of the most striking of this most superb series of experiments is one which, although we have described it before, we cannot omit on the present occasion, as it formed one of the principal demonstrations shown by Mr. Crookes the other evening. This experiment is the production of intense heat by the concentration of streams of molecules upon a focal point, which thus receives the combined impacts of the great majority of the molecules projected from the negative pole. The apparatus by which Mr. Crookes demonstrated this beautiful phenomenon is shown in Fig. 3. A negative pole a, which is in the

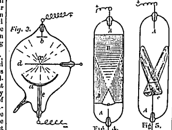


Fig. 3. Fig. 4. Fig. 5.

form of a large cup of spherical curvature, is fixed by the stem c at the lower portion of a glass bulb similar to that of a radiometer, the positive pole b being fixed at the top of the bulb. At d is placed a narrow strip of platinum foil, at such a distance from the cup-shaped electrode a as to pass through its centre of curvature x. From what has already been said it will be seen that when the two electrodes are connected to the poles of an induction coil, a concentrated fire of molecular projectiles is received upon the platinum strip d at the point x, and the effect is to cause this point at once to glow with incandescence, and so great is the heat produced that unless the action be promptly stopped the platinum would be fused and the instrument destroyed.

This little apparatus shows in a very beautiful manner the deflection of the molecular streams under the influence of magnetism, for if a magnet be manipulated near the bulb the incandescent spot may be made to travel to and fro along the platinum strip or directed to any one point, or by deflecting it to the right or left of the strip it may be thrown off it altogether, no incandescence being produced.

For the exhibition of the "phosphorescent" effects of molecular impact, the tube shown in Fig. 4 is perhaps the most striking; it consists of a cylindrical tube A A, having a semi-cylindrical negative pole C at its lower end. Above this is fixed a phosphorescent screen or plate B B coated with M. Becquerel's luminous sulphide of calcium. When this tube is placed in circuit with the induction coil the field of molecular disturbance is splendidly marked out by the phosphorescent figure on the screen, the planes of molecular streams first being brought to a focus, which is shown by the small area and greater brilliancy of their point of intersection, and then, diverging again, producing a surface of illumination diminishing in intensity as the distance from the focus is increased. The light emitted from this tube was strong enough to enable objects to be seen in an otherwise dark room, and it was perfectly possible to read small print when the paper was held near the illuminated tube. For optical beauty, however, the tube shown in Fig. 5 was perhaps the most remarkable of the whole series. In construction it differed from the last piece of apparatus only in being without the flat phosphorescent screen, the beautiful effects being produced by the green phosphorescence of the tube itself. A A is a cylindrical vacuum tube having a semi-cylindrical electrode at C, which is connected with the negative pole of an induction coil. When the circuit of the coil is completed, the beautiful green light of molecular impact that is produced, and the planes of disturbance intersecting in a sharply defined focal line crossing and impinging on the opposite cylindrical surfaces of the glass envelope so as to form ellipses of brilliant green phosphoresence, can hardly be imagined without being seen, and the action of the cylindrical electrode being to condense the molecular streams in one plane but not in others, produces the effect of two flat surfaces of elliptic boundary crossing one another, the space between and above them being filled with a beautiful but less intense illumination.

Fig. 6 represents an apparatus which illustrates

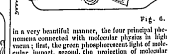


Fig. 6.

in a very beautiful manner, the four principal phenomena connected with molecular physics in high vacua; first, the green phosphorescent light of molecular impact, second, the projection of molecular shadows, third, the magnetic deflection of the trajectory of molecules, and fourth, the mechanical action of the gaseous molecules projected from the negative pole. A A is a vacuum tube carrying at C a concave circular negative electrode whose centre of curvature falls about the middle of the tube, at this spot a light wheel B is pivotted upon a horizontal axis. This wheel, which is shown enlarged in Fig. 7, consists of a disc of thin mica

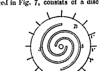


Fig. 7.

carrying around its periphery a number of equidistant radial vanes of aluminum, whose planes are perpendicular to the plane of the disc. The wheel, therefore, bears some resemblance to a water-wheel. When this tube is placed in connexion with the induction coil, a concentrated stream of molecules is projected on to the wheel, which is pivotted at or near the focus of the electrode C, and falling neither above nor below its axis, no rotation takes place; but when a small magnet M, which can be turned on a vertical axis, is put into such a position that the cone of molecular rays is bent upwards, the focus of impact is received by the upper vanes, and the wheel rotates with great rapidity in the direction indicated by the arrow. On however reversing the position of the magnet, the molecular streams are repelled, and falling on the lower vanes of the wheel, cause it to revolve in the opposite direction. To express the effect in a very few words, one position of the magnet converts the movement into an over-shot wheel, while the another position into an under-shot wheel, while the intermediate position, by allowing the stream to strike the wheel equally above and below its centre, has no motive effect upon it, and consequently it remains at rest. In order to make the rotation of

* See ENGINEERING, vol. xxvi., page 481.

* See ENGINEERING, vol. xxvi., p. 481. † Ibid., p. 481.

76

THE ELECTRIC DISCHARGE WITH THE CHLORIDE OF SILVER BATTERY

MESSRS. De La Rue and Müller, in the second part of the researches which they have carried on during three and a half years, have contributed facts of the highest value towards the solution of the problem presented by the beautiful phenomenon of stratification produced by electric discharges in vacuum tubes. The following are some of the more important results of these experiments as described by the authors.[1]

These phenomena, first noticed by M. Abria in 1843, were independently re-observed by Mr. (now Sir William) Grove in 1852, and have since engaged the attention of many physicists. The late Mr. Gassiott, working at first with an induction coil, but more recently on the same lines as the voltaic batteries of high potential,[2] published results of great interest; while, on the other hand, Mr. W. Spottiswoode is still pursuing with great acumen and originality a similar investigation, both with the induction coil and the Holtz machine, with which he has recently used condensers of great capacity.

Throughout our labours we have felt so strongly the necessity of obtaining numerical results as data for the foundation of a theory, that we have not hesitated to risk much in this cause. By the fusion of terminals, or the sudden discharge of the condenser, we have lost a vast number of very beautiful tubes; but gradually by the adoption of various devices, and by the employment of instruments specially constructed and insulated to suit the high potentials we deal with, we have succeeded in overcoming the various impediments, so that we can now readily obtain values for the physical quantities that enter into consideration in our experiments.

There is a serious trouble connected with the study of the discharge in rarefied gases, for, after a very short time, the tubes completely and permanently change, so as no longer to present the splendid stratifications witnessed on a first trial. We believe these changes occur much more rapidly with the battery in consequence of the greater amount of current, than with the induction coil; but the fact appears to have been well known to Dr. Geissler, of Bonn, who, on the occasion of a visit to our laboratory, brought with him some tubes through which no current had previously passed (virgin tubes, as he called them), which presented most beautiful phenomena lost for ever after too brief a period.

Tube 123 (cyanogen), for example, when first connected with the battery, presented strata which completely filled the tube without leaving a dark space near the negative, some threading themselves on it, as shown on the left of Fig. 1; but after a few seconds the strata widened out as on the right hand figure, then other changes occurred, and the first phases have never been reproduced.

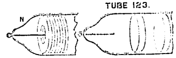


FIG. 1.

Another case is presented by the nitrogen tube Fig. 2, the right-hand figure showing the first phase, and the left-hand figure a second phase, which in its turn has for ever disappeared, and has been replaced by the ordinary disk-form of strata.

FIG. 2.

After spending much time in experiments with tubes prepared for us by Dr. Geissler, Messrs. Alvergniat Frères, of Paris, and Mr. Hicks, of Hatton Garden, with the vexation of finding that we could not often enough repeat our experiments, we ultimately came to the conclusion to have others made, but not exhausted, and to perform ourselves the charging and exhaustion. The tubes we usually employ have a glass stop-cock fitted to them at each end; they are 32 inches long, and from 1·75 to 2 inches in diameter; the terminals are of aluminium, and about 29 inches apart, one being a ring, the other a wire bent at a right angle, so as to point in the direction of the axis of the tube (see No. 144, Fig. 3), for we have found that the phenomena vary according as the ring or wire is made positive.

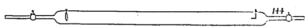


FIG. 3.

These we exhaust and fill with any gas we may wish to experiment with, and gradually exhaust again, noting the phenomena presented at different pressures, with different potentials, and with different amounts of current. We re-fill and exhaust the tube again and again, and mostly obtain, under the same conditions, as nearly as possible the same phenomena, of which we are careful to make sketches and, if possible, to obtain photographic records.

In some cases we make use of tubes provided with a calibrated chamber between two stop-cocks, as *a*–*b*, No. 145, Fig. 4, the chamber in this particular case having $\frac{1}{200}$th of the capacity of the tube, this tube has also an absorption chamber communicating through a cock and intended to contain spongy palladium. After a tube has been exhausted so as to produce a particular phase, and in the course of the experiment the exhaustion has been carried beyond that degree which permits of the reproduction of that phase, one or more charges of gas may be successively admitted into the tube by filling the calibrated chamber with gas at any particular pressure, and then opening the stop-cock communicating with the tube; the lost phase is thus reproduced.

The apparatus which we have found it advantageous to adopt for the exhaustion of our tubes is shown in Fig. 5; it comprises three means of exhaustion which are successively employed as the vacuum becomes more perfect. The first is an Alvergniat high-pressure water *trompe* in connection with the high-pressure water-main of the

[1] See *Phil. Trans.*, vol. clxix., pp. 55-121.

[2] Mr. Gassiott made several batteries of different kinds in the course of his experiments; on the occasion of a visit to his laboratory, January 26, 1875, the current of his Leclanché battery was measured by us with a voltameter. The current of 2000 new cells was found to be 0·07464 W; that of the whole 3000 cells, 1000 of which had been a long time in use, 0·04718 W. Taking the Leclanché as 1·48 volt the internal resistance of the new battery must have been 19·83 ohms per cell; that of the whole 3000, 31·87 ohms per cell. The striking distance of the whole 3000 between a conical point and a disk 0·125 inch diameter was only 0·125 inch; whence the inference is that the insulation was, at that time, imperfect.

77

74 78

79

West Middlesex Water Company, the head of water being 106 feet; it produces a vacuum to within half-an-inch (0·47 in. = 12 millims.) of the height of the barometer. The pipe leading to it is so marked in the drawing; it is attached, through a cock, to a four-way-junction-piece F, provided with three more cocks, communicating:—one to one end of the tube T, one to the last drying bottle of the gas generator G G′, and one to a mercurial gauge. The

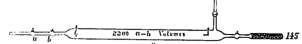


Fig. 4.

other end of the vacuum tube T communicates by means of a Y-piece to both, an Alvergniat mercurial pump, on the right of the figure, and a Sprengel pump, on the left. After the *trompe* has done its work, the Alvergniat is used for rapid exhaustion, and then shut off by means of the glass cock C, leaving the exhaustion to be completed by the Sprengel; we have thus obtained, by the *pumps alone*, in tubes 32 inches long and 2 inches in diameter, vacua of only 0·002 millimetre pressure, equal to 2·6 millionths of an atmosphere—a vacuum so perfect that the current of 8040 cells would not pass. The apparatus is in connection with a McLeod gauge, by means of which pressures to 0·00005 mm. can be determined. Besides this gauge, the Sprengel and Alvergniat pumps have their own gauges, which read to a millimetre. M is a rotating mirror consisting of a four-sided prism mounted on a horizontal axis and provided with a multiplying wheel; on each face of the prism is fastened a piece of looking-glass. The reflection of the tube in the mirror enables one to examine

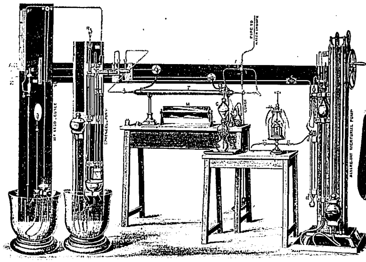


Fig. 5.

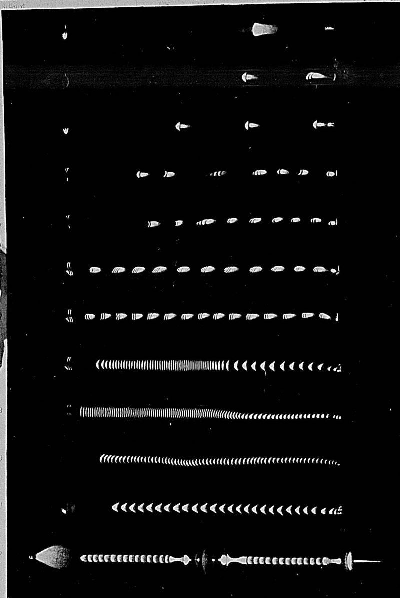
whether an apparently nebulous discharge is simply nebulous or consists really of strata, also whether and in what direction there is a flow of strata which may appear quite steady to the eye. The observations are facilitated by covering the tube with a half cylinder of cardboard having a slit in the direction of its axis about $\frac{1}{10}$ inch wide. R is a radiometer attached to the Sprengel; *d*, *d*, a drying tube containing sticks of potash used when gas is introduced from a reservoir through the Alvergniat.

The resistance of vacuum tubes does not depend solely or mainly on the distance between the terminal, but it does greatly on their diameter.

In order to test how much of this depends on the length of any constriction, we had made two tubes, 154 and 155, Fig. 6, of nearly the same length (16 inches), and internal diameter $\frac{13}{16}$ths of an inch, the residual gas in each case being carbonic acid, CO_2. From results obtained with these tubes where the constricture varied in length in the ratio of 125 to 1, it became evident that the main effect is due to the simple constricture of the tube.

The diagram Fig. 7, shows the arrangement by which,

7



FAC SIMILE OF PHOTOGRAPHS

Fl. Journal July 1879

81

first of these mounds, and then divided into two branches' one of which commenced to flow towards Adernò, and the other towards Biancavilla, but the supply died out at the source, and the new streams solidified at a height of 2,000 metres, having flowed for a mile and a quarter as a stream 400 metres in breadth. This stream did but little damage; it did not penetrate into the cultivated region, and but in short distance into the woody region. It came into contact, however, with a bed of snow, part of which it converted into clouds of steam, while another portion was liquefied and rushed down the sides of the mountain in a foaming torrent, carrying with it a good deal of *débris*.

The outflow of lava ceased on the south side of the mountain, because the lava found a vent at a lower level on the north side. As the one decreased in activity the other increased. On May 28th Silvestri visited the scene of the northern eruption. A great column of smoke appeared about 20° east of north, while a shower of sand descended, producing the "sad leaden light" (*la luce triste plumbea*) observable during an eclipse. More than two pounds of this sand were collected in ten minutes in an inverted umbrella, and the north flanks of the mountain were soon covered with it. Silvestri ascended from Randazzo towards the new craters, and when at a height of about 2,000 metres and near Monte Nero he heard loud subterranean detonations, and perceived severe oscillations of the soil. Soon afterwards he came upon the great rift, together with several smaller ones, converging towards the principal crater. In the immediate neighbourhood of Monte Nerò and Timpa Rossa three new craters were seen, from one of which dense clouds of white smoke issued, while the others emitted lava and showers of ashes and incandescent stones. Frequent flashes of lightning issued from the smoke. The stream of lava near its source emitted a very bright light which, when viewed by a direct vision spectroscope, gave the lines of hydrogen, calcium, sodium, and potassium. The lava flowed downwards at a rapid rate: the wood of Collebasso was destroyed, and by the evening of May 29 it had flowed 6¼ miles, destroying the bridge of Passo Pisciaro and crossing the postal road between Randazzo and Linguaglossa. On Sunday the 31st the stream was rapidly approaching Mojo; the inhabitants became frightened, and brought out the figure of their patron Saint Antony, which was carried in procession to the edge of the stream, while the people fell on their knees and besought the Deity to save them from the impending danger. After the evening of June 1 the force of the eruption began somewhat to abate, and by the 6th inst. it was practically at an end. The lava stream ran nearly 7 miles from its source, and ultimately stopped 500 yards from the river Alcantara, and about half a mile from the village of Mojo. At its termination it is 23 feet in breadth and nearly 32 feet in height. The lava stream entered the bed of the Pisciaro torrent with a velocity of from 4 to 5 metres a minute, which was reduced to 2 metres a minute in the lower valley of less inclination. In 76 hours the lava flowed more than six miles from its source.

Indications of a disturbed volcanic condition were manifest last October, when powerful shocks of earthquake were felt in the territory of Mineo, Palagonia, Vizzini, Scordia, Militello, and Caltagirone. Mineo was the centre of disturbance, and here the shocks continued at intervals during the month of October. Loud subterranean noises were also heard at intervals. Two months later an eruption of mud and gas took place near Paternò, on the southern flanks of Etna. The mud was hot, salt, and petroleum-bearing (*fango salato termale petroleifero*), and its ejectment continued for several months. Towards the end of December last the whole eastern sea-board was visited by a strong shock of earthquake; and soon afterwards a great increase of smoke from the central crater of Etna showed that the dynamic activity of the mountain was unusually near the surface.

Even now we cannot regard the eruption as at an end Ten days after the cessation of the flow of lava telegrams from Rome (dated June 17) announced that the neighbourhood of Santa Venere and Guardia had been visited by repeated shocks of earthquake. A telegram on the following day announced that "an earthquake of great violence" had occurred near Aci Reale, destroying five villages. There is evidently a great deal of volcanic energy still pent up not far from the surface, and we must fear that before long a further outburst will relieve the imprisoned Titanic forces.

G. F. RODWELL

THE ELECTRIC DISCHARGE WITH THE CHLORIDE OF SILVER BATTERY[1]

II.

THE HISTORY OF A TUBE

No. 129, Hydrogen

WE now give an account of the very great variety of phenomena presented by the same tube charged with hydrogen, No. 129 (see Plate), under different conditions of exhaustion when used in connection with batteries of various potentials, and traversed by currents of different strengths.

This tube is 32 inches long and 1·6 inch in diameter, the terminals are a straight wire and a ring, about 1 inch in diameter, both of aluminium; it is furnished with a glass stop-cock at each end, as represented in Fig. 3. The glass stop-cocks are connected with the mercurial pumps (Alvergniat and Sprengel) and with the gas generator respectively, as shown in Fig. 5.

Tube 129, 5th Charge of Hydrogen.—A glow at both terminals was first seen when the pressure was 17·2 mm., 22,632 M,[2] with 8,040 cells, and great heat developed in the dark discharge near the middle of the tube. The spectroscope showed faintly the C and F lines.

Pressure 16·5 mm., 21,710 M, 8,040 cells. One luminosity like that on the right hand of Fig. 10, sho out from the positive and approached to within 6 inches of the negative, then receded back and disappeared.

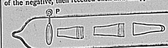


FIG. 10.

Pressure 15·8 mm., 20,789 M, 8,040 cells. 3 luminosities, very steady, which moved slowly and steadily towards the negative. The tube hottest in dark part where there was probably a non-luminous entity.

Pressure 14 mm., 18,421 M, with 6,840 cells, the current was unsteady, but it was perfectly steady with 8,040, and 6 arrow-headed luminosities like that on the left of Fig. 11, were produced and soon disappeared.

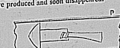


FIG. 11.

Pressure 10·3 mm., 13,552 M, with 8,040 cells. 8 luminosities something like 1, Fig. 12.

Pressure 9·4 mm., 12,368 M, with 8,040 cells. 12 luminosities like those, Fig. 7 in the Plate. The C and F lines seen in the glow around the negative.

Pressure 7·7 mm., 10,132 M, with 8,040 cells. 10 luminosities like Fig. 6 in the Plate; these ran together and disappeared and reappeared in a few seconds.

[1] Continued from p. 178.

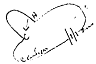
[2] M = millionths of an atmosphere.

82

Kely 1879
Boston Journal of Chemistry

The explanation of the movement of the radiometer is this: the light, or the total bundle of rays included in the term "light," falling upon the blackened side of the vanes, becomes absorbed, and thereby raises the temperature of the black side; this causes extra excitement of the air molecules which come in contact with it, and pressure is produced, causing the fly of the radiometer to turn round.

H. O.



Electric Discharges in Vacuum Tubes.—Mr. J. F. Moulton demonstrated the results of the experiments of Mr. Spottiswoode and himself on the sensitiveness of electric discharges in vacuum tubes. These experiments were undertaken to find the cause of the numerous layers or strata in the discharge, a Holt machine being employed. It was observed that when feeble currents were drawn from the machine, the discharge could be depressed by laying the finger on the tube, and this depression always occurs with intermittent currents; therefore the feeble currents from a continuous current Holtz discharge themselves like intermittent currents by reason of their feebleness. This sensitiveness of the discharge to the approach of the finger was found to be due to the conductivity and electric capacity of the hand. Electricity, opposite in kind to the discharge, is induced on the finger, and streaming upon the tube neutralizes part of the discharge therein. This effect was also shown by means of tin foil rings round the tube. An intermittent current is of course capable of this static induction on neighboring conductors. The luminous discharge in a vacuum tube consists of a bright sharp glow at the negative terminal, followed by a dark space, then a hazy bluish light at the positive pole. The striæ or layers in these sensitive tubes merely repeat this appearance. They can be artificially produced by placing the fingers, or rings of metal, at intervals along a tube conveying an amorphous discharge; for in this case the induced electricity discharging itself from the fingers breaks up the amorphous discharge into dark and bright layers. In these stratified discharges the electricity appears to travel *per saltum*, or by stepping stones, as one may say, and the glow seems to be a molecular structure, a view which is supported by Mr. Crookes' experiments. A negative discharge from the finger produces a dark space in the tube discharge, and a positive one a bright line; therefore, one can tell the kind of discharge passing in a tube by laying a finger on it. If the same pole be brought to both ends of a tube, a discharge will take place from each end, and there will be a dark space in the middle, the electricity here seeming to turn back again the way it came. The discharge from the pole through a vacuum tube would therefore appear to be not akin to a conduction but to a disruptive discharge. It is a leap in the dark, and the phenomena observed are due to the gaseous nature of the medium. These experiments point to the possibility of completing a circuit by positive electricity alone.

Professor Guthrie suggested that by combining vacuum tubes with the induction balance of Prof. Hughes, it might be possible to get an optical balance for measuring inductive capacity.

Oxygen in the Sun.—Dr. Henry Draper, of New York, who is now on a visit to England, then addressed the meeting on his alleged discovery of oxygen in the sun by bright lines in the solar spectrum. He said that hitherto he had not been able to find these lines projecting from the limb of the sun like hydrogen, and his impression is that oxygen resides lower than the reversing layer. He had lately been extending the dispersion of the spectrum of terrestrial oxygen, and from a light of maximum intensity of one candle power had now got a dispersion of 80 inches from A to O. He exhibited two of the original negatives of the solar spectrum, showing the bright lines.

Sc. Am. July 26 1879

83

primary to the secondary wire. It was ultimately entirely remade in February, 1878, and the secondary wire coiled on a separate ebonite cylinder to insure efficient insulation, which was accomplished.

In every case where the strata are to the eye or rotating mirror perfectly steady, slight deflections of the needle are seen; these generally indicate a resultant *direct* current (break-contact), and in the fewer number of cases an *inverse* current indicating, in the first case, a *sudden* decrease and *slow* increase of current through the tube. These deflections, though very manifest, do not amount to more than about three or four divisions of the galvanometer scale, a deflection which indicates a current of only 0·0000000023 W. At the advent or retreat of a stratum at the positive pole there is frequently produced a deviation of 300 divisions, indicating a current of 0·000000001812 W; before a stratum leaves the positive terminal or dies out on it, there is usually a tremulous motion of that stratum visible to the eye and indicated by rapid pulsations of the galvanometer.

On the suggestion of Prof. Clerk Maxwell we have recently introduced the telephone into the primary current, as shown in Fig. 20, and also in the secondary current of coil 819.

In all cases where the condenser C was discharging itself gradually through the tube, a low rustling sound was distinctly audible to sensitive ears so long as the stratification remained *apparently* perfectly steady. When the phase of confused stratification which immediately precedes extinction was reached, the sound in the telephone became very loud and rose in pitch, with some tubes becoming quite shrill. These results, therefore, confirm the conclusion already arrived at from other experiments, namely, that the discharge in vacuum tubes is intermittent; but we do not pretend that they make it manifest that stratification is *dependent* upon intermittence.

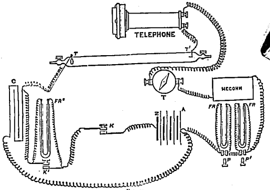


Fig. 20

In the course of our experiments, using sometimes 11,000 cells, we have arrived at the following facts:—

1. *The discharge in a vacuum tube does not differ essentially from that in air and other gases at ordinary atmospheric pressures; it cannot be considered as a current in the ordinary acceptation of the term, but must be of the nature of a disruptive discharge, the molecules of the gas acting as carriers of electrification. The gases in all probability receive impulses in two directions at right angles to each other, that from the negative being the more continuous of the two. Metal is frequently carried from the terminals and is deposited on the inside of the tube, so as to leave a permanent record of the spaces between the strata.*

2. *As the exhaustion proceeds, the potential necessary to cause a current to pass diminishes up to a certain point, whence it again increases, and the strata thicken and diminish in number, until a point is reached at which, notwithstanding the high electromotive force available, no discharge through the residual gas can be detected.* Thus, when one pole of a battery of 8,040 cells was led to one of the terminals of tube 143, Fig. 21, which has a radiometer attached to it, the other terminal of the tube, distant only 0·1 inch, being connected through a sensitive Thomson galvanometer to the other pole of the battery (earth), the current observed was not greater than that which was found to be due to conduction over and through the glass. Although no current passed, the leading wires acting inductively stopped the motion of the radiometer, as has been observed by Sir William Grove.

3. *All strata have their origin at the positive pole.* Thus, in a given tube, with a certain gas, there is produced at a certain pressure, in the first instance, only one luminosity which forms on the positive terminal, then, as the exhaustion is gradually carried further, it detaches itself, moving towards the negative, and being followed by other luminosities, which gradually increase in number up to a certain point.

4. *With the same potential the phenomena vary irregularly with the amount of current.* Sometimes, as the current is increased, the number of strata in certain tubes increases, and as it is diminished their number decreases; but with other tubes the number of strata frequently increases with a diminution of current. If the source of the current is a charged condenser, the flow being from one of its plates through resistances and the tube to the other; then, as the potential of the condenser falls and the current diminishes, the number of strata alters; if the strata diminish in number with the fall of potential, then the stratum nearest the positive wire disappears on it, the next then follows and disappears, and so on with others; if, on the other hand, the charge of the condenser is very gradually increased, the strata pour in, one after the other, in the most steady and beautiful manner from the positive.

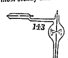


Fig. 21.

5. *A change of current frequently produces an entire change in the colour of the strata:* for example, in a hydrogen tube from a cobalt blue to a pink. It also changes the spectrum of the strata; moreover, the spectra of the illuminated terminals and the strata differ.

84

See the next article for 1st Number

MOLECULAR PHYSICS IN HIGH VACUA[1]

II.

I HAVE hitherto spoken of and illustrated these phenomena in connection with *green* phosphorescence. It does not follow, however, that the phosphorescence is always of that colour. This coloration is a property of the particular kind of glass in use in my laboratory. I have here (Fig. 7) three bulbs composed of different glass; one is uranium glass (*a*), which phosphoresces of a dark green colour; another is English glass (*b*), which phosphoresces of a blue colour; and the third (*c*) is soft German glass—of which most of the apparatus before you is made—which phosphoresces of a bright apple-green colour. It is therefore plain that this particular green phosphorescence is solely due to the glass which I am using. Were I to use English glass I should have to speak of blue phosphorescence, but I know of no glass which is equal to the German in brilliancy.

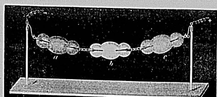


FIG. 7.

My earlier experiments were almost entirely carried on by the aid of the phosphorescence which glass takes up when it is under the influence of the electric discharge *in vacuo*; but many other substances possess this phosphorescent power, and some have it in a much higher degree than glass. For instance, here is some of the luminous sulphide of calcium prepared according to M. Ed. Becquerel's description. When it is exposed to light—even candlelight—it phosphoresces for hours with a rich blue colour. I have prepared a diagram with large letters written in this luminous sulphide; before it is exposed to the light the letters are invisible, but Mr. Gimingham has just exposed it in another room to burning magnesium, and now it is brought into the darkened theatre you will see the word "φῶς,"—*light*, a very suitable word for so beautiful a phosphorescence—shining brightly in luminous characters. The first letter, φ, shines with an orange light; it is a sulphide of calcium prepared from oyster-shells. The other letters, shining with a blue light, are sulphide of calcium prepared from precipitated carbonate of lime. Once the phosphorescence is excited the letters shine for several hours. I will put the diagram at the back, and we shall see how it lasts during the remainder of the lecture. This substance, then, is phosphorescent to light, but it is also much more strongly phosphorescent to the molecular discharge in a good vacuum, as you will see when I pass the discharge through this tube (Fig. 8). The white plate (*a*, *b*) in the centre of the tube is a sheet of mica painted over with the luminous sulphide of which the letter φ was composed in the diagram you have just seen. On connecting the poles with the coil, the mica screen glows with a strong yellowish green light, bright enough to illuminate all the apparatus near it. But there is another phenomenon to which I now desire to draw attention: on the luminous screen is a kind of distorted star-shaped figure. A little in front of the negative pole I have fixed a star (*c*) cut out in aluminium, and it is the image of this star which you see on the screen. It is evident that the rays coming from the negative pole project an image of anything that happens to be in front of it. The discharge, therefore, must come from the pole in straight lines, and does not merely permeate all parts of the tube and fill it with light as it would were the exhaustion less good. Where there is nothing in the way the rays strike the screen and produce phosphorescence, and where there is an obstacle they are obstructed by it, and a shadow is thrown on the screen. I shall have more to say about this shadow presently; I merely now wish to establish the fact that these rays driven from the negative pole produce a shadow.

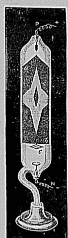


FIG. 8.

I must draw your attention to an important experiment connected with these molecular rays, but unfortunately it is a very delicate one, and very difficult to show to many at once; but I hope, if you know beforehand what to look for, you will all be able to see what I wish to show. In this pear-shaped bulb (Fig. 9A) the negative pole (*a*) is at the pointed end. In the middle is a cross (*b*) cut out of sheet aluminium, so that the rays from the negative pole projected along the tube will be partly intercepted by the aluminium cross, and will project an image of it on the hemispherical end of the tube which is phosphorescent. I think you will all now see the shadow of the cross on the end of the bulb (*c*, *d*), and notice that the cross is black on a luminous ground. Now, the rays from the negative pole have been passing by the side of the aluminium cross to produce the shadow; they have been hammering and bombarding the glass till it is appreciably warm, and at the same time they have been producing another effect on that glass—they have deadened its sensibility. The glass has got tired, if I may use the expression, by the enforced phosphorescence. Some change has been produced by this bombardment which will prevent the glass from responding easily to additional excitement; but the part that the shadow has fallen on is not tired—it has not been phosphorescing at all, and is perfectly fresh; therefore if I throw this star down—I can easily do so by giving the apparatus a slight jerk, for it has been most ingeniously constructed with a hinge by Mr. Gimingham—and so allow the rays from the negative pole to fall uninterruptedly on to the end of the bulb, you will suddenly see the black cross (*c*, *d*, Fig. 9B) change to a luminous one (*e*, *f*), because the background is only faintly phosphorescing, whilst the part which had the black shadow on it retains its full phosphorescent power. The luminous cross is now dying out. This is a most delicate and venturous experiment, and I am fortunate in having succeeded so well, for it is one that cannot be rehearsed. After resting for a time the glass seems to partly recover its power of phosphorescing, but it is never so good as it was at first.

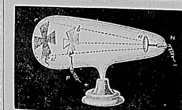


FIG. 9 A.

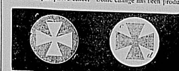


FIG. 9 B.

[1] A short-hand report of a lecture delivered at the Royal Institution on Friday, April 4, 1879. By William Crookes, F.R.S. Contributed by the author. Continued from p. 231.

85

We have, therefore, found an important fact connected with this phosphorescence. Something is projected from the negative pole which has the power of hammering away at the glass in front of it, in such a way as to cause it not only to vibrate and become temporarily luminous while the discharge is going on, but to produce an impression upon the glass which is permanent. The explanation which has gradually evolved itself from this series of experiments is this:—The exhaustion in these tubes is so high that the dark space, as I showed you at the commencement of this lecture, that extended round the negative pole, has widened out till it entirely fills the tube. By great rarefaction the mean free path has become so long that the hits in a given time may be disregarded in comparison to the misses, and the average molecule is now allowed to obey its own motions or laws without interference. The mean free path is in fact comparable to the dimensions of the vessel, and we have no longer to deal with a continuous portion of matter, as we should were the tubes less highly exhausted, but we must here contemplate the molecules *individually*. At first this was only a convenient working hypothesis. Long-continued experiment then raised this provisional hypothesis almost to the dignity of a theory, and now the general opinion is that this theory gives a fairly correct explanation of the facts. In these highly exhausted vessels the mean free path of the residual molecules of gas is so long that they are able to drive across from the pole to the other side of the tube with comparatively few collisions. The negatively electrified molecules of the gaseous residue in the tube therefore dash against anything that is in front, and cast shadows of obstacles just as if they were rays of light. Where they strike the glass they are stopped, and the production of light accompanies this sudden arrest of velocity.

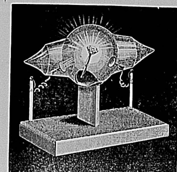


FIG. 10.

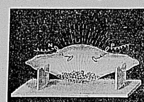


FIG. 11

Other substances besides English, German, and uranian glass, and Becquerel's luminous sulphides are also phosphorescent. I think, without exception, the diamond is the most sensitive substance I have yet met for ready and brilliant phosphorescence. I have here a tube, similar to those already exhibited, containing a mica screen painted with powdered diamond, and when I turn on the coil, the brilliant blue phosphorescence of the diamond can be seen, quite overpowering the green phosphorescence of the glass. Here, again, is a very curious diamond, which I was fortunate enough to meet with a short time ago. By daylight it is green, produced, I fancy, by an internal fluorescence. The diamond is mounted in the centre of this exhausted bulb (Fig. 10), and the negative discharge will be directed on it from below upwards. On darkening the theatre you see the diamond shines with as much light as a candle, phosphorescing of a bright green.

In this other bulb is a remarkable collection of crystals of diamonds, which have been lent me by Prof. Maskelyne. When I pass the discharge over them I am afraid you will only be able to see a few points of light, but if you will examine them after the lecture, you will see them phosphoresce with a most brilliant series of colours—blue, apricot, red, yellowish green, orange, and pale green.

Next to the diamond the ruby is one of the most remarkable stones for phosphorescing. In this tube (Fig. 11) is a collection of ruby pebbles, for the loan of which I am indebted to my friend Mr. Blogg, of the firm of Blogg and Martin, who placed a small sackful at my disposal. As soon as I turn on the induction spark you will see these rubies shining with a brilliant rich red colour, as if they were glowing hot. Now the ruby is nothing but crystallised alumina with a little colouring-matter, and it became of great interest to ascertain whether the artificial ruby made by M. Feil, of Paris, would glow in the same manner. I had simply to make my wants known to M. Feil, and he immediately sent me a box containing artificial rubies and crystals of alumina of all sizes, and from those I have selected the mass in this tube which I now place under the discharge; they phosphoresce of the same rich red colour as the natural ruby. It scarcely matters what colour the ruby is, to begin with. In this tube of natural rubies there are stones of all colours—the deep red ruby and the pale pink ruby. There are some so pale as to be almost colourless, and some of the highly-prized tint of pigeon's blood; but in the vacuum under the negative discharge they all phosphoresce with about the same colour.

As I have just mentioned, the ruby is crystallised alumina. In a paper published twenty years ago by Ed. Becquerel,[1] I find that he describes the appearance of alumina as glowing with a rich red colour in the phosphoroscope (an instrument by which the duration of phosphorescence in the sunlight can be examined). Here is some chemically pure precipitated alumina which I have prepared in the most careful manner. It has been heated to whiteness, and you see it glows with the rich red colour which is supposed to be characteristic of alumina. The mineral known as corundum is a colourless variety of crystallised alumina. Under the negative discharge in a vacuum, corundum phosphoresces of a rose-pink colour. There is another curious fact in which I think chemists will feel interested. The sapphire is also crystallised alumina, just the same as the ruby. The ruby has a little colouring-matter in it, giving it a red colour; the sapphire has a colouring-matter which gives it a blue colour, whilst corundum is white. I have here in a tube a very fine crystal of sapphire, and, when I pass the discharge over it, it gives alternate bands of red and green. The red we can easily identify with the glow of alumina; but what is the green? If alumina is precipitated and purified as carefully as in the case I have just mentioned, but in a somewhat different manner, it is found to glow with a rich green colour. Here are the two specimens of alumina in tubes, side by side. Chemists would say that there was no difference between one and the other; but I connect them with the induction-coil, and you see that one glows with a bright green colour, whilst the other glows with a rich red colour. Here is a fine specimen of chemically pure alumina,

[1] *Annales de Chimie et de Physique*, 3rd series, vol. lvii. p. 50, 1859.

86

87

violently from the negative pole. If I place something in front of these molecules, they show the force of impact by the heat which is produced. Can I make this mechanical action evident in a more direct way? Nothing is simpler. I have only to put some easily moving object in the line of discharge in order to get a powerful mechanical action. Mr. Gimingham, with great

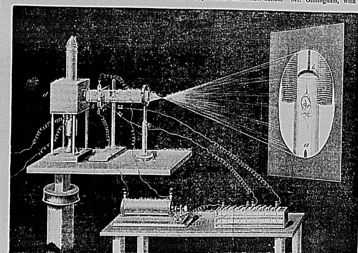


FIG. 16.

skill, has constructed a piece of apparatus which I will presently put in the electric lantern, so that all will be able to see its action. But first I will explain the construction by means of this diagram (Fig. 19). The negative pole (*a*, *b*) is in the form of a very shallow cup. In front of the cup is a mica screen

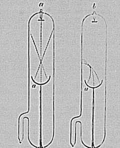


FIG. 17.

(*c*, *a*), wide enough to intercept nearly all the molecular rays coming from the negative pole. Behind this screen is a mica wheel (*e*, *f*) with a series of vanes, making a sort of paddle-wheel of it. So arranged, the molecular stream from the pole *a b* will nearly all be cut off from the wheel, and what escapes over and under the screen will hit the vanes equally, and will not produce any movement. I now put a magnet, *g*, over the tube, so as to

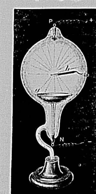


FIG. 18.

deflect the stream over or under the obstacle *c d*, and the result will be rapid motion in one or the other direction, according to

MOLECULAR PHYSICS IN HIGH VACUA[1]

WHEN I was asked, a month or two ago, to illustrate in this theatre some of my recent researches on molecular physics in high vacua, I exclaimed, "How is it possible to bring such a subject worthily before a Royal Institution audience when none of the experiments can be seen more than three feet off?" If to-night I am fortunate enough to show all the experiments to those who are not far distant, and if I succeed in making most of them visible at the far end of the theatre, such a success will be entirely due to the great kindness of your late secretary, Mr. Spottiswoode, who has placed at my disposal his magnificent induction-coil—not only for this lecture, but for some weeks past in my own laboratory—thus enabling me to prepare apparatus and vacuum tubes on a scale so large as to relieve me of all anxiety so far as the experimental illustrations are concerned.

Before describing the special researches in molecular physics which I propose to illustrate this evening, it is necessary to give a brief outline of one small department of the modern theory of the constitution of gases. It is not easy to make clear the kinetic theory, but I will try to simplify it in this way:—Imagine that I have in a large box a swarm of bees, each bee independent of its fellow, flying about in all manner of directions and with very different velocities. The bees are so crowded that they can only fly a very short distance without coming into contact with one another or with the sides of the box. As they are constantly in collision, so they rebound from each other with altered velocities and in different directions, and when these collisions take place against the sides of the box pressure is produced. If I take some of the bees out of the box, the distance which each individual bee will be able to fly before it comes into contact with its neighbour will be greater than when the box was full of bees; and if I remove a great many of the bees I increase to a considerable extent the average distance that each can fly without a collision. This distance I will call the bee's *mean free path*. When the bees are numerous the mean free path is very short; when the bees are few the mean free path will be longer, the length being inversely proportional to the number of bees present. Let us now imagine a loose diaphragm to be introduced in the centre of the box, so as to divide the number of bees equally. The same number of bees being on each side, the impacts on the diaphragm will be equal; and the mean speed of the bees being the same, the pressure will be identical on each side of the diaphragm, and it will not move.

Let me now warm one side of this division so as to let it communicate extra energy to a bee when it touches it. As before, a bee will strike the diaphragm with its normal mean velocity, but will be driven back with extra velocity, the reaction producing an increase of pressure on the diaphragm. It will be found, however, that although the diaphragm is free to move, the extra strength of the recoil on the warm side does not produce any motion. This at first sight seems contrary to the law of action and reaction being equal. The explanation is not difficult to understand. The bees which fly away from the diaphragm have drawn energy from it, and therefore move quicker than those which are coming towards it; they beat back the crowd to a greater distance, and keep a greater number from striking the diaphragm. Near to the heated side of the diaphragm the density is less than the average, while beyond the free path the density is above the average, and this greater crowding extends to all other parts of the box. Thus it happens that the extra energy of the impacts against the warm side of the diaphragm is exactly compensated by the increased number of impacts on the cool side. In spite therefore of the increased activity communicated to a portion of the bees, the pressure on the two sides of the diaphragm will remain the same. This represents what occurs when the extent of the box containing the bees is so great, compared with the mean free path, that the abrupt change in the velocities of those bees which rebound from the walls of the box produces only an insensible influence on the motions of bees at so great a distance as the diaphragm.

I will next ask you to imagine that I am gradually removing bees from our box, still keeping the diaphragm warm on one side. The bees getting fewer the collisions will become less frequent, and the distance each bee can fly before striking its neighbour will get longer and longer, and the crowding in front of them will grow less and less. The compensation will also diminish, and the warmed side of the diaphragm will have a tendency to be beaten back. A point will at last be reached on the warm side, when the mean free path of the bees will be long enough to admit of their dashing right across from the diaphragm to the side of the box, without meeting more than a certain number of in-coming bees in their flight. In this case the bees will no longer fly quite in the same direction as before. They will now fly less sideways, and more forwards and backwards between the heated face of the diaphragm and the opposed wall of the box. Because of this preponderating motion, and also because they will thereby less effectually keep back bees crowding in from the sides, there will now be a greater proportionate pressure both on the hot face of the diaphragm and on that part of the box which is in front of it. Hence the pressure on the hot side will now exceed that on the cool side of the diaphragm, which will consequently have a backward movement communicated to it.

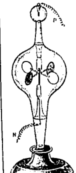


FIG. 1.

I may diminish the size of the bees as much as I like, and by correspondingly increasing their number the mean free path will remain the same. Instead of bees let me call them molecules, and instead of having a few hundreds or thousands in the box let me have millions and billions and trillions; and if we also diminish the mean free path to a considerable extent, we get a rough outline of the kinetic theory of gases. (I may just mention that the mean free path of the molecules in air, at the ordinary pressure, is the ten-thousandth of a millimetre.)

Three years ago I had the honour of bringing before you the results of some researches on the radiometer. Let me now take up the subject where I then left off. I have here two radiometers which have been rotating before you under the influence of a strong light shining upon them.

The explanation of the movement of the radiometer is this—the light, or the total bundle of rays included in the term "light," falling upon the blackened side of the vanes, becomes absorbed, and thereby raises the temperature of the black side: this causes extra excitement of the air molecules which come in contact with it, and pressure is produced, causing the fly of the radiometer to turn round.

I have long believed that a well-known appearance observed in vacuum tubes is closely related to the phenomena of the mean

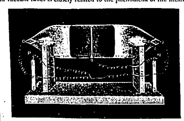


FIG. 2.

free path of the molecules. When the negative pole is examined while the discharge from an induction coil is passing through an exhausted tube, a dark space is seen to surround it. This dark space is found to increase and diminish as the vacuum is varied, in the same way that the ideal layer of molecular pressure in the radiometer increases and diminishes. As the one is perceived by the mind's eye to get greater, so the other is seen by the bodily eye to increase in size. If the vacuum is insufficient to permit the radiometer to turn, the passage of electricity shows

[1] A short-hand report of a lecture delivered at the Royal Institution on Friday, April 4, 1879. By William Crookes, F.R.S. Contributed by the author.

that the "dark space" has shrunk to small dimensions. It is a natural inference that the dark space is the mean free path of the molecules of the residual gas.

The radiometer which has just been turning under the influence of the lime-light is not of the ordinary kind. Fig. 1 will explain its construction.

It is similar to an ordinary radiometer with aluminium disks for vanes, each disk coated on one side with a film of mica. The fly is supported by a hard steel instead of glass cup, and the needle point on which it works is connected by means of a wire with a platinum terminal sealed into the glass. At the top of the radiometer bulb a second terminal is sealed in. The radiometer can therefore be connected with an induction-coil, the movable fly being made the negative pole.

As soon as the pressure is reduced to a few millims. of mercury, a halo of velvety violet light forms on the metallic side of the vanes, the mica side remaining dark. As the pressure diminishes, a dark space is seen to separate the violet halo from the metal. At a pressure of half a millim. this dark space extends to the glass, and positive rotation commences. On continuing the exhaustion the dark space further widens out and appears to flatten itself against the glass, when the rotation becomes very rapid.

You perceive a dark space behind each vane and moving round with it. In the first experiment, radiation from the lime-light falling on the metallic sides of the vanes, produced a layer of molecular pressure which drove the fly round; so here the induction-current has produced molecular excitement at the surface of the vanes forming the negative pole, extending up to the side of the glass.

When the negative pole is in rapid rotation it is not easy to see this dark space, so I have arranged a tube in which the dark space will be visible to all present. The tube, as you will see by the diagram (Fig. 2), has a pole in the centre in the form of a metal disk, and other poles at each end. The centre pole is made negative, and the two end poles connected together are made the positive terminal. The dark space will be in the centre. When the exhaustion is not very great the dark space extends only a little distance on each side of the negative pole in the centre. When the exhaustion is very good, as it is in the tube before you, and I turn on the coil, the dark space is seen to extend for about two inches on each side of the pole.

Here, then, we see the induction spark actually illuminating the lines of molecular pressure caused by the excitement of the negative pole. The thickness of this dark space—nearly two inches—is the measure of the mean free path between successive collisions of the molecules of the residual gas. The extra velocity with which the negatively electrified molecules rebound from the excited pole keeps back the more slowly moving molecules which are advancing towards that pole. The conflict occurs at the boundary of the dark space, where the luminous margin bears witness to the energy of the discharge.

I will endeavour to throw on the screen an illustration of this dark space. A stream of water falls from a small jet on to a horizontal plate of glass. The water spreads over the plate and forms a thin film. The jet of water in the centre, from the velocity of its fall, drives the film of water before it on all sides, raising it into a ring-shaped heap. As I diminish the force of the jet the ring contracts; this is equivalent to the exhaustion getting less. When I increase the force of water the ring expands in size, the effect being analogous to an increase of exhaustion in my tubes. The extra velocity of the falling particles of water drives the in-coming particles of water before them, and raises a ridge round the side which exactly represents the luminous halo to the dark space to be seen in this tube.

If, instead of a flat disk, a metal cup is used for the negative pole, the successive appearances on exhausting the tube are somewhat different. The velvety violet halo forms over each side of the cup. On increasing the exhaustion the dark space widens out, retaining almost exactly the shape of the cup. The bright margin of the dark space becomes concentrated at the concave side of the cup to a luminous focus, and widens out at the convex side. When the dark space is very much larger than the cup, its outline forms an irregular ellipsoid drawn in towards the focal point. Inside the luminous boundary a dark violet light can be seen converging to a focus, and, as the rays diverge on the other side of the focus, spreading beyond the margin of the dark space; the whole appearance being strikingly similar to the rays of the sun reflected from a concave mirror through a foggy atmosphere. This proves a somewhat important point; it shows that the molecules thrown off the excited negative pole leave it in a direction almost normal to the surface.

I can illustrate this property of the molecular rays by an experiment. This diagram (Fig. 3) is a representation of the tube which is before you. It contains, as a negative pole, a hemi-cylinder (*a*) of polished aluminium. This is connected with a fine copper wire, *b*, ending at the platinum terminal, *c*.

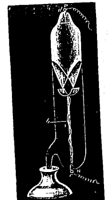


FIG. 3.

At the upper end of the tube is another terminal, *d*. The induction-coil is connected so that the hemi-cylinder is negative and the upper pole positive, and when exhausted to a sufficient extent, as is the case with this tube, the projection of the molecular rays to a focus is very beautifully shown. The rays are driven from the hemi-cylinder in a direction normal to its surface; they come to a focus and then diverge, tracing their path in brilliant green phosphorescence on the surface of the glass.

You will notice that the rays which project from the negative pole and cross in the centre have a bright green appearance; that colour is entirely due to the phosphorescence of the glass. At a very high exhaustion the phenomena noticed in ordinary vacuum tubes when the induction spark passes through them—an appearance of cloudy luminosity and of stratifications—disappears entirely. No cloud or fog whatever is seen in the body of the tube, and with such a vacuum as I am working with in these experiments—about a millionth part of an atmosphere—the inner surface of the glass glows with a rich green phosphorescence, the intensity of colour varying with the perfection of the vacuum. It scarcely begins to show much before the 800,000th of an atmosphere. At about a millionth of an atmosphere the phosphorescence is very strong, and after that it begins to diminish

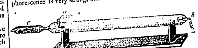


FIG. 4.

until there are not enough molecules left to allow the spark to pass.[1]

I have here a tube which will serve to illustrate the dependence of the green phosphorescence of the glass on the degree of perfection of the vacuum (Fig. 4). The two poles are at *a* and

[1] 1·0 millionth of an atmosphere = 0·00076 millim.
1315·789 millionths of an atmosphere = 1·0 millim.
1,000,000 " " " = 760·0 millims.
" " " " = 1 atmosphere.

90

NOUVELLES RECHERCHES DE M. CROOKES

SUR LE RADIOMÈTRE.

M. Crookes a montré que le mouvement du radiomètre est dû à la présence de gaz résiduel. Il a étudié dernièrement la répulsion exercée par la radiation d'une lampe sur des disques de mica et de moelle de sureau recouverts de diverses poudres ou précipités chimiques, et suspendus dans le vide d'un appareil de torsion.

Le tube de verre horizontal *a b* (fig. 1) contient un fléau en paille, à la fois léger et suffisamment rigide. Le fil de torsion *c d*, en flint-glass, est fixé

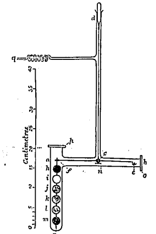


Fig. 1.

en *d* à un bouchon à l'émeri ; pour avoir une fermeture hermétique, on coule autour du bouchon un mastic formé de deux parties de résine et trois de cire d'abeilles. En *c* est un miroir de verre argenté; en *e* une petite cuvette destinée à recevoir les contre poids des disques suspendus à l'autre extrémité. Ces disques, au nombre de six, sont collés sur une tige de verre rigide avec un peu de mastic, et cette tige est ajustée à l'extrémité du fléau au moyen d'une lame d'aluminium. Le premier de ces disques, *h*, est toujours en moelle recouverte de noir de fumée : les autres sont changés à chaque expérience. Un petit aimant permet d'amener le fléau au 0° sans enlever le bouchon *d*. Deux glaces sont mastiquées en *o* et *p* ; on les enlève pour changer les disques ; on fait le vide dans

91

l'appareil par le tube *q* qui communique avec une machine pneumatique à mercure.

Dans la figure 2, l'appareil est en expérience : on voit des trous percés dans le mur en face du miroir

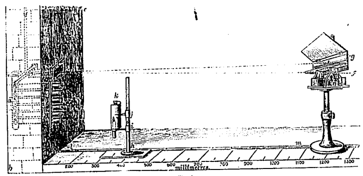


Fig. 2.

et des disques. Le premier *d* est limité par une carte noircie vers l'intérieur; les autres sont munis

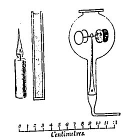


Fig. 3.

de tubes également noircis. Les intervalles sont remplis de coton cardé. L'appareil est en outre pro-

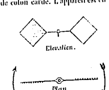


Fig. 4.

tégé par une rangée de bouteilles pleines d'eau et un écran en bois.

L'image d'une lampe fournie par le miroir *c* se promène sur la division d'une règle *g* placée à

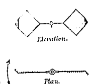


Fig. 5.

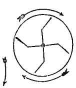


Fig. 6.

1m,50 de distance ; le déplacement de cette image mesure la déviation du fléau.

Une seconde lampe, dont on connait la distance à

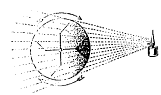
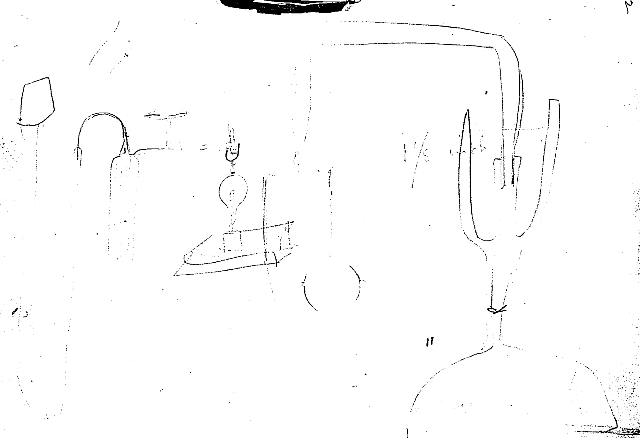


Fig. 7.

l'appareil, envoie ses rayons à tel ou tel disque que l'on veut.

Les poudres étaient appliquées sur les disques comme une peinture à l'eau, sans mastic. On reconnaissait que le vide était toujours poussé au même

92



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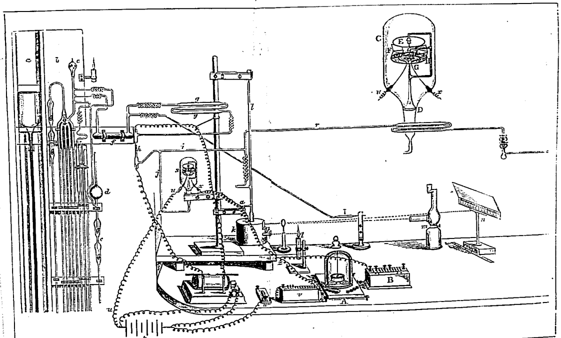


Fig. 15. — *a*, *b*. Partie supérieure de la pompe pneumatique. — *d*, *e*. Appareil de Mac-Leod pour mesurer la pression résiduelle. — *f*. Tube à acide phosphorique anhydre. — *g*. Tubes contenant du soufre précipité du cuivre réduit. — *h*. Tube de Geissler pour examiner le spectre du gaz résiduel. — *k*, *m*, *n*, *p*, *q*. Appareil pour mesurer la viscosité du gaz. — *s*. Appareil fig. 14 : le cercle de platine est recouvert d'un disque de mica noirci. — *t*. Pile. — *r*, B. Boîtes de résistance. — *w*. Commutateur. — A. Galvanomètre.

CONTRIBUTIONS TO MOLECULAR PHYSICS IN HIGH VACUA.*

Eng Mechanic July Aug 1879

94

THIS paper is a continuation of one "Of the Illumination of Lines of Molecular Pressure, and the Trajectory of Molecules" (p. 383, Vol. XXVIII.). The author has further examined the action of the molecular rays electrically projected from the negative pole in very highly exhausted tubes, and finds that the green phosphorescence of the glass (by means of which the presence of the molecular rays is manifested) does not take place close to the negative pole. Within the dark space there is absolutely no phosphorescence; at very high exhaustions the luminous boundary of the dark space disappears, and now the phosphorescence extends all over the sensitive surface. Assuming that the phosphorescence is due either directly or indirectly to the impact of the molecules on the phosphorescent surface, it is reasonable to suppose that a certain velocity is required to produce the effect. The author adduces arguments to show that within the dark space, at a moderate exhaustion, the velocity does not accumulate to a sufficient extent to produce phosphorescence, but at higher exhaustions the mean free path is long enough to allow the molecules to get up sufficient speed to excite phosphorescence. At a very high exhaustion there are fewer collisions, and the initial speed of the molecules close to the negative pole not being thereby reduced, phosphorescence takes place close to the pole.

Experiments are described in which a pole folded into corrugations is used at one end of a tube, the pole at the other end being flat, set obliquely to the axis of the tube, and having a plate of mica in front pierced with a hole opposite the centre of the pole. The questions which this apparatus was designed to answer are: (1) Will there be two sets of molecular projections from the corrugated pole when made negative, one perpendicular to each facet, or will the projection be perpendicular to the electrode as a whole, *i.e.*, along the axis of the tube? (2) Will the molecular rays from the oblique flat pole, when this is made negative, issue through the aperture of the screen along the axis of the tube, *i.e.*, direct to the positive pole, or will they leave the pole normal to the surface and strike the glass on its side? With the corrugated pole experiment shows that at high exhaustions molecular rays are projected from each facet to the inner surface of the tube, where they excite phosphorescence, and form portions of ellipses by the intersection of the planes of molecular rays with the cylindrical tube. When the oblique flat pole is made negative, a stream of molecules shoots from it nearly normal to its surface, and those which pass through the hole in the plate of mica strike the side of the tube, forming an oval patch of a green colour.

The oval patch in this apparatus happens to fall on a portion of the glass which has previously had its phosphorescence excited by the molecular discharge from the other corrugated pole. The phosphorescence from this pole is always more intense than that from the flat pole, and the glass, after having been excited by the energetic bombardment, ceases to respond readily to the more feeble excitement from the flat pole. The effect, therefore, is that, when the oval spot appears, it has a dark band across it where the phosphorescence from the other pole has been taking place. The glass recovers its phosphorescent power to some extent after rest.

In this apparatus a shifting of the line of molecular discharge is noticed. If the coil is stopped and then set going repeatedly, always keeping the oblique pole negative, the spot of green light occurs on the glass at the spot where it should come supposing the discharge were normal to the surface of the pole. But if once the flat pole is made positive,

* Abstract of a Paper read before the Royal Society.

the next time it is made negative the spot of light appears nearer the axis of the tube, and instantly shifts to its normal position, where it remains so long as its pole is made negative. There seems no limit to the number of times this experiment can be repeated.

A suggestion having been made by Professor Stokes that a third, idle, pole should be introduced between the negative and positive electrodes, experiments are described with an apparatus constructed accordingly. The potential of the idle poles (of which there are two) at low exhaustions is very feebly positive; as the exhaustion gets better the positive potential increases, and at a vacuum so good as to be almost non-conducting, the positive potential of the idle poles is at its greatest. The result is that an idle pole in the direct line of fire between the positive and negative poles, and consequently receiving the full impact of the molecules driven from the negative pole, has a strong positive potential.

It is found that when the shadow of an idle pole is projected on a phosphorescent screen the trajectory of the molecules suffers deflection when the idle pole is suddenly uninsulated by connecting it with earth. The same result is produced by connecting the idle pole with the negative wire through a very high resistance, such as a piece of wet string, instead of connecting it with earth. A tube, which has already been described in a paper read before the Royal Society on December 5th last, is used to illustrate this deflection. The shadow of an aluminium star is projected on a phosphorescent screen. So long as the metal star is insulated the shadow remains sharp, but on uninsulating the star by connecting it with an earth wire the shadow widens out, forming a tolerably well-defined penumbra outside the original shadow, which can still be seen unchanged in size and intensity. On removing the earth connection, the penumbra disappears, the umbra remaining as before.

It is also found that the shadow of the star is sharply projected when it is made the positive pole, the negative pole remaining unchanged.

These experiments are explained by the results just mentioned, that the idle pole, the shadow of which is cast by the negative pole, has strong positive potential. The stream of molecules must be assumed to have negative potential; when they actually strike the idle pole they are arrested, but those which graze the edge are attracted inwards by the positive potential and form the umbra. When the idle pole is connected with earth, its potential would become zero were the discharge to cease; but inasmuch as a constant supply of positive electricity is kept up from the passage of the current, we must assume that the potential of the idle pole is still sufficient to more than neutralise the negative charge which the impinging molecules would give it. The effect, therefore, of alternately uninsulating and insulating the idle pole is to vary its positive potential between considerable limits, and consequently its attractive action on the negative molecules which graze its edge. The result is a wide or a narrow shadow, according to circumstances.

After a definite shadow is produced, it is found that increasing the exhaustion makes very little change in the umbra, but it causes the penumbra to increase greatly in size. Experiments recorded in the Paper already quoted have proved that the velocity of the molecules is greater as the vacuum gets higher, and consequently the trajectory of the molecules under deflecting action, whether of a magnet or of an insulated idle pole, is flatter at high than at low vacua.

An experiment is next described, having for its object to ascertain whether two parallel molecular rays from two adjacent negative poles attract or repel each other. It is considered that if the stream carries an electric current, attraction should ensue, but if they are simply streams of similarly electrified bodies, the result would be repulsion. Experiment proves that the latter alternative happens, lateral repulsion taking place between two streams moving in the same direction.

Many experiments are given to illustrate the law of action of magnets on the molecular stream, but the results are of too complicated a character to bear condensation without the diagrams accompanying the original paper.

The molecular stream is sufficiently sensitive to show appreciable deflection by the magnetism of the earth.

The author, after numerous experiments, has succeeded in obtaining continuous rotation of the molecular stream under the influence of a magnet, analogous to the well-known rotation at lower exhaustions. Comparative experiments are given with a "high vacuum" tube, where no luminous gas is visible, but only green phosphorescence on the surface of the glass, and a "low vacuum" tube, in which the induction spark passes in the form of a luminous band of light joining the two poles. These two tubes are mounted over similar electro-magnets, the direction of discharge being in a line with the axis of the magnet. Numerous experiments, the details of which are given in the paper, show that the law is not the same at high as at low exhaustions. At high exhaustions the magnet causes the molecular rays to rotate in the same direction, whether they are coming towards the magnet or going from it, the direction of rotation being entirely governed by the magnetic pole presented to the stream. The north pole rotates the molecular discharge in a direct sense, independent of the direction in which the induction current passes. The direction of rotation impressed on the molecules by a magnetic pole is opposite to the direction of the electric current circulating round the magnet. These results offer an additional proof that the stream of molecules driven from the negative pole in high vacua do not carry an electric current in the ordinary sense of the term.

The author, after giving details of experiments in which platinum and glass are fused in the focus of converging molecular rays projected from a concave pole, describes observations with the spectroscope, which show that glass obstinately retains at even a red heat a compound of hydrogen—probably water—which is only driven completely off by fusion. The permanent deadening of the phosphorescence of glass is shown by projecting the shadow of a metal cross on the end of a bulb for a considerable time. On suddenly removing the cross, its image remains visible, bright upon a dark ground.

One of the most striking of the phenomena attending this research is the remarkable power which the molecular rays in a high vacuum have of causing phosphorescence in bodies on which they fall. Substances known to be phosphorescent under ordinary circumstances shine with great splendour when subjected to the negative discharge in a high vacuum. Thus Becquerel's luminous sulphide of calcium has been found invaluable in this research for the preparation of phosphorescent screens whereon to trace the paths and trajectories of the molecules. It shines with a bright blue-violet light, and when on a surface of several square inches is sufficient to faintly light a room.

The only body which the author has yet met with which surpasses the luminous sulphides, both in brilliancy and variety of colour, is the diamond. Most diamonds from South Africa phosphoresce with a blue light. Diamonds from other localities shine with different colours, such as bright blue, apricot, pale blue, red, yellowish green, orange, and pale green. One very beautiful diamond in the author's collection gives almost as much light as a candle when phosphorescing in a good vacuum.

Next to the diamond, alumina and its compounds are the most strikingly phosphorescent. The ruby glows with a rich full red, and it is of little consequence what degree of colour the stone possesses naturally, the colour of the phosphorescence is nearly the same in all cases; chemically prepared and strongly ignited alumina phosphoresces with as rich a red glow as the ruby. The phosphorescent glow does not, therefore, depend on the colouring matter. E. Becquerel has shown by experiments with his phosphoroscope that alumina and many of its compounds phosphoresce of a red colour after insolation.

Nothing can be more beautiful than the effect presented by a mass of rough rubies when glowing in a vacuum; they shine as if they were red hot, and the illumination effect is almost equal to that of the diamond under similar circumstances. Masses of artificial ruby in crystals prepared by M. Ch. Feil, behave in the vacuum like the natural ruby.

In the spectroscope the alumina-glow shows one intense and sharp red line less refrangible than the line B, and a faint continuous spectrum ending at about B. The wave-length of the red line is 6895. The paper concludes with some notes by Professor Maskelyne, on the connection between molecular phosphorescence and crystalline structure.

The crystals experimented on have been the diamond, emerald, beryl, sapphire, ruby, quartz, phenakite, tinstone, hyacinth (zircon), tourmaline, andalusite, enstatite, minerals of the augite class, apatite, topaz, chrysoberyl, peridot, garnet, and boracite. Of these, the only crystals which give out light are diamond, ruby, emerald, sapphire, tinstone, and hyacinth. The light from emerald is crimson, and is polarised, apparently completely, in a plane perpendicular to the axis. Sapphire gives out a bluish-grey and a red light polarised in a plane perpendicular to the axis. The ruby light exhibits no marked distinction in the plane of its polarisation.

Among positive crystals tinstone glows with a fine yellow light, polarised in a plane parallel to the axis of the crystal. So far, the experiments accord with the quicker vibrations being those called into play, and therefore in a negative crystal the extraordinary, and in a positive crystal the ordinary, is the ray evoked. Hyacinth, however, introduces a new phenomenon, being dichroic, the colours, in three different crystals, being pale, pink and lavender—blue, pale blue and deep violet, and yellow and deep violet-blue, polarised in opposite planes. The only conclusion arrived at is, that the rays whose direction of vibration corresponds to the direction of maximum optical elasticity in the crystal, are always originated where any light is given out. As yet, however, the induction on which so remarkable a principle is suggested, cannot be considered sufficiently extended to justify that principle being accepted as other than probable.

edge.

95

"Kravogl's air-pump contains a hollow glass cylinder AB tapering at the upper end, and surmounted by a kind of funnel. The piston is of the same shape as the cylinder, and is covered with a layer of mercury, whose depth over the point of the piston is about $\frac{1}{50}$th of an inch when the piston is at the bottom of its stroke, but is nearly an inch when the piston rises and fills the funnel-shaped cavity in which the pump-barrel terminates. A small interval, filled by the liquid, is left between the barrel and the piston; but at the bottom of the barrel the piston passes through a leather box carefully made, so as to be perfectly air-tight.

"The air from the receiver passes through the lateral opening *c*; it is driven before the mercury into the funnel above. With the air passes a certain quantity of mercury, which is detained by a steel valve, *c*, at the narrowest part of the funnel. This valve

Iron July 26 1879

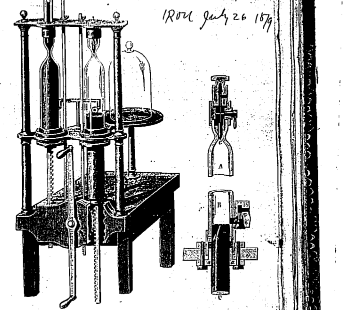


Fig. 115. Kravogl's Air Pump.

rises automatically when the surface of the mercury is at a distance of about half an inch from the funnel, and falls back into its former position when the piston is at the end of its upward stroke. In the downward stroke, when the mercury is again half an inch from the funnel, the valve opens again and allows a portion of the mercury to pass.

"The effect of this arrangement is easily understood; there is no 'untraversed space,' the presence of the mercury above and around the piston causes a very complete fit, and excludes the external air; and hence the machine, when well made, is very effective.

"When this is the case, and when the mercury used in the apparatus is perfectly dry, a vacuum of about $\frac{1}{250}$th of an inch can be obtained. The dryness of the mercury is a very important condition, for at ordinary temperatures the elastic force of the vapour of water has a very sensible value. If we wish to employ the full powers of the machine, we must have, between the vessel to be exhausted of air and the pump-barrel, a desiccating apparatus.

"The arrangement of the valve *c* is peculiar. It is of a conical form, so as, in its lowest position, to permit the passage of air coming from the receiver. Its ascent is produced by the pressure of the mercury, which forces it against the conical extremity of the passage, and the liquid is thus prevented from escaping.

"The figure represents a double-barrelled machine analogous to the ordinary air-pump. Besides the pinion working with the racks of the pistons, there is a second smaller pinion, not shown in the figure, which governs the movements of the valves *c*. All the parts of this machine, as the stop-cocks, valves, pipes, &c., must be of steel

over

to avoid the action which the mercury would have upon any other metal."

"Geissler, of Bonn, has invented a mercurial air-pump, in which the vacuum is produced by communication of the receiver with the Torricellian vacuum. Fig. 146 represents this machine as constructed by Alvergniat. It consists of a vertical tube, which serves as a barometric tube, and communicates at the bottom, by means of a caoutchouc tube, with a globe which serves as the cistern.

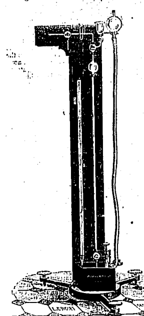


Fig. 146. Geissler's Machine.

"At the top of the tube is a three-way stop-cock, by which communication can be established either with the receiver to the left, or with a funnel to the right, which latter has an ordinary stop-cock at the bottom. By means of another stop-cock on the left, communication with the receiver can be opened or closed. These stop-cocks are made entirely of glass. The machine works in the following manner:—Communication being established with the funnel, the globe which serves as cistern is raised, and placed, as shown in the figure, at a higher level than the stop-cock of the funnel. By the law of equilibrium in communicating vessels, the mercury fills the barometric tube, the neck of the funnel, and part of the funnel itself. If the communication between the funnel and tube be now stopped, and the globe lowered, a Torricellian vacuum is produced in the upper part of the vertical tube.

"Communication is now opened with the receiver; the air rushes into the vacuum, and the column of mercury falls a little. Communication is now stopped between the tube and receiver, and opened between the tube and the funnel, the simple stop-cock of the funnel being, however, left shut. If at this moment the globe is replaced in the position shown in the figure, the air endeavours to escape by the funnel, and it is easy to allow it to do so. Thus, a part of the air of the receiver has been removed, and the apparatus is in the same position as at the beginning. The operation described is equivalent to a stroke of the piston in the ordinary machine, and this process must be repeated till the receiver be exhausted.

"As the only mechanical parts of this machine are glass stop-cocks, which are now executed with great perfection, it is capable of giving good results. With dry mercury a vacuum of $\frac{1}{250}$th of an inch may very easily be obtained. The working of the machine, however, is inconvenient, and becomes exceedingly laborious when the receiver is large. It is therefore employed directly only for producing a vacuum in very small vessels; when the spaces to be exhausted of air are at all large, the operation is begun with the ordinary machine, and the mercurial air-pump is only employed to render the vacuum thus obtained more perfect."

Sc. Am. S. Aug 9 1879

ELECTRIC DISCHARGES IN RAREFIED GASES.

MESSRS. DE LA RUE and Müller, in the researches which they have carried on during three and a half years, have contributed facts of the highest value toward the solution of the problem presented by the beautiful phenomenon of stratification produced by electric discharges in vacuum tubes. The results of their labors are given in full in the *Philosophical Transactions*.

The authors state that there is a serious trouble connected with the study of the discharge in rarefied gases, for, after a very short time, the tubes completely and permanently change, so as no longer to present the splendid stratifications witnessed on a first trial. We believe these changes occur much more rapidly with the battery in consequence of the greater amount of current than with the induction coil; but the fact appears to have been well known to Dr. Geissler, of Bonn, who, on the occasion of a visit to our laboratory, brought with him some tubes through which no current had previously passed (virgin tubes, as he called them), which presented must beautiful phenomena lost for ever after too brief a period.

A cyanogen tube, for example, when first connected with the battery, presented strata which completely filled the tube without leaving a dark space near the negative, some threading themselves on it, but after a few seconds the strata widened out as on the right hand figure, then other changes occurred, and the first phases have never been reproduced.

After spending much time in experiments with tubes prepared for us by Dr. Geissler, Messrs. Alvergniat Frères, of Paris, and Mr. Hicks, of Hatton Garden, with the vexation of finding that we could not often enough repeat our experiments, we ultimately came to the conclusion to have others made, but not exhausted, and to perform ourselves the charging and exhaustion. The tubes we usually employ have a glass stop-cock fitted to them at each end; they are 32 inches long, and from 1·75 to 2 inches in diameter; the terminals are of aluminum, and about 29 inches apart,

one being a ring, the other a wire bent at a right angle, so as to point in the direction of the axis of the tube, for we have found that the phenomena vary according as the ring or wire is made positive.

These we exhaust and fill with any gas we may wish to experiment with, and gradually exhaust again, noting the phenomena presented at different pressures, with different potentials, and with different amounts of current. We refill and exhaust the tube again and again, and mostly obtain, under the same conditions, as nearly as possible the same phenomena, of which we are careful to make sketches and, if possible, to obtain photographic records.

The apparatus which we have found it advantageous to adopt for the exhaustion of our tubes comprises three means of exhaustion, which are successively employed as the vacuum becomes more perfect. The first is an Alvergniat high-pressure water *trompe* in connection with the high-pressure water main of the West Middlesex Water Company, the head of water being 106 feet; it produces a vacuum to within half an inch (0·47 in. = 12 millims.) of the height of the barometer. The other end of the vacuum tube communicates by means of a Y-piece to both, an Alvergniat mercurial pump, and a Sprengel pump on the left. After the *trompe* has done its work, the Alvergniat is used for rapid exhaustion, and then shut off, leaving the exhaustion to be completed by the Sprengel; we have thus obtained, by the pumps alone, in tubes 32 inches long and 2 inches in diameter, vacua of only 0·002 millimeter pressure, equal to 2·6 millionths of an atmosphere—a vacuum so perfect that the current of 8,040 cells would not pass. The apparatus is in connection with a McLeod gauge, by means of which pressures to 0·00005 mm. can be determined. Besides this gauge the Sprengel and Alvergniat pumps have their own gauges, which read to a millimeter.

Our observations show clearly that discharge through rarefied gases cannot be at all analogous to conduction through metals; for a wire having a given difference of potential between its ends can permit one—and only one—current to pass; whereas from the measurements obtained, it became evident that with a given difference of potential between the terminals of a given vacuum tube currents of strengths varying from 1 to 135 can flow. We are therefore led to the conclusion that the discharge in a vacuum tube does not differ essentially from that in air and other gases at ordinary atmospheric pressures—that it is, in fact, a disruptive discharge.

In every case where the strata are to the eye or rotating mirror perfectly steady slight deflections of the needle are seen; these generally indicate a resultant direct current

increased, the strata pour in, one after the other, in the most steady and beautiful manner from the positive.

5. A change of current frequently produces an entire change in the color of the strata; for example, in a hydrogen tube from a cobalt blue to a pink. It also changes the spectrum of the strata; moreover, the spectra of the illuminated terminals and the strata differ.

6. If the discharge is irregular and the strata indistinct, an alteration of the amount of current makes the strata distinct and steady. Most frequently a point of steadiness is produced by the careful introduction of external resistance; subsequently the introduction of more resistance produces a new phase of unsteadiness, and still more resistance another phase of steady and distinct stratification.

7. The greatest heat is in the vicinity of the strata. This can be best observed when the tube contains either only one stratum, or a small number separated by a broad interval. There is reason to believe that even in the dark discharge there may be strata, for we have found a development of heat in the middle of a tube in which there was no illumination except on the terminals.

8. Even when the strata are to all appearance, perfectly steady, a pulsation can be detected in the current; but it is not proved that the strata depend upon intermittence.

9. There is no current from a battery through a tube divided by a glass division into two chambers, and the tube can only be illuminated by alternating charges.

10. In the same tube and with the same gas a very great variety of phenomena can be produced by varying the pressure and the current. The luminosities and strata, in their various forms, can be reproduced in the same tube, or in others having similar dimensions.

11. At the same pressure and with the same current the diameter of the tube affects the character of the discharge and the form and closeness of the stratification.

to avoid the action which the mercury would have upon any other metal."

"Geissler, of Bonn, has invented a mercurial air-pump, in which the vacuum is produced by communication of the receiver with the Torricellian vacuum. Fig. 146 represents this machine as constructed by Alvergniat. It consists of a vertical tube, which serves as a barometric tube, and communicates at the bottom, by means of a caoutchouc tube, with a globe which serves as the cistern.

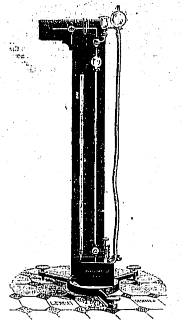


Fig. 146. Geissler's Machine.

"At the top of the tube is a three-way stop-cock, by which communication can be established either with the receiver to the left, or with a funnel to the right, which latter has an ordinary stop-cock at the bottom. By means of another stop-cock on the left, communication with the receiver can be opened or closed. These stop-cocks are made entirely of glass. The machine works in the following manner:—Communication being established with the funnel, the globe which serves as cistern is raised, and placed, as shown in the figure, at a higher level than the stop-cock of the funnel. By the law of equilibrium in communicating vessels, the mercury fills the barometric tube, the neck of the funnel, and part of the funnel itself. If the communication between the funnel and tube be now stopped, and the globe lowered, a Torricellian vacuum is produced in the upper part of the vertical tube.

"Communication is now opened with the receiver; the air rushes into the vacuum, and the column of mercury falls a little. Communication is now stopped between the tube and receiver, and opened between the tube and the funnel, the simple stop-cock of the funnel being, however, left shut. If at this moment the globe is replaced in the position shown in the figure, the air endeavours to escape by the funnel, and it is easy to allow it to do so. Thus, a part of the air of the receiver has been removed, and the apparatus is in the same position as at the beginning. The operation described is equivalent to a stroke of the piston in the ordinary machine, and this process must be repeated till the receiver be exhausted.

"As the only mechanical parts of this machine are glass stop-cocks, which are now executed with great perfection, it is capable of giving good results. With dry mercury a vacuum of $\frac{1}{250}$th of an inch may very easily be obtained. The working of the machine, however, is inconvenient, and becomes exceedingly laborious when the receiver is large. It is therefore employed directly only for producing a vacuum in very small vessels; when the spaces to be exhausted of air are at all large, the operation is begun with the ordinary machine, and the mercurial air-pump is only employed to render the vacuum thus obtained more perfect."

containing a ring, the other a wire bent at a right angle, so as to point in the direction of the axis of the tube, for we have found that the phenomena vary according as the ring or wire is made positive.

These we exhaust and fill with any gas we may wish to experiment with, and gradually exhaust again, noting the phenomena presented at different pressures, with different potentials, and with different amounts of current. We refill and exhaust the tube again and again, and mostly obtain, under the same conditions, as nearly as possible the same phenomena, of which we are careful to make sketches and, if possible, to obtain photographic records.

The apparatus which we have found it advantageous to adopt for the exhaustion of our tubes comprises three means of exhaustion, which are successively employed as the vacuum becomes more perfect. The first is an Alvergniat high-pressure water *trompe* in connection with the high-pressure water main of the West Middlesex Water Company, the head of water being 160 feet; it produces a vacuum to within half an inch (0·47 in. = 12 millims.) of the height of the barometer. The other end of the vacuum tube communicates by means of a Y-piece to both, an Alvergniat mercurial pump, and a Sprengel pump on the left. After the *trompe* has done its work, the Alvergniat is used for rapid exhaustion, and then shut off; leaving the exhaustion to be completed by the Sprengel; we have thus obtained, by the pumps alone, in tubes 32 inches long and 2 inches in diameter, vacua of only 0·002 millimeter pressure, equal to 2·6 millionths of an atmosphere—a vacuum so perfect that the current of 8,040 cells would not pass. The apparatus is in connection with a McLeod gauge, by means of which pressures to 0·00005 mm. can be determined. Besides this gauge the Sprengel and Alvergniat pumps have their own gauges, which read to a millimeter.

Our observations show clearly that discharge through rarefied gases cannot be at all analogous to conduction through metals; for a wire having a given difference of potential between its ends can permit one—and only one—current to pass; whereas from the measurements obtained, it became evident that with a given difference of potential between the terminals of a given vacuum tube currents of strengths varying from 1 to 135 can flow. We are therefore led to the conclusion that the discharge in a vacuum tube does not differ essentially from that in air and other gases at ordinary atmospheric pressures—that it is, in fact, a disruptive discharge.

In every case where the strata are to the eye or rotating-mirror perfectly steady slight deflections of the needle are seen; these generally indicate a resultant direct current (break contact), and in the fewer number of cases an inverse current indicating, in the first case, a sudden decrease and slow increase of current through the tube. These deflections, though very manifest, do not amount to more than about three or four divisions of the galvanometer scale, a deflection which indicates a current of only 0·00000000023 W. At the advent or retreat of a stratum at the positive pole there is frequently produced a deviation of 300 divisions, indicating a current of 0·00000001812 W.; before a stratum leaves the positive terminal or dies out on it, there is usually a tremulous motion of that stratum visible to the eye and indicated by rapid pulsations of the galvanometer.

On the suggestion of Prof. Clerk Maxwell we have recently introduced the telephone into the primary current, and also in the secondary current.

In all cases where the condenser, was discharging itself gradually through the tube, a low rustling sound was distinctly audible to sensitive ears so long as the stratification remained apparently perfectly steady. When the phase of confused stratification which immediately precedes extinction was reached, the sound in the telephone became very loud and rose in pitch, with some tubes becoming quite shrill. These results, therefore, confirm the conclusion already arrived at from other experiments, namely, that the discharge in vacuum tubes is intermittent; but we do not pretend that they make it manifest that stratification is dependent upon intermittence.

In the course of our experiments, using sometimes 11,000 cells, we have arrived at the following facts:

1. The discharge in a vacuum tube does not differ essentially from that in air and other gases at ordinary atmospheric pressures; it cannot be considered as a current in the ordinary acceptation of the term, but must be of the nature of a disruptive discharge, the molecules of the gas acting as carriers of electrification. The gases in all probability receive impulses in two directions at right angles to each other, that from the negative being the more continuous of the two. Metal is frequently carried from the terminals and is deposited on the inside of the tube, so as to leave a permanent record of the spaces between the strata.

2. As the exhaustion proceeds the potential necessary to cause a current to pass diminishes up to a certain point, whence it again increases, and the strata thicken and diminish in number, until a point is reached at which, notwithstanding the high electromotive force available, no discharge through the residual gas can be detected. Thus, when one pole of a battery of 8,040 cells was led to one of the terminals of the tube, which has a radiometer attached to it, the other terminal of the tube, distant only 0·1 inch, being connected through a sensitive Thomson galvanometer to the other pole of the battery (earth), the current observed was not greater than that which was found to be due to conduction over and through the glass. Although no current passed, the leading wires acting inductively stopped the motion of the radiometer, as has been observed by Sir William Grove.

3. All strata have their origin at the positive pole. Thus, in a given tube, with a certain gas, there is produced at a certain pressure, in the first instance, only one luminosity which forms on the positive terminal; then, as the exhaustion is gradually carried further, it detaches itself, moving toward the negative, and being followed by other luminosities, which gradually increase in number up to a certain point.

4. With the same potential the phenomena vary irregularly with the amount of current. Sometimes, as the current is increased, the number of strata in certain tubes increases, and as it is diminished their number decreases; but with other tubes the number of strata frequently increases with a diminution of current. If the source of the current is a charged condenser, the flow being from one of its plates through resistances and the tube to the other, then, as the potential of the condenser falls and the current diminishes, the number of strata alters; if the strata diminish in number with the fall of potential, then the stratum nearest the positive wire disappears on it, the next then follows and disappears, and so on with others; if, on the other hand, the charge of the condenser is very gradually increased, the strata pour in, one after the other, in the most steady and beautiful manner from the positive.

5. A change of current frequently produces an entire change in the color of the strata; for example, in a hydrogen tube from a cobalt blue to a pink. It also changes the spectrum of the strata; moreover, the spectra of the illuminated terminals and the strata differ.

6. If the discharge is irregular and the strata indistinct, an alteration of the amount of current makes the strata distinct and steady. Most frequently a point of steadiness is produced by the careful introduction of external resistance; subsequently the introduction of more resistance produces a new phase of unsteadiness, and still more resistance another phase of steady and distinct stratification.

7. The greatest heat is in the vicinity of the strata. This can be best observed when the tube contains either only one stratum, or a small number separated by a broad interval. There is reason to believe that even in the dark discharge there may be strata, for we have found a development of heat in the middle of a tube in which there was no illumination except on the terminals.

8. Even when the strata are to all appearance, perfectly steady, a pulsation can be detected in the current; but it is not proved that the strata depend upon intermittence.

9. There is no current from a battery through a tube divided by a glass division into two chambers, and the tube can only be illuminated by alternating charges.

10. In the same tube and with the same gas a very great variety of phenomena can be produced by varying the pressure and the current. The luminosities and strata, in their various forms, can be reproduced in the same tube, or in others having similar dimensions.

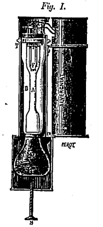
11. At the same pressure and with the same current the diameter of the tube affects the character of the discharge and the form and closeness of the stratification.

APPARATUS FOR MEASURING FIRE DAMP.

THE principle of this apparatus is based upon the property of palladium, when in a red hot state, of oxidizing fire-damp (carbureted hydrogen) into carbonic acid gas and water. The apparatus is constructed by Mr. Coquillon in two different shapes, namely, the *grisoumètre portatif* and *grisoumètre fixe*. Fig. 1 represents the portable grisometer. With it the quantity of fire damp contained in the air can be determined at any place in a very short time.

A represents a graduated glass cylinder, open at the bottom, but closed on top by a perforated rubber stopper. A palladium wire, F, passes through two of these perforations, and is connected with a battery by means of binding screws. A small glass tube, open below but closed on top, also passes

Fig. I.



through the stopper. The tube, A, is inclosed in a larger glass tube, B, also provided with a rubber stopper, through which another small tube like the one just described passes. A vessel, M, the bottom of which is composed of some membrane, is attached to the lower end of B. All these parts are incased in a sheet metal box or cylinder provided with two vertical slots for the purpose of enabling a person to read the scales. Before operating with the apparatus it is entirely filled with water. By opening the two small glass tubes and pressing the membrane upwards by the screw, S, a certain quantity of the gas or air to be examined can be admitted into the cylinders, A and B. The two small glass tubes are then closed, and the palladium is heated until it is red hot by means of the battery. As soon as the carbureted hydrogen is oxidized the levels in the two cylinders are made equal, the scales will indicate their position, and from the diminution of the water the quantity of carbureted hydrogen can be determined.

The fixed grisometer (Fig. 2) is adapted for measuring larger quantities of air. A is the graduated tube, B the palladium wire, C is a tube containing the gas or air, and F a

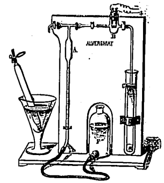


Fig. II.

vessel containing water. If the quantity of carbureted hydrogen is over 9 per cent., it will be necessary to mix the gas with air, as there always must be a surplus of oxygen. If a closed tube, D (Fig. 3), containing lye, be added to the apparatus, the same can be used for measuring any carbureted

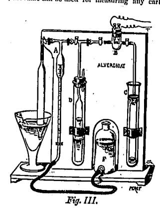


Fig. III.

gas, and is then known as the carborometer. For complicated gases it will be necessary to insert several tubes into D.—*Chemiker Zeitung.*

THE CONFINES OF MATTER.

N. Y. Sept 21/1879

In a lecture delivered in the latter part of last month before the British Association, Professor W. F. Crookes (who will, perhaps, be best remembered by the general public for his investigations of Spiritualism and his invention of the radiometer or so-called "light-mill," although its action is due not to light but to the molecular movements in the confined gas which are set up by heat) gave an extended account of his experiments in "radiant matter," or matter as far removed in its phenomena from gas as gas is removed from fluids. As long ago as 1816 Faraday suspected the existence of matter in this form, and although he did not experimentally know it, gave it the name which Professor Crookes has now adopted. In Dr. Bence Jones's "Life and Letters of Faraday" the following quotation is given: "I may now notice a curious progression in physical properties accompanying changes of form which is perhaps sufficient to induce in the inventive and sanguine philosopher a considerable degree of belief in the association of the radiant form with the others in the set of changes I have mentioned." As we ascend from the solid to the fluid and gaseous states physical properties diminish in number and variety, each state losing some of those which belonged to the preceding state. When solids are converted into fluids all the varieties of hardness and softness are necessarily lost. Crystalline and other shapes are destroyed. Opacity and color frequently give way to a colorless transparency, and a general mobility of particles is conferred. Passing onwards to the gaseous state, still more of the evident characters of bodies are annihilated. The immense differences in their weight almost disappear; the remains of difference in color that were left are lost. Transparency becomes universal, and they are all elastic. They now form but one set of substances, and the varieties of density, hardness, opacity, color, elasticity and form which render the number of solids and fluids almost infinite are now supplied by a few slight variations in weight and some unimportant shades of color. To those, therefore, who admit the radiant form of matter, no difficulty exists in the simplicity of the properties it possesses, but rather an argument in their favor. These persons show you a gradual resignation of properties in the matter we can appreciate as the matter ascends in the scale of forms, and they would be surprised if that effect were to cease at the gaseous state. They point out the greater exertions which nature makes at each step of the change, and think that, consistently, it ought to be greatest in the passage from the gaseous to the radiant form." According to this conception, radiant matter would bear no small resemblance to the "ultra-mundane corpuscles" which Le Sage imagined to be the physical cause of gravitation, coming in all directions from regions far beyond that part of the system of the world which is in any way known to us and driving bodies towards each other by physical impact. The present theory of gases is that they are composed of an almost infinite number of molecules which are constantly moving in every direction with velocities of all conceivable magnitudes. It follows from the vast number of these molecules that no molecule can move far in any direction without coming in contact with some other molecule. But if we exhaust the air or gas in a closed vessel the number of molecules is lessened, and the distance through which any one of them may pass without encountering another is increased, the length of the mean free path being inversely proportioned to the number of molecules present. The further this process is continued the longer becomes the mean free path, and the more the physical properties of the gas are modified. At a certain point of exhaustion the phenomena of the radiometer are possible, and the sails of the "mill" are turned by the radiant or straight-line motion of the molecules. When the exhaustion is carried still further, phenomena occur which are very distinct from those of air or gas at ordinary tension—so far removed, indeed, as to present matter in a state as distinct from gas as gas is from a liquid. In this fourth state "we seem at length to have within our grasp and obedient to our control the little indivisible particles which, with good warrant, are supposed to constitute the physical basis of the universe"—in other words, we have actually touched the borderland of matter and are on the threshold of the storehouse of force and energy—at the crag on which at the bidding of Force and Strength Hephaistos bound Prometheus for giving celestial fire to mankind.

When a discharge from an induction coil is passed through a vacuum tube—a perfect vacuum, it should be remembered, it is impossible to obtain—a dark space is seen around the negative pole, and this dark space increases and diminishes as the vacuum is varied according as the mean free path of the molecules increases or diminishes, being less when a greater number of molecules is present than in a smaller number. The thickness of the dark space is the measure of the mean free path between successive collisions of the molecules of the residual gas. By coming in contact with the negative pole of the coil the molecules are negatively electrified and rebound, keeping back the more slowly moving molecules which are advancing towards that pole, and the gaseous residue within the dark space is in an entirely different state from that of the residual gas in vessels at a lower degree of exhaustion. When a high state of exhaustion is reached the dark space—as Professor Crookes showed in his experiments before the British Association, his lecture being illustrated throughout with ocular demonstrations—may be widened out till it entirely fills the tube, and here by great rarefaction the mean free path becomes so long that the collisions of the molecules may be disregarded and the average molecule be considered as allowed to obey its own laws of motion without interference. They are able under the influence of the negative electricity imparted to them to dart transversely across the tube with comparatively few collisions, and radiating from the pole with enormous velocity they assume properties so novel and so characteristic as to justify their name of "radiant matter." The radiant matter darting in a beam athwart the dark space excites luminosity at its borders, where its velocity is arrested by the residual gas outside of the dark space when this does not fill the tube, but when there is no residual gas the molecules will have their velocity arrested only when they reach the sides of the glass; and here we come to the first and one of the most noteworthy properties of radiant matter discharged from the negative pole—its power, namely, of exciting phosphorescence when it strikes against solid matter. The number of bodies which respond luminously to this molecular bombardment is very great, and the resulting colors are of every variety. When a diamond is thus bombarded in a dark room it shines with as much light as a candle, phosphorescing with a bright green, and rubies shine with a brilliant rich red tone, as if they were glowing hot, as also does precipitated alumina. The phosphorescent properties of radiant matter are best developed in a vacuum equal to about one one-millionth of an atmosphere, after which it diminishes till the induction spark is unable to pass. The second property of radiant matter, as developed in Professor Crookes's experiments, is that it proceeds in straight lines and absolutely refuses to turn a corner. It will be remembered that a phosphorescent light appeared where the beam of radiant matter was arrested by the side of the vacuum tube; if now a V-shaped tube be employed, a pole being at the extremity of each arm, the whole of the right arm will be flooded with light when the electricity is there turned on, which, however, stops abruptly at the bottom of the arm and will not turn the corner—the same being the case with the left arm when the conditions are reversed, the light always following the negative pole and leaving the positive side with scarcely any luminosity. This is entirely at variance with the phenomena ordinarily exhibited in vacuum tubes which are not highly enough exhausted to exhibit the properties of the fourth form of matter. In such tubes the luminosity caused by the phosphorescence of residual gas follows all the convolutions into which glass-blowers can contrive to twist the glass. The negative pole being at one end and the positive pole at the other in such cases, the luminous phenomena seem to depend more on the positive than on the negative, but at a very high exhaustion the phenomena noticed in the ordinary vacuum tube when the induction spark passes through it—an appearance of cloudy luminosity and of stratifications—wholly disappear. No cloud or fog whatever is seen in the body of the tube, and the only light observed is that from the phosphorescent surface of the glass. Moreover, in a low vacuum the position of the positive pole is of every importance, while in a high vacuum its position scarcely matters at all, the phenomena seeming to depend entirely on the negative pole. If the negative pole points in the direction of the positive, all very well, but if it is entirely in the opposite direction it is of little consequence—the radiant matter darts all the same in a straight line from the negative. Another property of this newly discovered form of matter is that when it is intercepted by solid matter it casts a shadow. Radiant matter comes from the pole in straight lines, and does not merely permeate all parts of the tube and fill it with light, as would be the case were the exhaustion less good. Where there is nothing in the way the rays strike the glass and produce phosphorescence, and where solid matter intervenes they are obstructed and a shadow is cast. If a cruciform screen of aluminium is introduced into the tube so as to intercept some of the molecules darting from the negative pole a shadow will be cast on the glass behind the screen, and where the molecules have shot past the edges of the aluminium and fallen on the tube the glass where they have made their impact will presently become so hammered and bombarded as to have grown "tired"—that is, its sensibility will be lessened so that it will fail to respond easily to additional excitement. But the part on which the shadow of the cross has fallen is not tired, but perfectly fresh, and when the screen is made to drop, the shadow will at once shine brilliantly inside of the tired and somewhat darkened area of the former phosphorescence. Glass thus bombarded never recovers its first sensibility, and this demonstrates another property of radiant matter, which is that it is projected with great velocity from the negative pole and not only strikes the glass in such a way as to cause it to vibrate and become temporarily luminous while the discharge is going on, but the molecules hammer away with sufficient energy to produce a permanent impression on the glass. Moreover, radiant matter exerts strong mechanical action where it strikes. It has just been shown that it is arrested by solid matter placed in its path. If this solid matter is easily moved the impact of the molecules will reveal itself in mechanical action. A

small wheel so placed that the molecules may play upon its paddles will revolve as in the radiometer, the swiftness of its revolutions increasing with the increase of the exhaustion of the tube, and if a ring of platinum wire in the tube be made hot with the aid of a galvanic battery the intensity of the motion of the wheel will be still further increased, showing that in a high vacuum radiant matter is excited not only by the negative pole of an induction coil, but also by heat directly applied. Still another and in some respects a most curious property of this form is that matter in this state of tenuity is deflected by a magnet. A tube is taken having at one end a small potash tube which if heated will slightly lower the vacuum. When the induction coil is turned on and a magnet is placed under the tube a ray of radiant matter traces its trajectory along the tube in a curved line under the influence of the magnet. These molecules, it should be remembered, are true projectiles shot from the negative pole, and may be likened to a discharge of iron bullets from a mitrailleuse, while the magnet beneath will represent the earth curving the trajectory of the shot by gravitation. Here, as in all projectiles, if the deflecting force remains constant, the curve traced by the projectile varies with the velocity. The velocity of the molecules cannot here be directly varied, but their velocity may be impeded by lowering the vacuum, by admitting more molecules to the tube, which is accomplished by vaporizing part of the potash. Instantly the stream of projected radiant matter responds, the magnetism has a longer time to act on each of the molecules, the trajectory becomes more and more curved with the increasing vaporization of the potash, until, instead of shooting nearly to the end of the tube, the molecular bullets fall to the bottom before they have got half way. In the case of the wheel mentioned above, the stream can be so deflected by aid of the magnet that the wheel may be driven either as an over-shot or under-shot water-wheel. Radiant matter also produces heat when its motion is arrested. If a small tube be taken with a cup-shaped negative pole, the molecules may be projected to a focus in the middle of the tube, whence by a magnet they may be deflected to the side and made to fall upon a bit of wax, which will presently melt. But so intense becomes the heat under the hammering of the molecules, as a blacksmith heats his iron to redness on his anvil, that soon the glass itself softens, the atmosphere presses it in and it melts completely. Iridio-platinum is one of the most refractory of metals—one with which Mr. Edison has of late been experimenting for use in his electric lamp—but it yields to the power of the radiant molecules, which, being centred upon it, first raise it to a white heat, then cause it to glow with almost insupportable brilliancy and then melt it like lead. Touching the chemistry of radiant matter, Professor Crookes has experimented with many varieties of matter reduced to the radiant state, and finds that whether the gas be hydrogen, carbonic acid or atmospheric air, the molecules retain their chemical characteristics. By introducing into the tubes appropriate absorbents of residual gas it is seen that chemical attraction goes on long after the attenuation has reached its best stage for the exhibition of physical phenomena, and this even when the degree of tenuity has reached the one twenty-millionth of an atmosphere, a degree which corresponds to about the one hundredth of an inch in a barometric column three miles high. So far, therefore, as it can at present be said, the radiant form of matter differs from the three other forms solely in its physical characters, as only indeed it might have been expected to differ, chemical changes being molecular and molecules being the "manufactured article," of which the material universe is composed. The formation of a molecule is an event which does not belong to the present system of nature; so far as we know, it is not going on on the earth or in the sun or in the stars, nor has it so gone on since these bodies began to be formed, and as all matter, in whatever form, is composed of molecules, it was to be expected that, when acting in a free path they would still retain their intimate chemical relations when by chance they should be brought in contact with other and different molecules.

In the exhaustion of his tubes Professor Crookes brought matter to such an extreme of tenuity that it is objected to his work that primary importance can hardly be attached to it. But when all is said, a tube containing a gas at a density of one one-millionth of an atmosphere is far from holding a vacuum. In one of his experiments he used a bulb about five and two-fifths in diameter. According to the best authorities such a bulb contains more than 1,000,000,000,000,000,000—a million million million molecules. When exhausted to a one-millionth of an atmosphere it would still retain a million million molecules, of which 300,000,000 placed in a row would cover about a linear inch, and such a number of molecules certainly justifies the treatment of them as mater. The mind has no picture of such a number, but to suggest some idea of it, the Professor perforated his exhausted bulb with a spark from the induction coil, producing a hole of microscopic fineness which was, nevertheless and of course sufficiently large to allow molecules to enter and destroy the vacuum. Supposing that the bulb were indestructible and had been pierced at the time of the birth of the solar system, supposing it to have been present when the earth was without form and void, supposing it to have borne witness to all the stupendous changes evolved during the full cycles of geologic time, "to have seen the first living creature appear and the last man to disappear, supposing it to survive until the fulfilment of the mathematician's prediction that the sun, the source of energy, four million centuries from its formation will ultimately become a burnt-out cinder," supposing that molecules entered the bulb continuously at the rate of one hundred million a second, the bulb would hardly then have admitted its full quadrillion of molecules. As matter of fact it took but about ten minutes to fill the vacuum through the hole thus punctured, so that, instead of entering through the microscopic puncture at the rate of 100,000,000 a second, the rate must have been something like three hundred trillions per second. It is to the bombardment of particles of such exceeding smallness as this that the reduction of the most refractory substances is due when the molecules act as radiant matter. In some of its properties, as the experiments of Professor Crookes show, the properties of this form of matter show it to be as material as a stone, while in others it assumes almost the character of radiant energy, and when dealing with it we seem to be in the shadowy realm between the known and the unknown, on the very boundaries of the "Unseen Universe," where force and matter meet in their most intimate occult relations.

MR. CROOKES ON RADIANT MATTER.

Eng Mechanic Sep 5 1879

DURING the meeting of the British Association, Mr. W. Crookes delivered the Friday evening lecture in the Albert Hall, Sheffield, on a subject he has made peculiarly his own, viz., Radiant Matter. The title of the lecture, and the name of the phenomena it described, is borrowed from one of Faraday's lectures, in which that great philosopher said:—"If we conceive a change as far beyond vaporisation as that is above fluidity, and then take into account also the proportional increased extent of alteration as the changes rise, we shall perhaps, if we can form any conception at all, not fall far short of Radiant Matter; and as in the last conversion many qualities were lost, so here also many more would disappear." About three years afterwards (1819) Faraday, while admitting that the existence of radiant matter had not been proved, demonstrated the probability of its existence. It was left to Mr. Crookes, *facile princeps* in the art of experimentation, to prove that there is such a state of matter, and on December 5, last year, he described his researches, and exhibited their results before the Royal Society (see p. 383, Vol. XXVIII.). Since then he has made numerous further experiments and has constructed many elaborate and expensive pieces of apparatus, some of which were used in the lecture, which, we need scarcely say, was attended by a distinguished if not numerous audience. Readers of the article above mentioned and of Mr. Crookes's paper, p. 572 ante, will be familiar with the principal phenomena of an ultra-gaseous state of matter, and of the "dark space" rendered visible in a vacuum tube. This dark space is found to increase and diminish as the vacuum is varied, and is found to be the mean free path of the molecules of the residual gas. Mr. Crookes exhibited a great variety of apparatus and made many experiments, fully convincing his audience of the truth of Faraday's expression, radiant matter. The first experiment was the now familiar demonstration that radiant matter exerts powerful phosphorogenic action where it strikes, and the variety of phosphorescence was shown by means of bulbs of uranium glass, phosphorescing green, English glass, blue, and a soft German glass which phosphoresces a bright apple green. Many other substances possess the phosphorescent power in a higher degree than glass—notably the luminous sulphide of calcium,—but the diamond is the most sensitive that Mr. Crookes has yet met with. A curious fluorescent diamond, green by daylight and colourless by candlelight, was mounted in an exhausted bulb, and the molecular discharge was directed upon it from below upwards, when, the room being darkened, the diamond shone with as much light as a candle, phosphorescing of a bright green. Mr. Crookes then exhibited a tube containing a fine collection of ruby pebbles, which, as soon as the induction-spark was turned on, shone with a brilliant rich red tone, as if glowing hot, although some of the stones were so pale as to be almost colourless. The ruby is nothing more than crystallised alumina with a little colouring matter, but its rich red phosphorescence is a property of the alumina, for Mr. Crookes showed that some precipitated alumina glowed under the molecular discharge with the same rich red colour. There is one particular degree of exhaustion more favourable than any other for the development of the properties of radiant matter. Roughly speaking, it may be put at the millionth of an atmosphere. At this degree of exhaustion the phosphorescence is very strong, and after that it begins to diminish until the spark refuses to pass. This fact Mr. Crookes demonstrated by means of a vacuum tube in which the exhaustion had been carried as far as possible, and to which a smaller tube containing some fragments of caustic potash was attached. By heating the latter a trace of aqueous vapour was sent into the larger tube, and the degree of exhaustion being thus reduced the phenomena of phosphorescence made their appearance in the otherwise non-conducting tube.

Mr. Crookes then showed that the radiant matter whose impact on the glass causes an evolution of light, absolutely refuses to turn a corner. It would illuminate one arm of a V-shaped tube, but would not enter the other. In the ordinary phenomena exhibited by vacuum tubes it is customary, in order to bring out the striking contrasts of colour, to bend the tubes into very elaborate designs. The luminosity caused by the phosphorescence of the residual gas follows all the convolutions into which skilful glass-blowers can manage to twist the glass. The negative pole being at one end and the positive pole at the other, the luminous phenomena seem to depend more on the positive than on the negative at the ordinary exhaustion hitherto used to get the best phenomena of vacuum tubes. But at a very high exhaustion the phenomena noticed in ordinary vacuum tubes when the induction spark passes through them—an appearance of cloudy luminosity and of stratifications — disappear entirely. In the low vacuum the position of the positive pole is of every importance, whilst in a high vacuum the position of the positive pole scarcely matters at all; the phenomena seem to depend entirely on the negative pole. If the negative pole points in the direction of the positive, all very well, but if the negative pole is entirely in the opposite direction it is of little consequence: the radiant matter darts all the same in a straight line from the negative. Radiant matter comes from the pole in straight lines, and does not merely permeate all parts of the tube and fill it with light, as would be the case were the exhaustion less good. Where there is nothing in the way the rays strike the screen and produce phosphorescence, and where solid matter intervenes they are obstructed by it, and a shadow is thrown on the screen. This was shown by means of a tube containing a cross of aluminium, which partly intercepted the rays from the negative pole, and the shadow of which was thrown upon the luminous end of the tube. By an ingenious arrangement the cross is made to fall down out of the way, when, instead of the black shadow, a luminous cross is seen, because the background is capable of only faintly phosphorescing, whilst the part which had the black shadow upon it retains its full phosphorescent power. Here, therefore, is another important property of radiant matter. It is projected with great velocity from the negative pole, and not only strikes the glass in such a way as to cause it to vibrate and become temporarily luminous while the discharge is going on, but the molecules hammer away with sufficient energy to produce a permanent impression upon the glass.

Mr. Crookes then showed by means of a little paddle-wheel mounted on rails within a tube, that radiant matter exerts strong mechanical action where it strikes, for the little wheel was made to run backwards and forwards by reversing the stream of radiant matter. This experiment was repeated in other forms, and it was shown that radiant matter in high vacua is not only excited by the negative pole of an induction coil, but that a hot wire will set it in motion with sufficient force to drive a radiometer vane-wheel. Experiments were also made to show the effect of a magnet upon the line of phosphorescent light, and to prove that radiant matter is deflected by magnetic action. This was effectively shown upon the screen by means of a little wheel which was made to turn in alternate directions by the deflection of the radiant matter against its upper or lower paddles. Radiant matter also produces heat when its motion is arrested. The glass becomes very warm where the green phosphorescence is strongest. Mr. Crookes demonstrated this fact by showing that the focus became so hot that glass was melted, while in another experiment he caused a piece of iridio-platinum to become white hot, to glow with almost insupportable brilliancy, and

102

finally to melt. Mr. Crookes stated that the highest vacuum he has yet succeeded in obtaining was the 1-20,000,000th of an atmosphere, a degree which corresponds to about the hundredth of an inch in a barometrical column three miles high. In conclusion the lecturer said that "We have actually touched the border land where matter and energy seem to merge into one another, the shadowy realm between known and unknown, which for me has always had peculiar temptations. I venture to think that the greatest scientific problems of the future will find their solution in this border land, and even beyond; here, it seems to me, lie ultimate realities, subtle, far-reaching, wonderful."

103

ON RADIANT MATTER[1]

To throw light on the title of this lecture I must go back more than sixty years—to 1816. Faraday, then a mere student and ardent experimentalist, was twenty-four years old, and at this early period of his career he delivered a series of lectures on the general properties of matter, and one of them bore the remarkable title, "On Radiant Matter." The great philosopher's notes of this lecture are to be found in Dr. Bence Jones's "Life and Letters of Faraday," and I will here quote a passage in which he first employs the expression *Radiant Matter*:—

"If we conceive a change as far beyond vaporisation as that is above fluidity, and then take into account also the proportional increased extent of alteration as the changes rise, we shall perhaps, if we can form any conception at all, not fall far short of radiant matter; and as in the last conversion many qualities were lost, so here also many more would disappear."

Faraday was evidently engrossed with this far-reaching speculation, for three years later—in 1819—we find him bringing fresh evidence and argument to strengthen his startling hypothesis. His notes are now more extended, and they show that in the intervening three years he had thought much and deeply on this higher form of matter. He first points out that matter may be classed into four states—solid, liquid, gaseous, and radiant—these modifications depending upon differences in their several essential properties. He admits that the existence of radiant matter is as yet unproved, and then proceeds, in a series of ingenious analogical arguments, to show the probability of its existence.[2]

If, in the beginning of this century, we had asked, What is a gas? the answer then would have been that it is matter, expanded and rarefied to such an extent as to be impalpable, save when set in violent motion; invisible, incapable of assuming or of being reduced into any definite form like solids, or of forming drops like liquids; always ready to expand where no resistance is offered, and to contract on being subjected to pressure. Sixty years ago such were the chief attributes assigned to gases. Modern research, however, has greatly enlarged and modified our views on the constitution of these elastic fluids. Gases are now considered to be composed of an almost infinite number of small particles or molecules, which are constantly moving in every direction with velocities of all conceivable magnitudes. As these molecules are exceedingly numerous, it follows that no molecule can move far in any direction without coming in contact with some other molecule. But if we exhaust the air or gas contained in a closed vessel, the number of molecules becomes diminished, and the distance through which any one of them can move without coming in contact with another is increased, the length of the mean free path being inversely proportional to the number of molecules present. The further this process is carried the longer becomes the average distance a molecule can travel before entering into collision; or, in other words, the longer its mean free path the more the physical properties of the gas or air are modified. Thus, at a certain point, the phenomena of the radiometer become possible, and on pushing the rarefaction still further, *i.e.*, decreasing the number of molecules in a given space and lengthening their mean free path, the experimental results are obtainable to which I am now about to call your attention. So distinct are these phenomena from anything which occurs in air or gas at the ordinary tension, that we are led to assume that we are here brought face to face with matter in a fourth state or condition, a condition as far removed from the state of gas as a gas is from a liquid.

Mean Free Path. Radiant Matter

I have long believed that a well-known appearance observed in vacuum tubes is closely related to the phenomena of the mean free path of the molecules. When the negative pole is examined while the discharge from an induction-coil is passing through an exhausted tube, a dark space is seen to surround it. This dark space is found to increase and diminish as the vacuum is varied, in the same way that the mean free path of the molecules lengthens and contracts. As the one is perceived by the mind's eye to get greater, so the other is seen by the bodily eye to increase in size; and if the vacuum is insufficient to permit much play of the molecules before they enter into collision, the passage of electricity shows that the "dark space" has shrunk to small dimensions. We naturally infer that the dark space is the mean free path of the molecules of the residual gas, an inference confirmed by experiment.

I will endeavour to render this "dark space" visible to all present. Here is a tube (Fig. 1) having a pole in the centre in

FIG. 1.

the form of a metal disk, and other poles at each end. The centre pole is made negative, and the two end poles connected together are made the positive terminal. The dark space will be in the centre. When the exhaustion is not very great the dark space extends only a little on each side of the negative pole in the centre. When the exhaustion is good, as in the tube before you, and I turn on the coil, the dark space is seen to extend for about an inch on each side of the pole.

Here, then, we see the induction spark actually illuminating the lines of molecular pressure caused by the excitement of the negative pole. The thickness of this dark space is the measure of the mean free path between successive collisions of the molecules of the residual gas. The extra velocity with which the negatively electrified molecules rebound from the excited pole, keeps back the more slowly moving molecules which are advancing towards that pole. A conflict occurs at the boundary of the dark space, where the luminous margin bears witness to the energy of the discharge.

Therefore the residual gas—or, as I prefer to call it, the gaseous residue—within the dark space, is in an entirely different state to that of the residual gas in vessels at a lower degree of exhaustion. To quote the words of our last year's President, in his address at Dublin:—

"In the exhausted column we have a vehicle for electricity not constant like an ordinary conductor, but itself modified by the passage of the discharge, and perhaps subject to laws differing materially from those which it obeys at atmospheric pressure."

In the vessels with the lower degree of exhaustion, the length of the mean free path of the molecules is exceedingly small as compared with the dimensions of the bulb, and the properties belonging to the ordinary gaseous state of matter, depending upon constant collisions, can be observed. But in the phenomena now about to be examined, so high is the exhaustion carried that the dark space around the negative pole has widened out till it entirely fills the tube. By great rarefaction the mean free path

[1] A lecture delivered to the British Association for the Advancement of Science, at Sheffield, Friday, August 22, 1879, by William Crookes, F.R.S.

[2] "I may now notice a curious progression in physical properties accompanying changes of form, and which is perhaps sufficient to induce, in the inventive and sanguine philosopher, a considerable degree of belief in the association of the radiant form with the others in the set of changes I have mentioned.

"As we ascend from the solid to the fluid and gaseous states, physical properties diminish in number and variety, each state losing some of those which belonged to the preceding state. When solids are converted into fluids, all the varieties of hardness and softness are necessarily lost. Crystalline and other shapes are destroyed. Opacity and colour frequently give way to a colourless transparency, and a general mobility of particles is conferred.

"Passing onward to the gaseous state, still more of the evident characters of bodies are annihilated. The immense differences in their weight almost disappear; the remains of difference in colour that were left are lost. Transparency becomes universal, and they are all elastic. They now form but one set of substances, and the varieties of density, hardness, opacity, colour, elasticity, and form, which render the number of solids and fluids almost infinite, are now supplied by a few slight variations in weight, and some unimportant shades of colour.

"To those, therefore, who admit the radiant form of matter, no difficulty exists in the simplicity of the properties it possesses, but rather an argument in their favour. These persons show you a gradual resignation of properties in the matter we can appreciate as the matter ascends in the scale of forms, and they would be surprised if that effect were to cease at the gaseous state. They point out the greater exertions which nature makes at each step of the change, and think that, consistently, it ought to be greatest in the passage from the gaseous to the radiant form."—*Life and Letters of Faraday*, vol. i. p. 308.

(*Phrynosoma cornutum*) from Texas, presented by Mr. Ernest E. Sabel; a Sulphur-breasted Toucan (*Ramphastos carinatus*) three Black-necked Stilt Plovers (*Himantopus nigricollis*), two Cayenne Lapwings (*Vanellus cayennensis*) from South America, a Slow Loris (*Nycticebus tardigradus*) from Malacca, a Radiated Tortoise (*Testudo radiata*) from Madagascar, two Electric Silurus (*Malapterurus beninensis*) from West Africa, purchased; a Squirrel-like Phalanger (*Belideus sciurea*), born in the Gardens.

ON RADIANT MATTER.[1]

Nature Sept 4/79

Radiant Matter exerts strong Mechanical Action where it Strikes

WE have seen, from the sharpness of the molecular shadows, that radiant matter is arrested by solid matter placed in its path.

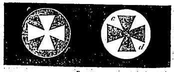


FIG. 10.

If this solid body is easily moved the impact of the molecules will reveal itself in strong mechanical action. Mr. Gimingham has constructed for me an ingenious piece of apparatus which when placed in the electric lantern will render this mechanical action visible to all present. It consists of a highly-exhausted glass tube (Fig. 11), having a little glass railway running along it from one end to the other. The axle of a small wheel revolves on the rails, the spokes of the wheel carrying wide mica paddles. At each end of the tube, and rather above the centre, is an aluminium pole, so that whichever pole is made negative the stream of radiant matter darts from it along the tube, and striking the upper vanes of the little paddle-wheel, causes it to turn round and travel along the railway. By reversing the poles I can arrest the wheel and send it the reverse way, and if I gently incline the tube the force of impact is observed to be sufficient even to drive the wheel up-hill.

This experiment therefore shows that the molecular stream

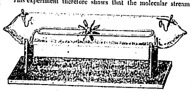


FIG. 11.

from the negative pole is able to move any light object in front of it.

The molecules being driven violently from the pole there should be a recoil of the pole from the molecules, and by arranging an apparatus so as to have the negative pole movable and the body receiving the impact of the radiant matter fixed, this recoil can be rendered sensible. In appearance the apparatus (Fig. 12) is not unlike an ordinary radiometer with aluminium disks for vanes, each disk coated on one side with a film of mica. The fly is supported by a hard steel instead of glass cup, and the needle-point on which it works is connected by means of a wire with a platinum terminal sealed into the glass. At the top of the radiometer bulb a second terminal is sealed in. The radiometer therefore can be connected with an induction-coil, the movable fly being made the negative pole.

For these mechanical effects the exhaustion need not be so high as when phosphorescence is produced. The best pressure for this electrical radiometer is a little beyond that at which the dark space round the negative pole extends to the sides of the glass bulb. When the pressure is only a few millims. of mercury, on passing the induction current a halo of velvety violet light forms on the metallic side of the vanes, the mica side remaining dark. As the pressure diminishes, a dark space is seen to separate the violet halo from the metal. At a pressure of half a millim. this dark space extends to the glass, and rotation commences. On continuing the exhaustion the dark space further widens out and appears to flatten itself against the glass, when the rotation becomes very rapid.

Here is another piece of apparatus (Fig. 13) which illustrates

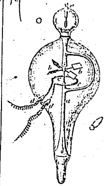


FIG. 12.

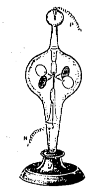


FIG. 13.

the mechanical force of the radiant matter from the negative pole. A stem (*a*) carries a needle-point in which revolves a light mica fly (*b b*). The fly consists of four square vanes of thin clear mica, supported on light aluminium arms, and in the centre is a small glass cap which rests on the needle-point. The vanes are inclined at an angle of 45° to the horizontal plane. Below the fly is a ring of fine platinum wire (*c c*), the ends of which pass through the glass at *d d*. An aluminium terminal (*e*) is sealed in at the top of the tube, and the whole is exhausted to a very high point.

By means of the electric lantern I project an image of the vanes on the screen. Wires from the induction-coil are attached,

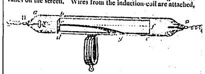


FIG. 14.

so that the platinum ring is made the negative pole, the aluminium wire (*e*) being positive. Instantly, owing to the projection of radiant matter from the platinum ring, the vanes rotate with extreme velocity. Thus far the apparatus has shown nothing more than the previous experiments have prepared us to expect; but observe what now happens. I disconnect the induction-coil altogether, and connect the two ends of the platinum wire with a small galvanic battery; this makes the ring *c c* red-hot, and under this influence you see that the vanes spin as fast as they did when the induction-coil was at work.

Here, then, is another most important fact. Radiant matter in these high vacua is not only excited by the negative pole of an induction-coil, but a hot wire will set it in motion with force sufficient to drive round the sloping vanes.

[1] A lecture delivered to the British Association for the Advancement of Science, at Sheffield, Friday, August 22, 1879, by William Crookes, F.R.S. Continued from p. 423.

Radiant Matter is deflected by a Magnet

I now pass to another property of radiant matter. This long glass tube (Fig. 14), is very highly exhausted; it has a negative pole at one end (*a*) and a long phosphorescent screen (*b, c*) down the centre of the tube. In front of the negative pole is a plate of mica (*b, d*) with a hole (*e*) in it, and the result is, when I turn on the current, a line of phosphorescent light (*e, f*) is projected along the whole length of the tube. I now place beneath the tube a powerful horse-shoe magnet: observe how the line of light (*e, g*) becomes curved under the magnetic influence waving about like a flexible wand as I move the magnet to and fro.

This action of the magnet is very curious, and if carefully followed up will elucidate other properties of radiant matter. Here (Fig. 15) is an exactly similar tube, but having at one end a small potash tube, which if heated will slightly injure the vacuum. I turn on the induction current, and you see the ray of radiant matter tracing its trajectory in a curved line along the screen, under the influence of the horse-shoe magnet beneath. Observe the shape of the curve. The molecules shot from the negative pole may be likened to a discharge of iron bullets from a mitrailleuse, and the magnet beneath will represent the earth curving the trajectory of the shot by gravitation. Here on this luminous screen you see the curved trajectory of the shot accurately traced. Now suppose the deflecting force to remain constant, the curve traced by the projectile varies with the velocity. If I put more powder in the gun the velocity will be greater and the trajectory flatter, and if I interpose a denser resisting medium between the gun and the target, I diminish the velocity of the shot, and thereby cause it to move in a greater curve and come to the ground sooner. I cannot well increase before you the velocity of my stream of radiant molecules by putting more

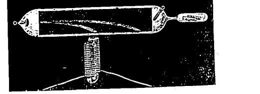


FIG. 15.

powder in my battery, but I will try and make them suffer greater resistance in their flight from one end of the tube to the other. I heat the caustic potash with a spirit-lamp and so throw in a trace more gas. Instantly the stream of radiant matter responds. Its velocity is impeded, the magnetism has longer time on which to act on the individual molecules, the trajectory gets more and more curved, until, instead of shooting nearly to the end of the tube, my molecular bullets fall to the bottom before they have got more than half-way.

It is of great interest to ascertain whether the law governing the magnetic deflection of the trajectory of radiant matter is the same as has been found to hold good at a lower vacuum. The experiments I have just shown you were with a very high vacuum. Here is a tube with a low vacuum (Fig. 16). When I turn on the induction spark, it passes as a narrow line of violet light

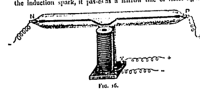


FIG. 16.

joining the two poles. Underneath I have a powerful electro-magnet. I make contact with the magnet, and the line of light dips in the centre towards the magnet. I reverse the poles, and the line is driven up to the top of the tube. Notice the difference between the two phenomena. Here the action is temporary. The dip takes place under the magnetic influence; the line of discharge then rises and pursues its path to the positive pole. In the high exhaustion, however, after the stream of radiant matter had dipped to the magnet, it did not recover itself, but continued its path in the altered direction.

By means of this little wheel, skilfully constructed by Mr. Gimingham, I am able to show the magnetic deflection in the electric lantern. The apparatus is shown in this diagram (Fig. 17). The negative pole (*a, b*) is in the form of a very shallow cup. In front of the cup is a mica screen (*c, d*), wide enough to intercept the radiant matter coming from the negative pole. Behind this screen is a mica wheel (*e, f*) with a series of vanes, making a sort of paddle-wheel. So arranged, the molecular rays from the pole *a b* will be cut off from the wheel, and will not produce any movement. I now put a magnet, *g*, over the tube, so as to deflect the stream over or under the obstacle *c, d*, and the result will be rapid motion in one or the other direction, according to the way the magnet is turned. I throw the image of the apparatus on the screen. The spiral lines painted on the wheel show which way it turns. I arrange the magnet to draw the molecular stream so as to beat against the upper vanes, and the wheel revolves rapidly as if it were an over-shot water-wheel. I turn the magnet so as to drive the radiant

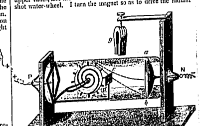


FIG. 17.

matter underneath; the wheel slackens speed, stops, and then begins to rotate the other way, like an under-shot water-wheel. This can be repeated as often as I reverse the position of the magnet.

I have mentioned that the molecules of the radiant matter discharged from the negative pole are negatively electrified. It is probable that their velocity is owing to the mutual repulsion between the similarly electrified pole and the molecules. In less high vacua, such as you saw a few minutes ago (Fig. 16), the discharge passes from one pole to another, carrying an electric current, as if it were a flexible wire. Now it is of great interest

106

rays is projected along the tube. I turn the magnetism on, and draw the focus to the side of the glass. The first thing you see is a small circular patch melted in the coating of wax. The glass soon begins to disintegrate, and cracks are shooting starwise from the centre of heat. The glass is softening. Now the atmospheric pressure forces it in, and now it melts. A hole (*e*) is perforated in the middle, the air rushes in, and the experiment is at an end.

I can render this focal heat more evident if I allow it to play on a piece of metal. The bulb (Fig. 21) is furnished with a negative pole in the form of a cup (*a*). The rays will therefore be projected to a focus on a piece of iridio-platinum (*b*) supported in the centre of the bulb.

I first turn on the induction-coil slightly, so as not to bring out its full power. The focus is now playing on the metal, raising it to a white heat. I bring a small magnet near, and you see I can deflect the focus of heat just as I did the luminous focus in the other tube. By shifting the magnet I can drive the focus up and down, or draw it completely away from the metal, and leave it non-luminous. I withdraw the magnet, and let the molecules have full play again; the metal is now white hot. I increase

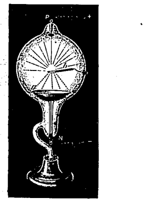


FIG. 21.

the intensity of the spark. The iridio-platinum glows with almost insupportable brilliancy, and at last melts.

The Chemistry of Radiant Matter

As might be expected, the chemical distinctions between one kind of radiant matter and another at these high exhaustions are difficult to recognise. The physical properties I have been elucidating seem to be common to all matter at this low density. Whether the gas originally under experiment be hydrogen, carbonic acid, or atmospheric air, the phenomena of phosphorescence, shadows, magnetic deflection, &c., are identical, only they commence at different pressures. Other facts, however, show that at this low density the molecules retain their chemical characteristics. Thus by introducing into the tubes appropriate absorbents of residual gas, I can see that chemical attraction goes on long after the attenuation has reached the best stage for showing the phenomena now under illustration, and I am able by this means to carry the exhaustion to much higher degrees that I can get by mere pumping. Working with aqueous vapour I can use phosphoric anhydride as an absorbent; with carbonic acid, potash; with hydrogen, palladium; and with oxygen, carbon, and then potash. The highest vacuum I have yet succeeded in obtaining has been the 1-20,000,000th of an atmosphere, a degree which may be better understood if I say that it corresponds to about the hundredth of an inch in a barometric column three miles high.

It may be objected that it is hardly consistent to attach primary importance to the presence of *Matter*, when I have taken extraordinary pains to remove as much matter as possible from these bulbs and these tubes, and have succeeded so far as to leave only about the one-millionth of an atmosphere in them. At its ordinary pressure the atmosphere is not very dense, and its recognition as a constituent of the world of matter is quite a modern notion. It would seem that when divided by a million, so little matter will necessarily be left that we may justifiably neglect the trifling residue and apply the term *vacuum* to space from which the air has been so nearly removed. To do so, however, would be a great error, attributable to our limited faculties being unable to grasp high numbers. It is generally taken for granted that when a number is divided by a million the quotient must necessarily be small, whereas it may happen that the original number is so large that its division by a million seems to make little impression on it. According to the best authorities, a bulb of the size of the one before you (13·5 centimetres in diameter) contains more than 1,000,000,000,000,000,000,000,000 (a quadrillion) molecules. Now, when exhausted to a millionth of an atmosphere we shall still have a trillion molecules left in the bulb—a number quite sufficient to justify me in speaking of the residue as *matter*.

To suggest some idea of this vast number I take the exhausted bulb, and perforate it by a spark from the induction coil. The spark produces a hole of microscopical fineness, yet sufficient to allow molecules to penetrate and to destroy the vacuum. The inrush of air impinges against the vanes, and sets them rotating after the manner of a windmill. Let us suppose the molecules to be of such a size that at every second of time a hundred millions could enter. How long, think you, would it take for this small vessel to get full of air? An hour? A day? A year? A century? Nay, almost an eternity! A time so enormous that imagination itself cannot grasp the reality. Supposing this exhausted glass bulb, indued with indestructibility, had been pierced at the birth of the solar system; supposing it to have been present when the earth was without form and void; supposing it to have borne witness to all the stupendous changes evolved during the full cycles of geologic time, to have seen the first living creature appear, and the last man disappear; supposing it to survive until the fulfilment of the mathematician's prediction that the sun, the source of energy, four million centuries from its formation, will ultimately become a burnt-out cinder;[1] supposing all this—at the rate of filling I have just described, 100 million molecules a second—this little bulb even then would scarcely have admitted its full quadrillion of molecules.[2]

But what will you say if I tell you that all these molecules, this quadrillion of molecules, will enter through the microscopic hole before you leave this room? The hole being unaltered in size, the number of molecules undiminished, this apparent paradox can only be explained by again supposing the size of the molecules to be diminished almost infinitely—so that instead of entering at the rate of 100 millions every second, they troop in at a rate of something like 300 trillions a second. I have done the sum, but figures when they mount so high cease to have any meaning, and such calculations are as futile as trying to count the drops in the ocean.

In studying this fourth state of matter we seem at length to have within our grasp and obedient to our control the little indivisible particles which with good warrant are supposed to constitute the physical basis of the universe. We have seen that in some of its properties radiant matter is as material as this table, whilst in other properties it almost assumes the character of radiant energy. We have actually touched the borderland where matter and force seem to merge into one another, the shadowy realm between Known and Unknown which for me has always

[1] The possible duration of the sun from formation to extinction has been variously estimated by different authorities, at from 18 million years to 400 million years. For the purpose of this illustration I have taken the highest estimate.

[2] According to Mr. Johnstone Stoney (*Phil. Mag.*, vol. 36, p. 141), 1 c.c. of air contains about 1,000,000,000,000,000,000,000 molecules. Therefore a bulb 13·5 centims. diameter contains $13\cdot5^3 \times 0\cdot5236 \times$ 1,000,000,000,000,000,000,000 or 1,288,252,350,000,000,000,000,000 molecules of air at the ordinary pressure. Therefore the bulb when exhausted to the millionth of an atmosphere, contains 1,288,252,350,000,000,000 molecules, leaving 1,288,251,061,747,650,000,000,000 molecules to enter through the perforation. At the rate of 100,000,000 molecules a second, the time required for them all to enter will be

12,882,510,617,476,500 seconds, or
214,708,510,291,275 minutes, or
3,578,475,171,521 hours, or
149,103,132,147 days, or
408,501,731 years.

107

CONTRIBUTIONS TO MOLECULAR PHYSICS IN HIGH VACUA[1]

II.

IT has been shown that the stream of molecules are shot off from the negative pole in a negatively charged condition, and their velocity is owing to the mutual repulsion between the similarly electrified pole and molecules. It became of interest to ascertain whether lateral repulsion was exerted between the molecules themselves. If the stream of molecules coming from the negative pole carried an electric current, two parallel rays should exert mutual attraction; but if nothing of the nature of an electric current was carried by the stream, it was likely that the two parallel rays would act simply as negatively electrified bodies and exert lateral repulsion. This was not difficult to put to the test of experiment.

A tube was made with two flat aluminium terminals, *a b*, close together at one end, and one terminal, *c*, at the other, as shown in Fig. 11. Along the centre of the tube, cutting the axis obliquely, is a screen of mica, painted over with a phosphorescent powder, and between the screen and the double poles, *a b*, is a disk of mica crossing the axis of the tube, and therefore nearly at right angles to the phosphorescent screen. In this mica disk are two slits—one opposite each pole *a* and *b*—running in such a direction that the molecular streams emanating from *a* and *b* when made negative shall pass through the slits, forming two horizontal sheets. These sheets striking against the oblique screen will be made evident as two horizontal lines of light. The poles *a* and *b* were somewhat bent, so that the lines of light were not quite parallel, but slightly converged. The tube being properly exhausted, the pole *a* was made negative, and *c* positive, the lower pole *b* being left idle. A sharp ray of phosphorescent light shot across the screen along the line *d f*. The negative wire was now transferred from *a* to *b*, when a ray of light shot along the screen from *e* to *f*. The two poles *a* and *b* were now connected by a wire, and the two together were made the negative pole. Two lines of light now shone on the screen, but their positions, instead of being, as before, *d f* and *e f*, were now *d g* and *e h*, as shown by the dotted lines. The wire joining the poles *a b* was removed, and the pole *a* made negative; the ray from it followed the line *d f* as before. While the coil was working, another wire hanging loose from the pole *b* was brought up to *a*, so as to make them both negative. Instantly the ray *e h* shot across the screen, and simultaneously the ray *d f* shifted its position up to *d g*. The same phenomena were observed when the pole *b* was connected with the coil, and contact was alternately made and broken with *a*; as the ray *d g* shot across, the ray *e f* dipped to *e h*.

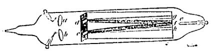


FIG. 11.

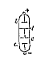


FIG. 12.

These experiments show that two parallel rays of molecules issuing from the negative pole exert lateral *repulsion*, acting like adjacent streams of similarly-electrified bodies. Had they carried an electric current they should have attracted each other, unless, indeed, the attraction in this case was not strong enough to overcome the repulsion.

Many experiments have been made to ascertain the law of the action of magnets and of wires carrying currents, on the stream of molecules.

As an indicator, a small tube, as shown in Fig. 12, was employed. The two poles are at *a* and *b*, *a* being the negative. At *c* is a plate of mica with a hole in its centre, and at *d* is a phosphorescent screen. A sharp image of the hole in the mica is projected on the centre of *d*, and the approach of a magnet causes this bright spot to move to different parts of the phosphorescent screen.

A large electro-magnet was used, actuated by two Grove's cells, and the indicator tube was carried round the magnet in different positions and the results noted. The molecular stream when under no magnetic influence passes along the axis of the tube, as shown by the small arrow (Fig. 12). It will be seen that the indicator can occupy three different directions in respect to the magnet. The magnet being held horizontally, the direction of the molecular stream may be parallel to the axis, tangential to it, or at right angles to it. In either of these positions, also, the stream may be directed one way or the other (by turning the tube round endwise). In these different positions various results are obtained which are easily illustrated with a solid model, but are somewhat complicated to explain by means of flat drawings. They are fully described in the paper.

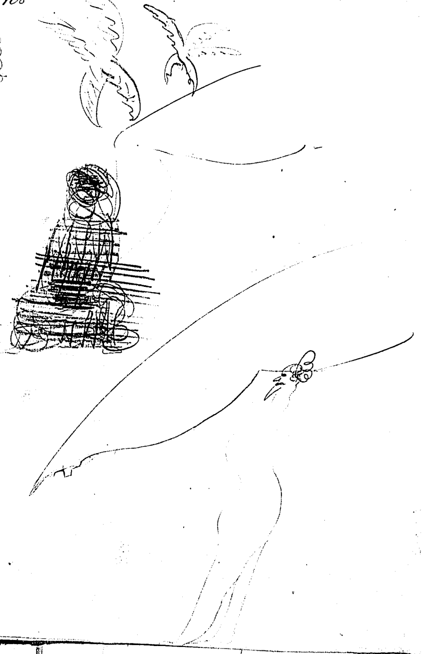
A long tube was made similar to the small indicator shown in Fig. 12, but having a molecular trajectory six inches long. It was only exhausted to the point at which the image of the spot was just seen sharply defined on the screen, as at higher exhaustions the action of magnetism is less. The phosphorescent screen was divided into squares for convenience of noting the deflection of the spot of light. So sensitive was this to magnetic influence, that when the tube was placed parallel to the earth's equator the earth's magnetism was sufficient to cause the spot to move 5 millims. away from the position it occupied when parallel to the dipping needle (in which position the earth's magnetism did not appear to act). When held equatorially and rotated on its axis, the spot of light, being always driven in one direction independent of the rotation of the tube, appeared to travel round its normal position in a circle of 10 millims. diameter.

I have long tried to obtain continuous rotation of the molecular rays under magnetic influence, analogous to the well-known rotation obtained at lower exhaustions. Many circumstances had led me to think that such rotation could be effected. After many failures an apparatus was constructed as follows, which gave the desired results:—

A bulb (Fig. 13) was blown of German glass, and a smaller bulb was connected to each end of the larger bulb by an open, very short neck. At each extremity was a long aluminium pole projecting partly into the large bulb and turned conical at the end. After good exhaustion the passage of an induction current through this apparatus fills the centre bulb with a very fine green light, whilst the neck surrounding the pole which happens to be negative is covered with two or three dark and bright patches in constant motion, following each other round first one way and then the other, constantly changing direction and velocity, sometimes dividing into other patches, and at others fusing together into one. After a

[1] "Contributions to Molecular Physics in High Vacua. Magnetic Deflection of Molecular Trajectory; Laws of Magnetic Rotation in High and Low Vacua; Phosphorogenic Properties of Molecular Discharge." By William Crookes, F.R.S. (Extracts from a paper in the *Philosophical Transactions* of the Royal Society, Part 2, 1879.) Continued from p. 104.

108



interval between them and their causes. In order to make any progress even in the subordinate task of tracing out the relations of these effects to one another, the inquirer finds it necessary to venture upon hypothesis, and in all metaphysical speculation we sadly miss that healthy discipline with which Nature in other branches of science relentlessly refutes our hypotheses if they are wrong. Here, then, is a region in which the plausible may be mistaken for the true; and it is unfortunately certain that it has sometimes been so mistaken by the ablest human minds.

The biological sciences treat of all the phenomena of living beings, except their mental phenomena, which are those which lie most remote from their causes. Here the complication is less, but it is still too great for the human mind to have yet penetrated behind it. We are still occupied with phenomena which lie at a great distance from their real causes. We are accordingly still far beyond the range of the exact sciences. Most of the great discoveries of biological science have been made by estimating the *general drift* of what is taught by a vast number of particular facts. This, it will be observed, is a kind of reasoning that is necessarily more or less inexact, and, as a consequence, it is one which requires wide intellectual training and great experience and tact to handle it with safety. When the investigator has brought these qualifications to his task, astonishing progress has been made in these sciences: without them the reasoning may degrade into being either trivial or loose.

In the rest of the study of Nature we are not embarrassed by the phenomena of life, and many mysteries therefore stand aside out of our path. Here lies the domain of the physical sciences. It is here that the mind of man has best been able to cope with the realities of the universe, and in which its greatest achievements have been effected. It is here that exact reasoning finds a predominant place.

The study of the physical sciences has been remitted by the British Association to its first two sections, chemistry being assigned to Section B, and the rest of the physical sciences to Section A. Accordingly, Section A includes the whole range of mathematics, along with the study of the conditions of rest and motion in that part of matter which is endowed with mass, and of the phenomena of sound, heat, light, and electricity, with the applications of these abstract studies in molecular physics and to astronomy, crystallography, and meteorology.

In meteorology, owing to the complication of the materials that have to be dealt with, we must have frequent recourse to the same kind of reasoning as has been found so effectual in the biological sciences; but in the other physical sciences which I have enumerated exact reasoning prevails, and on this account they are frequently classed together as the exact sciences.

The process of investigation in the exact sciences is fundamentally one in all cases. It has been well described by Mill in the third book of his "Logic." Nevertheless, it is notorious that minds which are well fitted for some branches of physical inquiry find difficulty—sometimes insuperable difficulty—in pursuing others. It is not every eminent mathematician who would have made an equally good chemist, or *vice versâ*. This is because there exists a practical distinction separating the investigation of exact science into two well-marked classes when they are viewed, not as they are in themselves, but in their relation to the powers of us human beings. I refer to the distinction between the experimental method or the method of observation, on the one hand; and the deductive method, or the method of reasoning, on the other. All valid investigations in exact science appeal to what can be directly perceived, and all lead to a conclusion which can be reasoned out from it; but there are some of these investigations in which the main difficulty consists in making the appeal to the senses, and there are others in which the main difficulty lies in the process of reasoning.

To contend with these difficulties successfully requires very different qualities of mind and body. In experimental science the powers principally called into requisition are readiness and closeness of observation, dexterity in manipulation, skill in devising expedients, accuracy in making adjustments, and great patience. It also requires that the investigator should have an accurate memory of what else he has witnessed resembling the phenomenon under observation, that he should be quick to detect every point of agreement and difference that can be perceived, and be skilful to select those which are significant, and to employ them as materials for provision to guide his further proceedings. But the strain on the reasoning powers is generally less, often of trifling amount. The question is put to Nature, and it is Nature usually that gives the bulk of the answer. The most striking monument of splendid achievements by the experimental method of investigation unaided by the deductive method is to be found in the science of chemistry.

An equally typical instance of the power of the deductive method is the science of mechanics. This science, which has sunk deeper into the secrets of Nature than any other science, and which is the science towards whom all other physical sciences are at present more or less gravitating, is essentially deductive. There is little or no difficulty about its fundamental data. They are facts of Nature so patent to all men, and so indelibly implanted in human conception, that some persons have supposed that we have an intuitive perception of them. But, while the materials from which the mind is to work are thus easily obtained, it has taxed to the utmost the reasoning powers of understandings like Newton's to evolve the few consequences of them which are already known, and the investigator has to call to his assistance every aid to prolonged consecutive thought which mathematicians can devise.

In grappling with the problems of Nature we are seldom allowed the choice of the method of investigation we shall employ. This is commonly settled for us and not by us. Where we cannot advance without further information, we must make further observations, i.e., we must employ the experimental method, the appeal *ad experientiam*; where we cannot advance without understanding better what the information we possess really amounts to, we must employ the deductive method.

No reach of intellect applied to the materials in existence before 1860 could have elicited the fact that iron exists upon the sun. This great discovery was made by Professor Kirchhoff, a scientific man who was equally versed in both methods of investigation. On the present occasion it was the experimental method he employed. He applied to the scrutiny of the sun's spectrum four prisms of the most homogeneous glass that could be procured, figured with the greatest accuracy that the eminent artist Steinheil could attain. He expended far more pains on their adjustment for each successive part of the spectrum than any of his predecessors had done, and he was rewarded by a more perfect vision of the sun's glorious spectrum than had met the human eye before. In a collateral inquiry, suggested by an observation made by Foucault, he and Bunsen placed a metallic vapour emitting bright rays in front of a still brighter incandescent body, so that the light from the brighter background had to pass through this vapour, and they found that this vapour now caused dark lines in the spectrum occupying the positions which its own bright lines had before filled. Professor Kirchhoff thereupon added an appliance to his spectroscope which enabled him to bring a metallic spectrum and the solar spectrum together into the field of view, alongside of one another. On accomplishing this he saw sixty of the brightest of the iron rays as continuations of sixty of the strongest of the dark lines in the sun's spectrum; and, by an elaborate scrutiny, he satisfied himself that the observations had been pushed to a sufficient degree of exactness to make sure that a deviation would have been detected in any one of these sixty cases if it had amounted to as much as one-fourth of the average interval between consecutive lines of the solar spectrum. From this it was obvious that the sixty coincidences are not due to chance, but indicate that there is really iron vapour in the path of the rays. It will be observed that Kirchhoff's great merit and the real difficulty of his work lay in the scientific foresight and the industry which were required to frame hypotheses that were worth testing, to guide the investigation by these hypotheses, to contrive, construct, and adjust adequate apparatus, and to make with it the elaborate observations and the exact observations and maps which were necessary. But when by these means the new facts had been brought to light, the inference from them that there is iron in the atmosphere of the sun was an easy one. This example will better convey than a definition what are the characteristic features of an experimental inquiry.

On the other hand, no series of observations or experiments, however skilfully arranged, could have enabled any one to understand the cause of that familiar but truly surprising phenomenon that a top stands upon its peg while it is spinning. But a full explanation of it is within the reach of any student who will train his mind to reason consecutively, and avail himself of the aids to prolonged consecutive thought which mathematicians have contrived. He will then see that the most obvious and familiar mechanical facts involve as necessary consequences all the phenomena which he finds in the schoolboy's top, in the physicist's gyroscope, and in the precision and nutation of the heavens. This, then, is a problem of Nature which falls within the province of the deductive method.

Wherever data are known exactly, these inferences from these data however remote may be depended upon as corresponding with what actually occurs in Nature. And if in such cases the mind of man has proved equal to the task of drawing inferences which can effectually grapple with the problems he finds around him in the universe—which is, alas! as yet but too seldom—then will the deductive method, our plummet, explore depths in the great ocean of existence which our anchors of experiment could not have reached.

The distinction which is here made between deductive and experimental investigations would have no place in a logical system. But it has direct reference to human convenience, and derives its importance from this circumstance. It is obvious, too, that an investigation may partake of both characters—that it may require all the powers of the scientific observer to get at the facts, or even to appreciate them, and all the resources of the mathematician to elicit the consequences of them. For instance, on beginning his electrical studies, the student of Nature must master a mixed experimental and deductive inquiry to get at the elementary fact that free electricity resides either at or outside the surfaces of conductors; and he must engage in a further inquiry, and one only within the reach of a trained mind, to deduce from this the law of the inverse square. And, again, no full appreciation or even intelligent use of the common electrostatic and electrodynamic measures which he meets at the threshold of his electrical studies is within the reach of the mere experimentalist or the mere theorist. And if this treacherous ground lies before the immature student at his entrance, what shall we say of the bogs he struggles into as he advances. We are perpetually meeting with inquiries of this mixed character in electricity and some of the other physical sciences, but they are comparatively rare in either mechanics or chemistry, and none that is difficult lies in the path of the beginner. How many students are there who are made to slur over the above and a multitude of similar difficulties, and who are told that they are learning science, when in fact what they are really learning is the pernicious habit of being content to see Nature through a fog or through other men's mental eyes.

In mechanics valuable progress can be made by the mere mathematician, the student of deductive science; and in chemistry similar progress can be made by the mere experimentalist. Of all the physical sciences these are the most purely deductive, and the most purely experimental. What I desire particularly to invite attention to is that the two great methods of investigation may best be acquired in these two sciences, and that for a really sound grasp of the remaining physical sciences, and especially with a view to further advance in physical science, a command of both methods of investigation is essential.

We must bear in mind, too, that either method of investigation may be misapplied, and that this is a risk carefully to be guarded against. The deductive method when misapplied lands us in speculation, the experimental method becomes empiricism; and it so happens that the sciences of mechanics and chemistry are not only monuments of the power of the two great methods of investigation, but instructive examples of their weakness also. For in chemistry, scarce any attempt at prolonged reasoning, carrying us by any lengthened flight to a distance from the experiments, can be relied on. The result has seldom risen to anything better than speculation. And on the other hand, in mechanics, conclusions which depend on experiments only are empirical; that is, they are deficient in accuracy, and their relation to the other phenomena of the science is left in darkness. Here, then, we find in these two sciences not only how strong these two methods of investigation are, but how weak they may become if misapplied.

I do not know whether any of my predecessors in this chair has experienced so much difficulty, or has hesitated so long and so much as I have hesitated in selecting the topic to which he would ask your attention. My first effort was an attempt to delineate the great recent progress of the mathematical and physical sciences, but it was unsatisfactory, partly from my own too scanty powers, and also because the variety and even disparity of the numerous sciences somewhat arbitrarily grouped together in Section A gave to the outline too sketchy a character. My next attempt was to make a selection among them, confining myself to those with which I am best acquainted, and endeavouring to direct attention to the problems which at the present time seem most to stand in need of solution. But here I felt unwilling either to bring forward or to withhold views which might be disputed. I then applied myself to the single consideration of what I hoped might prove useful and not inopportune at a time when one university, which I trust will prove a great university, is rising in the North of England, and when another university which has carefully and successfully fostered a high standard of education for thirty years, and which has thereby deserved and won the respect of educated men, has just been sacrificed to ecclesiasticism in the sister isle. In this university I have held the most central office for twenty-two years, and in the discharge of my duty had largely to influence its destiny in respect to almost every educational problem. Parliament in its wisdom has now seen fit to destroy this work, and I have not been without hope that from the experience which has been gained some effect which shall last may yet arise, and that the Queen's University may perhaps at its death bequeath a useful legacy to the University of Victoria. The advancement of science in the North of England will largely depend for many years on the wisdom of the regulations for scientific training which are adopted at first by the new university; and I have therefore ventured, at this peculiar juncture, to submit to the judgment of my scientific brethren the principles which much thought and many trials extending over several years have led me to believe should guide them in selecting this part of a curriculum.

I have sought to show that it is in the study of mechanics and in the practice of chemistry that the two great methods of investigation may best be acquired. In them they may be studied separately, by steps of graduated difficulty, and with a superabundance of materials; and each of them supplies the necessary cautions with respect to the method which is all powerful in the other. No scientific man is really equipped for the pursuits in which both methods have to be employed till he has separately acquired a grasp of each. For it is only then that he will be armed against the errors which lead so many to mistake empiricism on the one hand and speculation on the other for solid science, or to underrate solid science mistaking it for speculation. Nor is it only in his scientific occupations that he will derive benefit from this training. All exact reasoning, whether in science or in common life, belongs to these great divisions; and in the numberless instances in which we must be satisfied with reasoning which falls short of being exact, our only safety lies in having by the practice of exact reasoning, both deductive and experimental, attained to that intellectual tact and caution which alone will enable us to handle with safety the sharp and slippery tool. It is thus that a sound judgment with regard to truth may best be acquired by man or woman; and soundness of judgment is the noblest endowment of man's understanding, just as veracity is first among his virtues.

ON RADIANT MATTER.*

By William Crookes, F.R.S.

To throw light on the title of this lecture I must go back more than sixty years—to 1816. Faraday, then a mere student and ardent experimentalist, was twenty-four years old, and at this early period of his career he delivered a series of lectures on the General Properties of Matter, and one of them bore the remarkable title "On Radiant Matter." The great philosopher's notes of this lecture are to be found in Dr. Bence Jones's "Life and Letters of Faraday," and I will here quote a passage in which he first employs the expression Radiant Matter:

"If we conceive a change as far beyond vaporisation as that is above fluidity, and then take into account also the proportional increased extent of alteration as the changes rise, we shall perhaps, if we can form any conception at all, not fall far short of radiant matter; and as in the last

* A lecture delivered to the British Association for the Advancement of Science, at Sheffield, Friday, August 22, 1879.

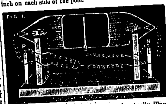
conversion many qualities were lost, so here also many more would disappear."

Faraday was evidently engrossed with this far-reaching speculation, for three years later—in 1819—we find him bringing fresh evidence and argument to strengthen his startling hypothesis. His notes are now more extended, and they show that in the intervening three years he had thought much and deeply on this higher form of matter. He first points out that matter may be classed into four states—solid, liquid, gaseous, and radiant—these modifications depending upon differences in their several essential properties. He admits that the existence of radiant matter is as yet unproved, and then proceeds, in a series of ingenious analogical arguments to show the probability of its existence.*

If, in the beginning of this century, we had asked, What is a gas? the answer then would have been that it is matter, expanded and rarefied to such an extent as to be impalpable, save when set in violent motion; invisible, incapable of assuming or of being reduced into any definite form like solids, or of forming drops like liquids; always ready to expand where no resistance is offered, and to contract on being subjected to pressure. Sixty years ago such were the chief attributes assigned to gases. Modern research, however, has greatly enlarged and modified our views on the constitution of these elastic fluids. Gases are now considered to be composed of an almost infinite number of small particles or molecules, which are constantly moving in every direction with velocities of all conceivable magnitudes. As these molecules are exceedingly numerous, it follows that no molecule can move far in any direction without coming in contact with some other molecule. But if we exhaust the air or gas contained in a closed vessel, the number of molecules becomes diminished, and the distance through which any one of them can move without coming in contact with another is increased, the length of the mean free path being inversely proportional to the number of molecules present. The further this process is carried the longer becomes the average distance a molecule can travel before entering into collision; or, in other words, the longer its mean free path, the more the physical properties of the gas or air are modified. Thus, at a certain point, the phenomena of the radiometer become possible, and on pushing the rarefaction still further, *i.e.*, decreasing the number of molecules in a given space and lengthening their mean free path, the experimental results are obtainable to which I am now about to call your attention. So distinct are these phenomena from anything which occurs in air or gas at the ordinary tension, that we are led to assume that we are brought face to face with matter in a fourth state or condition, a condition as far removed from the state of gas as a gas is from a liquid.

Mean Free Path. Radiant Matter.—I have long believed that a well-known appearance observed in vacuum tubes is closely related to the phenomena of the mean free path of the molecules. When the negative pole is examined while the discharge from an induction coil is passing through an exhausted tube, a dark space is seen to surround it. This dark space is found to increase and diminish as the vacuum is varied, in the same way that the free mean path of the molecules lengthens and contracts. As the one is perceived by the mind's eye to get greater, so the other is seen by the bodily eye to increase in size; and if the vacuum is insufficient to permit much play of the molecules before they enter into collision, the passage of electricity shows that the "dark space" has shrunk to small dimensions. We naturally infer that the dark space is the mean free path of the molecules of the residual gas, an inference confirmed by experiment.

I will endeavour to render this "dark space" visible to all present. Here is a tube (Fig. 1), having a pole in the centre in the form of a metal disc, and other poles at each end. The centre pole is made negative, and the two end poles connected together are made the positive terminal. The dark space will be in the centre. When the exhaustion is not very great the dark space extends only a little on each side of the negative pole in the centre. When the exhaustion is good, as in the tube before you, and I turn on the coil, the dark space is seen to extend for about an inch on each side of the pole.



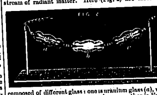
Here, then, we see the induction spark actually illuminating the lines of molecular pressure caused by the excitement of the negative pole. The thickness of this dark space is the measure of the mean free path between successive collisions of the molecules of the residual gas. The extra velocity with which the negatively electrified molecules rebound from the excited pole keeps back the more slowly moving molecules which are advancing towards that pole. A conflict occurs at the boundary of the dark space, where the luminous margin bears witness to the energy of the discharge.

Therefore the residual gas—or, as I prefer to call it, the gaseous residue—within the dark space is in an entirely different state to that of the residual gas in vessels at a lower degree of exhaustion. To quote the words of our last year's President, in his address at Dublin:

"In the exhausted column we have a vehicle for electricity not constant like an ordinary conductor, but itself modified by the passage of the discharge, and perhaps subject to laws differing materially from those which it obeys at atmospheric pressure."

In the vessels with the lower degree of exhaustion, the length of the mean free path of the molecules is exceedingly small as compared with the dimensions of the bulb, and the properties belonging to the ordinary gaseous state of matter, depending upon constant collisions, can be observed. But in the phenomena now about to be examined, so high is the exhaustion carried that the dark space around the negative pole has widened out till it entirely fills the tube. By great rarefaction the mean free path has become so long that the hits in a given time in comparison to the misses may be disregarded, and the average molecule is now allowed to obey its own motions or laws without interference. The mean free path, in fact, is comparable to the dimensions of the vessel, and we have no longer to deal with a continuous portion of matter, as would be the case were the tubes less highly exhausted, but we must here contemplate the molecules individually. In these highly exhausted vessels the molecules of the gaseous residue are able to dart across the tube with comparatively few collisions, and radiating from the pole with enormous velocity, they assume properties so novel and so characteristic as to entirely justify the application of the term borrowed from Faraday, that of radiant matter.

Radiant Matter exerts Powerful Phosphorogenic Action where it Strikes.—I have mentioned that the radiant matter within the dark space excites luminosity where its velocity is arrested by residual gas outside the dark space. But if no residual gas is left, the molecules will have their velocity arrested by the sides of the glass; and here we come to the first and one of the most noteworthy properties of radiant matter discharged from the negative pole—its power of exciting phosphorescence when it strikes against solid matter. The number of bodies which respond luminously to this molecular bombardment is very great, and the resulting colours are of every variety. Glass, for instance, is highly phosphorescent when exposed to a stream of radiant matter. Here (Fig. 2) are three bulbs

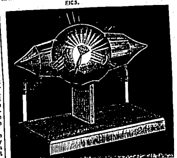


composed of different glass: one is uranium glass (*a*), which phosphoresces of a dark green colour; another is English glass (*b*), which phosphoresces of a blue colour; and the third (*c*) is soft German glass—of which most of the apparatus before you is made—which phosphoresces of a bright apple-green.

My earlier experiments were almost entirely carried on by the aid of the phosphorescence which glass takes up when it is under the influence of the radiant discharge; but many other substances possess this phosphorescent power in a still higher degree than glass. For instance, here is some of the luminous sulphide of calcium prepared according to M. Ed. Becquerel's description. When the sulphide is exposed to light—even candlelight—it phosphoresces for hours with a bluish white colour. It is, however, much more strongly phosphorescent to the molecular discharge in a good vacuum, as you will see when I pass the discharge through this tube.

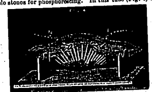
Other substances, besides English, German, and uranium glass, and Becquerel's luminous sulphides, are also phosphorescent. The rare mineral phenakite (aluminate of glucinum) phosphoresces blue; the mineral spodumene (a silicate of aluminium and lithium) phosphoresces a rich golden yellow; the emerald gives out a crimson light. But without exception, the diamond is the most sensitive substance I have yet met for ready and brilliant phosphorescence. Here is a very curious fluorescent diamond, green by daylight, colourless by candlelight. It is mounted in the centre of an exhausted bulb (Fig. 3), and the molecular

FIG. 3.



discharge will be directed on it from below upwards. On darkening the room you see the diamond shines with as much light as a candle, phosphorescing of a bright green.

Next to the diamond the ruby is one of the most remarkable stones for phosphorescing. In this tube (Fig. 4) is a



fine collection of ruby pebbles. As soon as the induction spark is turned on you will see these rubies shining with a brilliant rich red tone, as if they were glowing hot. It scarcely matters what colour the ruby is, to begin with. In this tube of natural rubies there are stones of all colours—the deep red and also the pale pink ruby. There are some so pale as to be almost colourless, and some of the highly-prized tint of pigeon's blood; but under the impact of radiant matter they all phosphoresce with about the same colour.

Now the ruby is nothing but crystallised alumina with a little colouring matter. In a paper by Ed. Becquerel,* published twenty years ago, he describes the appearance of alumina as glowing with a rich red colour in the phosphoroscope. Here is some precipitated alumina prepared in the most careful manner. It has been heated to whiteness, and you see it also glows under the molecular discharge with the same rich red colour.

The spectrum of the red light emitted by these varieties of alumina is the same as described by Becquerel twenty years ago. There is one intense red line, a little below the fixed line B in the spectrum, having a wave-length of about 6895. There is a continuous spectrum beginning at about B, and a fewer fainter lines beyond it, but they are so faint in comparison with this red line that they may be neglected. This line is easily seen by examining with a small pocket spectroscope the light reflected from a good ruby.

There is one particular degree of exhaustion more favourable than any other for the development of the properties of radiant matter which are now under examination. Roughly speaking it may be put at the millionth of an atmosphere.† At this degree of exhaustion the phosphorescence is very strong, and after that it begins to diminish until the spark refuses to pass.‡

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* "I may now notice a curious progression in physical properties accompanying changes of form, and which is perhaps sufficient to induce, in the inventive and sanguine philosopher, a considerable degree of belief in the association of the radiant form with the others in the set of changes I have mentioned.

"As we ascend from the solid to the fluid and gaseous states, physical properties diminish in number and variety, each state losing some of those which belonged to the preceding state. When solids are converted into fluids, all the varieties of hardness and softness are necessarily lost. Crystalline and other shapes are destroyed. Opacity and colour frequently give way to a colourless transparency, and a general mobility of particles is conferred.

"Passing onward to the gaseous state, still more of the evident characters of bodies are annihilated. The immense differences in their weight almost disappear; the remains of differences in colour that were left, are lost. Transparency becomes universal, and they are all elastic. They now form but one set of substances, and the varieties of density, hardness, opacity, colour, elasticity and form, which render the number of solids and fluids almost infinite, are now supplied by a few slight variations in weight, and some unimportant shades of colour.

"To those, therefore, who admit the radiant form of matter, no difficulty exists in the simplicity of the properties it possesses, but rather an argument in their favour. These persons show you a gradual resignation of properties in the matter we can appreciate as the matter ascends in the scale of forms, and they would be surprised if that effect were to cease at the gaseous state. They point out the greater exertions which nature makes at each step of the change, and think that, consistently, it ought to be greatest in the passage from the gaseous to the radiant form."—*Life and Letters of Faraday*, vol. i., page 308.

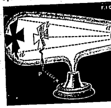
* Annales de Chimie et de Physique, Third Series, vol. lvii., p. 50, 1859.

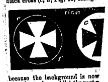
† 1.0	millionth of an atmosphere	=	0.00076 mm.
1315.789	" "	=	1.0 mm.
1,000,000.	" "	=	760.0 mm.
1,000,000.	" "	=	1 atmo.

‡ Nearly 100 years ago Mr. Wm. Morgan communicated to the Royal Society a paper entitled "Electrical Experiments made to ascertain the Non-Conducting Power of a Perfect Vacuum, &c." The following extracts from this paper, which was published in the Phil. Trans. for 1785 (vol. lxxv., p. 272), will be read with interest:

"A mercurial gage about 15 in. long, carefully and accurately boiled till every particle of air was expelled from the inside, was coated with tin-foil 5 in. down from its sealed end, and being inverted into mercury through a perforation in the brass cap which covered the mouth of the cistern; the whole was cemented together, and the air was exhausted from the inside of the cistern through a valve in the brass cap, which producing a perfect vacuum in the gage formed an instrument peculiarly well adapted for ex-

Radiant Matter when intercepted by Solid Matter casts a Shadow.



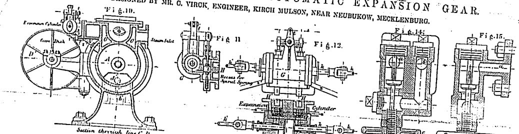


October ...	51.10	46.71	46.53	41.58	48.28	40.49
November ...	50.91	42.78	42.61	38.71	43.02	41.26
December ...						
1879.						
January ...	50.82	41.11	40.66	37.04	40.44	40.60
February ...	50.73	41.81	43.48	38.45	40.40	42.31
March ...	50.61	43.31	45.66	40.95	41.98	44.96
April ...	50.80	47.09	47.41	44.24	44.31	46.76
May ...	50.76	48.95	51.50	45.18	46.96	50.36
June ...	51.03	51.74	59.80	55.42	52.22	57.65
Totals 12 months	611.59	601.45	624.41	585.24	592.93	612.67
Average ...	50.96	50.37	52.03	48.77	49.41	51.04
Maximum ...	51.5	64.8	71.5	68.3	61.3	68.4
Minimum ...	50.5	39.7	33.6	35.25	38.2	38.2
Mean ...	51.0	52.25	52.55	50.77	49.75	53.3
Range ...	1.0	25.1	37.9	31.05	23.1	30.2

Leaf torn out here and placed as an exhibit in Interference Boehm vs Edison (Edison's Exhibit No. 8)

HORIZONTAL ENGINE WITH AUTOMATIC EXPANSION GEAR.

DESIGNED BY MR. C. VIRCK, ENGINEER, KIRCH MULSON, NEAR NEUBUKOW, MECKLENBURG.



steam space. They receive their movement by levers e and e^{11}, which engage at their one end with the valve spindles f and f^1, and at the other ends, which are provided with rollers to lessen friction and abrasion, with cams g and g^1 on the discs D and D¹. These discs are keyed on the shaft E, which is driven direct from the crankshaft F by the bevel wheels o and o^1, and which makes the same number of revolutions as the engine itself. The levers e and e^{11} are connected by the rod l, and if either of the two valves opens the other must shut, and *vice versâ*. (See also Figs. 1, 3, 4, 5, and 10.) By choosing a proper shape for the cams g and g^1, and a corresponding lap for the valves, a prompt motion, a correct compression, and a timely release can be easily obtained.

The steam valves are also worked, as far as their opening is concerned, by levers e^1 and e^{111}, which are of the same design as the levers e and e^{11}, and the cams f and f^1 on the discs D and D¹, but their closing is effected, at the proper instant, by a small steam cylinder G called the "expansion cylinder," and which is shown to an enlarged scale in Figs. 11, 12, and 13. It has two slide valves i and i^1, which are so connected with each other that if the one opens the other closes, and *vice versâ*, and which work in two separate steam chests H and H¹, these being placed in communication with the corresponding ends of the main steam cylinder A by two steam pipes z and z^1. The rods k and k^1, when they are moving outwards, can not engage with the levers e and e^1, on account of the slots y and y^1 at the ends of these rods, but when they are moving inwards the ends of the slots take hold of the pins x and x^1, and the levers must follow the movement of the rods, and the valves c and c^1 are closed.

If now the valve i of the expansion cylinder G be opened after the piston C of the main steam cylinder has made part of its stroke towards the left, steam will enter G from A, and the piston rod k will move inwards, and by imparting motion to the lever e^1 will shut the steam valve c, and the expansion in the main cylinder will begin; while if the valve i remains open until the end of the stroke, the steam, which has worked in the expansion cylinder at full boiler pressure, will expand back into the main cylinder. If now the valve i still remains open during the return stroke, the expanded steam in the expansion cylinder will find its way out through this very same valve into the main exhaust, and only when the expansion for the return stroke is initiated by the opening of the valve i^1, and the simultaneous closing of i, the communication between the two cylinders will be interrupted at this side, and reopened at the opposite one.

Such a motion of the valves as just described is automatically imparted to them by the governor R (see Figs. 3, 4, 6, and 7) which may have any speed most suitable to its construction, but the spindle n, which receives its rotation from the governor shaft by a pair of spur wheels, must make the same number of revolutions as the engine itself. On the top end it carries a sleeve o, with a cam r, which, on account of a spiral face worked on the upper part of the spindle n, must change its angular position when it is lifted or lowered by the governor; but if the governor does not alter the position of the sleeve, the cam simply participates in the rotation of the spindle n, and its position on it is so adjusted, that during each stroke of the engine the cam r strikes once against the frame p, and, by means of the connexions q, r, s, t, w, and w^1, acts on the valves i and i^1, opening the one and shutting the other. This will take place according to the height of the governor balls, and (on account of the spiral face on which the sleeve has to slide) sooner or later after the commencement of the stroke; the governor thus completely controls the expansion of the engine, and a correct and quick cut-off, varying from 0.03 to 0.8 of the stroke, can be obtained.

To gradually reduce the speed of the steam valves after they have closed their ports, and to prevent a shock, two steam dashpots, P and P¹ (which are cast together with the steam chests B and B¹) are provided, and the valve for regulating their action are shown in Figs. 14 and 15. The steam passage a, communicates with the dashpot, and the passage b with the steam chest, and the two small handwheels c and d serve to fix the valve in its proper position.

The expansion cylinder need only be made very small, as only the friction resulting from the stuffing boxes and the dead weights has to be overcome, and the cubical contents of it and its piping will always be but a small fraction of the necessary space between the piston and the cylinder cover of the engine.

The draining of the cylinder is effected at each stroke when the exhaust port is open through a hole or recess in the end, at the bottom of the exhaust valve, see Figs. 1 and 10, and a bridge in the centre of the port prevents the escape of the steam through this opening when the valve is closed.

ON RADIANT MATTER.*

By WILLIAM CROOKES, F.R.S.

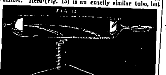
(*Concluded from page 168.*)

Radiant Matter is deflected by a Magnet.—I now pass to another property of radiant matter. This long glass tube (Fig. 14) is very highly exhausted; it has a negative

FIG. 14.

pole at one end (a) and a long phosphorescent screen (b c) down the centre of the tube. In front of the negative pole is a plate of mica (b d) with a hole (e) in it, and the result is, when I turn on the current, a line of phosphorescent light (e, f) is projected along the whole length of the tube. I now place beneath the tube a powerful horseshoe magnet: observe how the line of light (e, g) becomes curved under the magnetic influence, waving about like a flexible wand as I move the magnet to and fro.

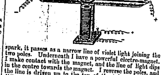
This action of the magnet is very curious, and if carefully followed up will elucidate other properties of radiant matter. Here (Fig. 15) is an exactly similar tube, but



having at one end a small potash tube, which if heated will slightly injure the vacuum. I turn on the induction current, and you see the ray of radiant matter tracing its trajectory in a curved line along the screen, under the influence of the horseshoe magnet beneath. Observe the shape of the curve. The molecules shot from the negative pole may be likened to a discharge of iron bullets from a mitrailleuse, and the magnet beneath will represent the earth curving the trajectory of the shot by gravitation. Here on this luminous screen you see the curved trajectory of the shot accurately traced. Now suppose the deflecting force to remain constant, the curve traced by the projectile varies with the velocity. If I put more powder in the gun the velocity will be greater and the trajectory flatter, and if I interpose a denser resisting medium between the gun and the target, I diminish the velocity of the shot, and thereby cause it to move in a greater curve and come to the ground sooner. I cannot well increase before you the velocity of my stream of radiant molecules by putting more powder in my battery, but I will try and make them suffer greater resistance in their flight from one end of the tube to the other. I heat the caustic potash with a spirit-lamp and so throw in a trace more gas. Instantly the stream of radiant matter responds. Its velocity is impeded, the individual molecules, the trajectory gets more and more curved, until, instead of shooting nearly to the end of the tube, my molecular bullets fall to the bottom before they have got more than half way.

It is of great interest to ascertain whether the law governing the magnetic deflection of the trajectory of radiant matter is the same as has been found to hold good at a lower vacuum. The experiments I have just shown you were with a very high vacuum. Here is a tube with a low vacuum (Fig. 16). When I turn on the induction

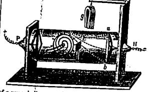
FIG. 16.



spark, it passes as a narrow line of violet light joining the two poles. Underneath I have a powerful electro-magnet. I make contact with the magnet, and the line of light dips in the centre towards the magnet. I reverse the poles, and the line is driven up to the top of the tube. Notice the difference between the two phenomena. Here the action is temporary. The dip takes place under the magnetic influence; the line of discharge then rises and pursues its path to the positive pole. In the high exhaustion, however, after the stream of radiant matter had dipped to the magnet it did not recover itself, but continued its path in the altered direction.

By means of this little wheel, skilfully constructed by Mr. Gimingham, I am able to show the magnetic deflection in the electric lantern. The apparatus is shown in this diagram (Fig. 17). The negative pole (a, b), is in the form

FIG. 17.



of a very shallow cup. In front of the cup is a mica screen (c, d), wide enough to intercept the radiant matter coming from the negative pole. Behind this screen is a mica wheel (e, f), with a series of vanes, making a sort of paddle-wheel. So arranged, the molecular rays from the pole a b will be cut off from the wheel, and will not produce any movement. I now put a magnet g over the tube, so as to deflect the stream over or under the obstacle c d, and the result will be rapid motion in one or the other direction, according to the way the magnet is turned. I throw the image of the apparatus on the screen. The spiral lines painted on the wheel show which way it turns. I arrange the magnet to draw the molecular stream so as to beat against the upper vanes, and the wheel revolves rapidly as if it were an overshot water-wheel. I turn the magnet so as to drive the radiant matter underneath; the wheel slackens speed, stops, and then begins to rotate the other way, like an undershot water-wheel. This can be repeated as often as I reverse the position of the magnet.

I have mentioned that the molecules of the radiant matter discharged from the negative pole are negatively electrified. It is probable that their velocity is owing to the mutual repulsion between the similarly electrified pole and the molecules. In less high vacua, such as you saw a few minutes ago (Fig. 16), the discharge passes from one

* A lecture delivered to the British Association for the Advancement of Science, at Sheffield, Friday, August 22, 1879.

ACTION OF MAGNETISM ON THE RADIOMETER.

Eng Mechanic Oct 17 1879

IN a recent number of Wiedemann's *Beiblätter*, some instructive experiments with the radiometer by Herr Basso are described.

Into the magnetic field of a strong electro-magnet Herr Basso brought an ordinary radiometer with four mica vanes blackened on one side, and let the rays of a gas-flame fall on it at first alone, and until it attained a constant velocity; then he closed the circuit of the electro-magnet so that the action of this was added to that of light. The result was that the constant velocity diminished (in one experiment, *e.g.*, in a ratio of $26 : 20\frac{3}{4}$). This retardation was chiefly caused, the author says, by the action of the poles of the large magnet on the vanes, perhaps also by magnetic action on the residual air contained in the radiometer, of which the oxygen is strongly magnetic, and by the production of electric currents through motion of the radiometer in presence of the magnetic pole.

The existence of induction currents in connection with the retardation appeared somewhat probable, because the retardation caused by magnetism was especially great (comparatively) in the case of a radiometer with metallic cross and metallic vanes.

A simple two-armed radiometer, with aluminium arms and mica veins, of which latter the one had one uncoated and one black side, while the two surfaces of the other were uncoated, stood still in darkness in the field of an unexcited electro-magnet, but turned quickly into the axial position as soon as the magnet was excited. The same radiometer showed a considerable retardation of the rotation produced by light whenever the action of magnetism was superadded.

Herr Basso also sought to measure the force which drives a body in rarefied air away from the light source. He did so by means of a differential radiometer consisting of a horizontal tube 24mm. in length, having glass globes blown at the ends. In the middle of the interior (which was rarefied of air) a vertical steel point supported an aluminium beam, the extremities of which were formed by vertical aluminium plates blackened on the same side, and situated exactly in the middle of the globes. When both vanes were simultaneously struck by rays of equal intensity there was no deflection. When one vane was exposed simply to the action of light, the other merely to magnetic action, these two forces tended, when the axis of the apparatus was at right angles to that of the electro-magnet, to deflect the balance in opposite directions. In this ways, *e.g.*, the flame of an ordinary stearine candle at 21ctm. distance proved equivalent in action to the magnetic action of the electro-magnet at 32mm. distance.

Mr. Crookes on Radiant Matter.

Mining Sci Press Jany 1880

A few weeks since Mr. William Crookes, F. R. S., gave at the London Institution an experimental demonstration of recent researches on radiant matter. He observed that modern research during the last sixty years had greatly enlarged and modified our views on the constitution of gases, which were now believed to be composed of small particles or molecules that were constantly moving in every direction with velocities of all conceivable magnitudes. As these molecules were exceedingly numerous, it followed that no molecule could move far in any direction without coming in contact with some other molecule; but if we exhausted the air or gas contained in a closed vessel, the number of molecules became diminished, and the distance through which any of them could move without coming in contact with another was increased, the length of the mean free path being inversely proportional to the number of molecules present. The further this process was carried, the longer became the average distance a molecule could travel before entering into collision; or, in other words, the longer its mean free path, the more the physical properties of the gas or air were modified. Thus, at a certain point the phenomena of the radiometer became possible, and on pushing the rarefaction still further—*i. e.*, decreasing the number of molecules in a given space and lengthening their mean free path—the experimental results were obtainable, to which Mr. Crookes called the attention of his audience, and which were fully explained in a lecture delivered by him to the British Association at Sheffield in August last.

So distinct, he remarked, were those phenomena from anything which occurred in air or gas at ordinary tension, that we were led to assume that we were here brought face to face with matter in a fourth state or condition—a condition as far removed from the state of gas as gas was from a liquid. In some of its properties radiant matter was as material as wood or tin, while in other properties it almost assumed the character of radiant energy. We had actually touched the borderland where matter and force seem to merge into each other—the shadowy realm between known and unknown, which for him had always had peculiar temptations. He ventured to think that the greatest scientific problems of the future would find their solution in this borderland, and even beyond; there, it seemed to him, lay ultimate realities, subtle, far-reaching and wonderful.

EXPERIMENTAL RESEARCHES IN ELECTRICITY[1]

SUPPLEMENT TO PART III.—*The Electric Condition of the Terminals of a Vacuum-Tube after their connection with the Source of Electricity has been broken*

THE question has been mooted whether there is a polarisation of the terminals of a vacuum-tube after the discharge through it has been interrupted by breaking connection between it and the source of electricity. This question is to be understood in the sense—does there exist a *chemical* polarisation as is the case for instance with the terminals of a voltameter under similar circumstances?

The problem is by no means easy of solution. The authors believe, however, that the few experiments they describe, selected from a long series, will show that there is really no such polarisation of the terminals.

In the first instance the case of the voltameter is considered; the arrangement of the apparatus employed in the experiments is shown in Fig. 1, where K K′ represent

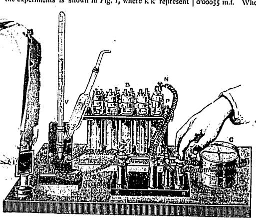


FIG. 1.

a special key for breaking connection between any piece of apparatus and the battery, B, and connecting it afterwards instantaneously with a galvanometer, G. The terminals of the battery are attached respectively to the screw-clamps, *c* and *d*, carried by an ebonite bar, supported on two ebonite columns, touch-points in metallic contact with *c* and *d*, pass through this bar, so that when the brass springs, *a c* and *b f*, are allowed to rise and press against these touch-points, the battery is in metallic connection with the screw-clamps, *a* and *b*, and any piece of apparatus attached to them, as, for example, the voltameter, V. The voltameter employed has a resistance of 20 ohms; its platinum electrodes are 2·5 inches long and 0·025 inch in diameter, and are separated 0·25 inch; it is charged with dilute pure sulphuric acid in the proportion of 1 volume of acid, sp. gr. 1·84, to 8 volumes of water. When the springs are suddenly pressed down by the fingers placed on the ebonite disks, *e* and *f*, the connection is broken between the voltameter and the battery, and it is connected instantaneously with the galvanometer G. The galvanometer actually employed was not that shown in the figure, but a Thomson galvanometer, whose constant

$$C_1 = \frac{1 \text{ volt}}{1 \text{ megohm}} = 1{,}874 \text{ scale divisions.}$$

On connecting a battery of 10 chloride of silver cells with the voltameter for a minute or less, and then suddenly pressing down the springs *e* and *f*, there was a deflection to the left, say, of more than 1000 scale divisions, although the $\frac{1}{999}$ shunt was used to reduce the current through the galvanometer; therefore, the deflection without the shunt would have been more than 1,000,000 divisions. By comparing this deflection with that produced by a half microfarad condenser, charged with 240 cells, it was ascertained that the deviation produced by the voltameter was equivalent to that of 111 microfarads.

The small condenser shown at C, Fig. 1, was substituted for the voltameter; it is made of a thin plate of glass inches square and 0·0115 inch thick; the tinfoil coating being 1·5 inch square, its capacity was found to b 0·00055 m.f. When charged with 3,600 cells, and after wards connected with the Thomso galvanometer through the $\frac{1}{9}$ shunt, b pressing down *e* and *f*, the deflectio was 136·5 divisions to the left; thi multiplied by 9·92, the value of th shunt was equivalent to 1,354 division

The apparatus, shown in Fig. which was constructed for anothe object already described,[1] was con nected with *a* and *b*; it consists essen tially of two disks, 3·1 inches diamete placed 0·13 inch apart. The capacit of this apparatus, when used as a air-condenser, was determined, an found to be 0·000058 m.f. With 3,60 cells no discharge took place, and i merely charged up as a condense The deflection produced, when th keys *e* and *f* were pressed down, wa (without shunt) 150 divisions, still t the left. It is evident, therefore, th the direction of the deviation throw no light on the question, for it is th same with the voltameter as with th condenser.

Tube 73, containing a residuum c acetylene, was now substituted for th air-condenser; it is 26·5 inches lon and 1·5 inch diameter, the distanc between the termals 23 inches; th tube was connected with 3,600 cell current 0·00581 W The tube potenti was found to be 2,980 cells, and its resistance 449,5 ohms. On pressing down the springs *e* and *f*, so as t break connection with the battery and connect th tube with the galvanometer, there was a deflection o 11 divisions to the left, the same as before. The curren was only

$$\frac{11}{1874 \times 1{,}000{,}000} = \frac{1}{170{,}000{,}000} \text{ W.}$$

The diagram, Fig. 3, will illustrate the action of th special key, Fig. 1. When the handle is moved t the left, the tube T T′ is placed in metallic connectio with the battery, whose terminals are shown attached t *c* and *d* (this is equivalent to the springs being allowed t press upwards against *c* and *d*, Fig. 1); when the handl is moved to the right, then the discharge of the batter through T T′ ceases, and the terminals of the tubes N an P are connected with the galvanometer, the extremities c whose coil are attached to *e* and *f* (this is equivalent t pressing down the springs in Fig. 1).

On another occasion with the same tube, No. 73, wit

[1] "Experimental Researches on the Electric Discharge with the Chloride of Silver Battery," by Warren De La Rue, M.A., D.C.L., F.R.S., and Hugo W. Müller, Ph.D., F.R.S.

[1] *Phil. Trans.*, vol. clxxi. p. 76; NATURE, vol. xxii. p. 152.

a discharge from 2,400 cells, the deviation to the left on passing down *e* and *f* was 20 divisions.

Tube 199, with a hydrogen charge, was now substituted; pressure 2 millims., 2,632 M, 5,100 cells, current 0·01639 W. This tube has already been described (NATURE, vol. xxii. p. 176); it is 37 inches (94 centims.) long, and $5\frac{13}{16}$ inches (14·8 centims.) in diameter. The distance between the terminals, a ring and a straight wire, is 33·5 inches (85 centims.). In the first place the battery was connected direct to the galvanometer, the positive to *e* and the negative to *f* (that is, in the same direction as if the positive were attached to *c* and the negative to *d*). A short piece of wire was inserted between *e* and *f* as a shunt, and the $\frac{1}{999}$ shunt was also used with the galvanometer, the direction of deviation was found to be to left, which it was desired to know.

On pressing down *e* and *f*, the deviation was to the left, and only amounted to 2 divisions. On another occasion, at the same pressure, 3,900 cells, current 0·02925 W., the deviation to the left on pressing down *e* and *f* was from 3 to 5 divisions.

The same tube, with a charge of coal-gas, pressure 3 millims., 3,947 M, current 0·01705 W., deflection, on pressing down *e* and *f*, 7 divisions to left.

The same tube, with air, pressure 1·5 millims., 1,974 M, current 0·02728 W., on pressing down *e* and *f*, deviation 20 divisions. The deviation was, therefore, greatest with air; but if due to a chemical polarisation, it would have been *a priori* expected to be greatest with coal-gas, which is a mixture of decomposable molecules. The result of the experiments with tube 199 gave the following deviations:—

Hydrogen.	Coal-gas.	Air.
3	7	20

Again, tube 199, 2,400 cells, pressure 1 millim., 1,316 M, current 0·02456 W., deflection on pressing down the keys, 16 to left; with 1,500 cells no discharge, yet a deflection of 10 divisions to the left was produced on pressing down the keys. The deflection in the latter case being clearly due to a static charge.

Experiments were now made in air with an apparatus similar to that already described in NATURE, vol. xxii. p. 174, but with disks instead of points, in order

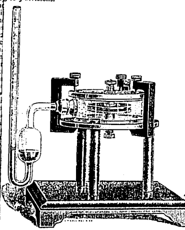


FIG. 2.

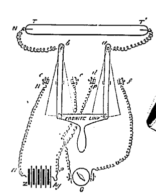


FIG. 3.

to obtain a vacuum vessel with large terminals. The terminals are two disks a little over $4\frac{1}{4}$ inches (11 centims.) in diameter, and in the first instance were placed 3 inches (7·62 centims.) apart. Pressure 4·5 millims., 5,921 M, 2,400 cells, current 0·04366 W., deviation on connecting the disks with the galvanometer, 10 divisions to left.

With 1,200 cells, no discharge took place, but on connecting the galvanometer a deviation of 27 divisions to the left was, nevertheless, produced.

At a pressure of 20 millims., 26,316 M, with 3,900 cells, no current passed, but the deviation on connecting the galvanometer, was 66·6 divisions to the left.

The disks were now placed at a distance of 2 inches (5·08 centims.), the pressure being still 20 millims., and the battery 3,900 cells, the discharge now took place, current 0·03896 W., deflection on connecting galvanometer 8·5 to left.

On reducing the battery to 2,400 cells, the discharge did not take place, but a deviation of 43 divisions was produced on pressing down *e* and *f*.

The disks were placed at 1 inch (2·54 centims.) apart, same pressure, with 3,900 cells, the current was 0·04201 W., deviation to left on connecting the galvanometer 13 divisions.

2,400 cells would not pass, but a deviation to the left of 47 divisions was obtained on connecting the galvanometer.

The following are the results of these experiments with the disks at various distances:—

Distance, inches.	No. of cells.	Pressure, mm.	Current.	Deflection on connecting galvanometer, divisions.
3	1,200	4·5	did not pass	27·0
3	2,400	4·5	passed	10·0
3	3,900	20·0	did not	66·6
2	3,900	20·0	passed	8·5
2	2,400	20·0	did not pass	43·0
1	3,900	20·0	passed	13·0
1	2,400	20·0	did not pass	47·0

So that in every case when the current had not passed

117

EDISON'S VACUUM APPARATUS.

With the exception of the peculiar carbon used by Mr. Edison in the construction of his lamps, there is nothing of more vital importance in the development of his system of electric illumination than the apparatus employed to exhaust the air from the little globes containing the carbon horseshoes, for upon the perfection of the vacuum depends the success of the lamp.

Since Otto Von Guericke invented the air-pump in 1650 it has been the subject of various modifications and improvements; but the most perfect forms of piston air-pump yet devised are incompetent to produce the degree of exhaustion demanded by modern experimenters.

In vacuum apparatus, as in most things connected with scientific investigation and experiment, the simplest means and methods prove the best. It seems that in the natural course of invention, simplicity is the latest feature attained. Air-pumps and vacuum apparatus form no exception to this general truth. The most recent as well as the most perfect air-pumps consist essentially of a glass tube and a column of mercury. Two forms of mercurial pump are used by Mr. Edison in removing the air from his lamp bulb; one for exhausting the greater volume of air, the other for perfecting the vacuum. The first is the invention of Geissler; the second, of Sprengel. The engraving shows the arrangement of these pumps in connection with the McLeod gauge, and other accessories.

Several sets of this apparatus are employed by Mr. Edison, and he has so far improved their construction and working as to enable the attendant to produce very high vacua in twenty-five minutes.

The Geissler pump, A, the Sprengel pump, B, and the McLeod gauge, C, are all connected with the socket that receives the lamp bulbs, through the bulb, E, which is partly filled with phosphorous anhydride—a powerful absorbent of moisture—and through the bulb, F, which contains gold leaf to absorb traces of mercurial vapor. Each set of apparatus is secured to a vertical board, behind which on a bracket near the top sets a reservoir of mercury, which supplies the Sprengel pump, B, through the flexible tube, *a*, and through a vertical glass tube, having at the top a trap, *b*, for receiving any air that may be carried by the mercury.

The Sprengel pump, E, consists of a glass tube about ⅛ inch in internal diameter and 36 inches in length, dipping at its lower end into mercury contained in the small vessel resting on the bracket, and having an overflow connected by a flexible tube with a mercury receiver. At the upper end of the ⅛-inch tube is formed a bulb, into which the mercury supply tube enters through a sealed joint (described elsewhere) and extends about two-thirds of the way down the bulb. The bulb is provided with a lateral tube by which it is connected with the Geissler tube, D, and with the bulbs, E and F, which communicate with the lamp bulbs, G. The Sprengel pump also connects with the Geissler pump, A, when the stopcock, *c*, is open.

The Geissler pump, A, is simply a glass tube, having a bulb blown in it, and communicating at its lower end with a mercury reservoir through a flexible tube, and connecting at its upper end with the Sprengel pump, B, as before described, and also with a bent discharge tube, *d*, of small caliber, which extends downward something over 36 inches and dips into mercury contained in a small cup provided with an overflow.

The McLeod gauge is no more complicated than either of the pumps. It consists of a bulb, *e*, blown on the end of a tube of small diameter, and having a still smaller tube, *f*, projecting from its upper surface. This tube is closed at the top, and its capacity bears a certain ratio to that of the bulb. It extends over the face of a scale, *f*. The longer and larger tube of the gauge is connected by a flexible tube with the mercury bottle seen resting on the bracket; and it is also connected by a small tube, *g*, with the system of tubes that connects the two pumps, the Geissler tube, and the lamp bulbs. The connecting tube, *g*, extends over the scale, *f*, parallel to and near the gauge tube, *f'*.

To produce a vacuum in the bulbs, G, the pinch-cock on the rubber pipe, *a*, is opened so as to permit a rapid succession of drops, or a full stream of mercury to flow down the internal tube of the Sprengel pump, B. This stream of mercury, falling through the space between the internal tube and the lower end of the bulb, enters the long tube of the pump, and carries with it a certain quantity of air, which is discharged together with the mercury into the cup at the bottom. As this process is too slow for creating a vacuum from the beginning, while the Sprengel pump is still working, the Geissler pump, A, is brought into use for removing the greater portion of the air. To operate this pump, the stopcock, *c*, is first closed, the reservoir of mercury—connected with the pump by a rubber tube—is raised by the attendant, as represented in the cut, until mercury flows up the long pump tube, and filling the bulb, drives out the air before it through the discharge tube, and finally overflows through the tube, *d*, into the cup at the lower end of the tube. The mercury reservoir is then lowered until the two vertical columns of mercury break in the bend of the discharge tube, and the mercury in the pump is below the stopcock, *c*, the latter is then opened, and the mercury reservoir is lowered until the mercury in the pump will sink no farther. The stopcock, *c*, is then closed and the operation is repeated two or three times. The Sprengel pump, which has been in operation meanwhile, is now permitted to finish the work. As the vacuum becomes more and more perfect the mercury rises in the pump, and when the drops strike the mercury column, a sharp metallic clink is heard, indicating that the atmospheric resistance to the falling metal is little or nothing. As fast as the mercury accumulates in sufficient quantities in the reservoir below, it is poured into the reservoir above.

Electric sparks from an induction coil are continually passed through the Geissler tube, D, as long as the vacuum is low enough to admit of it. Mr. Edison says that when a 9 inch spark fails to pass the ⅛ inch space between the electrodes in the tube the vacuum is still coarse.

The McLeod gauge is relied on mainly for testing the perfection of the vacuum. This gauge is operated by simply raising the mercury reservoir connected with it until the gauge bulb is sealed off from the other parts of the apparatus, the mercury, as it rises, closing the connecting tube, *g*. The mercury reservoir is then raised still further, until the mercury will go no higher in the gauge tube, *f'*. Should the mercury rise to the end of the gauge tube it would indicate a perfect vacuum, but this is never attained. The quantity of air contained in the tube, *f'*, indicates exactly the proportion of the air in the apparatus to the capacity of the apparatus or air at its normal density. Another method of calculating the value of the vacuum is based upon the difference in the level of mercury in the two tubes in front of the scale, *f*.

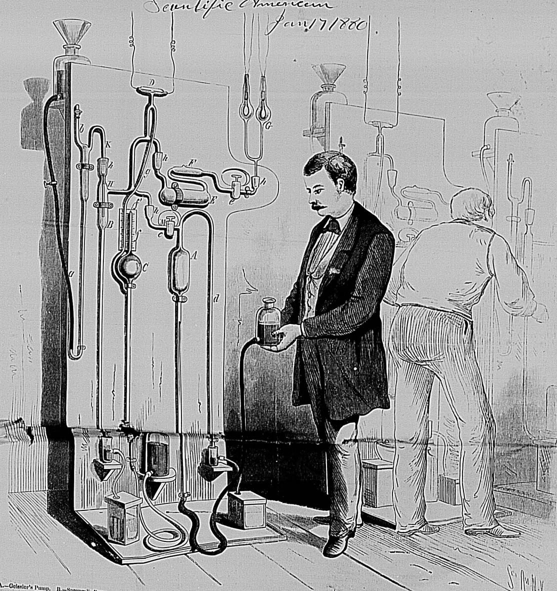
Mr. Edison informs us that the vacuum in his lamps is so nearly perfect that only a millionth of the original volume of air remains.

It is obvious that the Sprengel and Geissler pumps must be longer than a barometer, to obtain the full effect of the falling column of mercury. All of the rigid parts of this apparatus are made of glass, and wherever there is a joint or a stop cock, it is sealed with mercury. Figure 2 shows the upper portion of the Sprengel pump in detail, and also gives a good idea of the manner of sealing the joints. The bulb, H, has a conical mouth, I, into which is fitted and ground the enlarged portion, J, of the mercury tube, K. The space in the mouth, I, above the enlarged part of the tube, K, is filled with mercury.

Figure 3 represents a mercury-sealed stop cock, L being the stop cock, entirely surrounded by mercury contained in the cup, M.

The lamp bulbs, G, are connected with the apparatus by a joint similar to that represented in figure 2. From time to time, while the air is being exhausted from the lamps, they are tested by connection with wires from the electrical generator. When the vacuum is practically complete, the tubes connecting the lamps with the vacuum apparatus are heated by a spirit lamp, sealed and separated from each other and from the apparatus.

Scientific American Jan 17 1880



A.—Geissler's Pump. B.—Sprengel's Pump. C.—McLeod's Gauge. D.—Geissler Tube. E.—Bulb containing Phosphorous Anhydride. F.—Bulb containing Gold Leaf. G.—Electric Lamp Bulbs. *a*.—Mercury Suppy Tube. *b*.—Air Trap. *c* and *e*.—Mercury Sealed Stop Cocks. *d*.—Discharge Tube. *f*.—Scale. *f'*.—Gauge Tube. *g*.—Connecting Tube. *h*.—Mercury Sealed Joints.

VACUUM APPARATUS FOR EXHAUSTING EDISON'S ELECTRIC LAMPS.

Fig. 2.

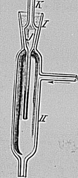
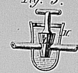


Fig. 3.

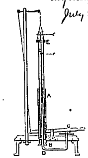


A MERCURIAL AIR-PUMP.

[17611.]—SEVERAL letters have lately appeared in the E.M. relative to the exhaustion of vacuum tubes and other small philosophical apparatus, and the best pumps for effecting their exhaustion successfully.

I herewith send a sketch and description of a

Eng Mechanic
July 23 1880



pump which I designed some short time ago. It combines the principle of the mercurial air-pump with that of the ordinary pump with barrel and piston, and being made of glass tubes and wood, with the exception of the valves, any amateur could construct one for himself with ease.

A is a wide glass tube, about 20in. in length, and closed at its lowest extremity by a perfectly-fitting indiarubber cork B. Through this, and up the centre of A, passes a small-bore tube C D, also of glass, the length of which, from C to the cork B, must be a little over 30in. Its lowest end is bent twice, at right angles, and the end *d* projects above the stand, and to it the tubes to be exhausted are fixed. Over this smaller tube, and inside A (i.e., between the two), slides another glass tube E F, contracted at its upper end, and having a band at E fixed to it, by which it can be raised and lowered by the string, which passes over the pulleys, and is attached to the lever G, as shown in the sketch.

The tubes C D and E F are closed at their upper ends by discs, or valves, *c c*, which fit air-tight when in contact with the ends of the tubes which they close. These discs are of thin brass, with a thin piece of indiarubber cemented on their under surfaces, and a fine steel wire, about 8in. in length, is fixed to the disc *c*, and passes downwards through a hole in the disc *c*, through which it must slide, with little friction, but air-tight. Each disc, or valve, is prevented from rising too far by pins which pass through guide-holes in their edges. The disc *c* is shown thus arranged; the disc *c* is exactly like it, but smaller.

The stand and lever, and its appendages, by which an up and down motion is imparted to the tube, is sufficiently explained by the sketch.

The outside tube A is filled nearly to the top with mercury, and when the end *d* of the inner tube is free to the air, the mercury will rise to the same level in the tube E F. But suppose the end *d* to be closed by a vacuum tube, to be exhausted, fixed to it, and the tube E F to be raised by raising the lever G. The air between the mercury and the top of the tube E F will be rarefied, and air from the vacuum tube will enter it to restore the equilibrium. But, at the same time that E F is being raised, the valve *c* is closed, because the steel wire is retained slightly by the disc or valve *c*, through which it passes with a certain amount of friction, due to the indiarubber facing; and, for the same reason, the valve *c* is opened. The valves being in these positions, the air is free to rise through the small tube and enter the amplified space in E F, and, at the same time, the mercury rises slightly in E F. When the tube descends, the positions of the valves are reversed, *c* being opened, and *c* closed; and thus the air in E F is discharged through *c*. E F is then raised a second time, when a fresh quantity of air is abstracted from the vacuum tubes to be discharged through the valve *c*, when the tube is depressed (it will, of course, descend by virtue of the atmospheric pressure). The mercury will continue to rise in E F, and sink in A, at every upward stroke, and that till the air is entirely exhausted from the tube, when the mercury will have risen nearly to the valve *c* in E F, and a column, 30in. in length, obtained.

I hope that I have made clear its construction and action, and trust that some of our numerous contributors will give their candid opinions as to whether the scheme is practicable or not. A cheap, simple, and effectual air-pump would, I am sure, be a welcome acquisition to the experimental amateur.

Norwich. A. E. Cattermole.

RADIANT MATTER.

[17195.]—Although the beautiful and important researches of Mr. Crookes, in relation to radiant matter, have attracted general attention, both here and on the Continent, no attempt, as far as I am aware, has yet been made to apply them to any of the numerous phenomena in physical science which have hitherto eluded philosophical explanation. I allude more particularly to certain phenomena, in which such a highly attenuated form of matter as that existing in the vacuum tubes of Mr. Crookes, appears to me to be intimately concerned—namely, the sun's corona, the zodiacal light, and comets. I wish, however, in these brief remarks, to refer to radiant matter solely in its relations to the latter class of bodies, and to point out a few of the analogies in a physical point of view between it and the vaporous substance of which all comets are found to be composed, and which the spectroscope seems to indicate as some volatile form of carbon. Like this radiant matter, this cometary matter exists, as I have intimated, in a state of extreme tenuity, or, to use the words of Sir John Herschel, it is a vapour or fog, of almost spiritual lightness, as is sufficiently proved by bright stars, such as Arcturus, in the case of Donati's comet of 1858, shining through the brightest part of the tail of that comet, without being in the least dimmed, although the light must have there shown through a thickness of 90,000 miles of this mist.

Now Sir John was so struck with the peculiar repulsive properties manifested by cometary matter under the influence of the sun, that he hesitated not to call it "levitating," in contra-distinction to "gravitating," or ordinary matter. And in the lecture on "Comets," in his familiar lectures on "Scientific Subjects," from which I have quoted, he speaks of "the phenomena of the tails of comets as affording positive and unrefutable demonstration of the existence in nature of a repulsive force co-extensive with but enormously more powerful than the attractive force we call gravity." This force, however, he affirms, cannot possibly be either electric or magnetic, because "the discrete particles which go to form a comet's tail, could by no possibility (their polar state being implied) be either attracted or repelled by a body, however powerfully magnetised or electrified, placed at the distance of the sun: for, he adds, "the attraction on one side of such a particle would be precisely equal to the repulsion on the other."

If, however, we regard radiant matter, to which in its marvellous tenuity the "levitating" matter of Herschel seems to be so closely allied, we find that it exhibits extreme mobility under the influence of the electric current, and also, as is beautifully shown by the radiometer, under the action of light and heat. In fact, this instrument appears to me to afford a ready explanation of the remarkable phenomenon already referred to, namely, the powerful repulsive energy evidently exerted by the sun upon the tails of comets, inasmuch as they are invariably thrown out, as is well known, in a direction exactly opposite the sun. For, if the arms of the radiometer are moved by heated molecular currents formed within it, and which thus exhibit considerable repulsive force, we can easily conceive that cometary matter in the neighbourhood of the sun may be so acted upon by its intense heat as to give rise to similar currents, and that the interior of the head of a comet may consequently be propelled outwards, or from the sun so as to form a tail, by the powerful tension or pressure of the highly-heated currents generated upon its exterior surface. This tail we may also conceive as capable of any extension, however vast, being, as it would, under the influence of similar propelling currents from its exterior, while acted upon by the sun. And here, to meet an objection to such a theory, it may be necessary to observe that cometary matter, notwithstanding its extreme tenuity, is, without doubt, under the control of gravity, and that coercive force is so great as a comet approaches the sun, that such matter is wholly prevented from passing away into free space, and is, therefore, *virtually* in the same condition as the radiant matter in the bulb of the radiometer. Or we may perhaps, better express what takes place in the case of the comet, by saying that its matter is acted upon by two forces, a powerful gravitating, and a far more powerful repulsive force, and that the molécules accordingly move in the direction of the resultant of these forces, or backwards when a tail is formed. This repulsive force may, perhaps, likewise account for the retrograde orbital motion of many comets.

Another remarkable characteristic of radiant matter may here be noticed, and which is particularly referred to in the able paper on the subject, from the *Revue des Deux Mondes*, which appeared in your 780th number, namely, "The Motion of Molecules in Right Lines"; the author observing if "they (the molecules in the vacuum tubes) are thus impelled, they ought to exercise mechanical power in the direction of their propagation. Their course is sufficiently long for this effort or pressure not to be transmitted instantaneously in every direction as taking place in gas at the ordinary tension." If, then, upon our hypothesis, radiant and cometary matter are identical in physical properties, we must regard the molecules of the latter as also differing from those of an ordinary gas in not transmitting pressure in every direction but only in that of their propagation; that is, conformably to observation, towards the tail. Thus, independently of the potent action of gravity upon it, cometary matter would have no tendency like a gas to pass away in any other direction into space.

If, too, both these forms of matter are governed by the same laws, it would seem that there is no necessity, from the phenomena of comets, to assume, as in the passage above quoted, Sir John Herschel assumed, the existence of a special all-powerful repulsive force residing in the sun, because the solar heat and light would, I conceive, be adequate to account for them, at least, in a dynamical point of view. There is also every reason to believe that the sun is, too, the centre of most powerful electric and magnetic forces, and these, like the calorific and luminous, would, as in ultra-gaseous or radiant matter, exert a direct influence upon the matter of comets, if both have the same physical constitution.

Another very striking feature in comets—their luminosity—seems also to be very well explained upon the theory which I have ventured to submit; for if, as it assumes, the matter of a comet is in an ultra-gaseous condition like that in a vacuum tube, it must, I repeat, be also in a state of violent intestine or molecular motion under solar energy; in other words, of intense heat, and may become consequently self-luminous or incandescent.

According to Wickmann, luminosity in Geissler tubes "appears far under a 100° cent."

I might refer likewise to the dark space around the negative pole of a vacuum tube in relation to the dark spaces between "the cappings of light" or envelopes formed sometimes in front of the nucleus of a comet, as in Donati's of 1858, but will not further extend my imperfect remarks.

Stoke Newington, April 5th. W. H. O.

EXPERIMENTAL RESEARCHES ON THE ELECTRIC DISCHARGE WITH THE CHLORIDE OF SILVER BATTERY.

Electrician July 31/1880

BY WARREN DE LA RUE, M.A., D.C.L., F.R.S., AND HUGO W. MÜLLER, PH.D., F.R.S.*

(CONCLUDED FROM PAGE 71.)

Experiments were now made in air with the apparatus (already described †) shown in Fig. 1, in order to obtain a vacuum vessel

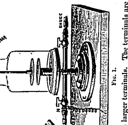


FIG. 1.

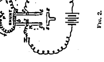


FIG. 2.

with larger terminals. The terminals are two discs a little over 4¼ inches (11 centims.) in diameter, and in the first instance were placed 3 inches (7·62 centims.) apart. Pressure 4·5 millims. 5,921 M, 2,400 cells, current, 0·04366 W., deviation on connecting the discs with the galvanometer, 10 divisions to left.

With 1,200 cells, no discharge took place, but on connecting the galvanometer a deviation of 27 divisions to the left nevertheless was produced.

At a pressure of 20 millims., 26,316 M, with 3,920 cells, n

* Abstract of a paper presented to the Royal Society.

† "Phil. Trans," Vol. clxxi., p. 75.

the lower arrow, and the deviation 1?? divisions ...

* The value of the shunt.

On pressing down the keys on to the metal slip placed under them to short-circuit the current, after the battery had been disconnected, the return current was in the reverse direction, as shown by the upper dotted arrow, the deviation being 425 divisions to the right. Even without pressing down the keys on to the metal slip nearly the same deviation was obtained on disconnecting battery as the return current then traversed the shunt from *a* to *b*.

On substituting either the bell-jar, with disc terminals, or the tube 199 for the voltameter, the deflection of the return static charge was in the same direction as the return current for the voltameter, so that, as we before stated, no inference can be drawn from the direction of the current as to its being produced by polarisation or a static charge. We think, however, that we have shown conclusively that the effect in the case of a vacuum tube is due to a static charge, and not to a polarisation of the terminals. We rest our opinion mainly on the fact that a greater deflection is produced, when the potential has not been lessened by a discharge through the tube, than that which occurs after the discharge has taken place, which, it had been surmised, might possibly produce a chemical polarisation.

LITERATURE.

Washburne's Cable and Telegraphic Manual and Error Detector. By Messrs. WASHBURNE AND PALMER. [Globe Stationery and Printing Company, 89, Liberty-street, New York.]

The authors of this little work give as their right to speak with authority on the subject a practical experience of thirteen years in working cables and land lines. From what we gather in reading the book we can for once safely say the authors were justified in writing it, the information and the advice given being very good. The work gives, in the first place, certain information relating to charges, counting, &c., followed by some excellent paragraphs on errors and methods of detection. The following may be given as an example of the authors' matter:—

WRITING ERRORS.

Eng Mechanic March 5 1880

RADIANT MATTER.*

By Adolphe Wurtz.

EVERYONE knows that matter presents itself to us in different states of aggregation, in solid, liquid, or gaseous conditions.

The gaseous state, in some respects the most subtle of all, has been the most difficult to understand and define, and although common facts of observation, such as the force of the wind, have shown to the Greeks the material nature of the atmosphere, yet the existence of aëriform fluids of different forms has only been recognised in modern times. This discovery is attributed to the Belgian Van Helmont, whose works go back to the first half of the seventeenth century. To him we owe the word "gas." It was he also who first distinguished permanent gases from vapours, a distinction which maintained itself in science for two and a half centuries, and which the recent discoveries of Messrs. Cailletet and Raoul Pictet have only just caused to disappear.

Aerial particles are formed of material particles like liquids and solids themselves, but these particles are placed at such distances that the force of attraction or cohesion has lost the power of aggregating them one to another. In a gas, this cohesion is sensibly nul, its ultimate particles, floating freely in space, being freed from it. They do not float in it in an indifferent manner, but are animated by an unheard-of quickness of movement, submitted to certain laws and producing certain effects. This idea was introduced into science about 1738, by Daniel Bernouilli and developed recently by different savants, at whose head shine Messrs. Clausius and Clerk-Maxwell.

Imagine a certain volume of ordinary air shut up in a closed space, of the form and capacity, for instance, of a cubic centimetre. In this little volume the air, consisting of four-fifths nitrogen, and one-fifth oxygen, contains, according to the ideas just brought forward, innumerable legions of gaseous molecules, moving in right lines with a mean velocity of 485 metres per second. Their number is so immense that every instant they meet, clash together and rebound in all directions, striking everywhere the sides of the containing vessel. The tension of the air, or of any gas, that is the pressure it exerts against the sides of the vessel, is exactly the result of these multiplied shocks—of this molecular bombardment. And such is the rapidity with which these movements takes place and are communicated from particle to particle that the pressure exercised is transmitted instantaneously on all sides. The distances passed over freely by the molecules of air between two collisions are extremely short at the temperature of freezing-point, and under the normal pressure, for, according to the calculation of the most learned scientists, they do not attain the ten-millionth of a millimetre, a distance about twenty-five times less than the smallest magnitude visible under a microscope. But where the pressure diminishes, the number of molecules diminishes in the same proportion, and becoming freer in their movement, can then pass over much larger spaces without colliding; in other words, in a rarefied atmosphere, the molecular paths or distances of free course become longer, and may attain as much as several centimetres when the rarefaction of the air is decreased to the millionth part of an atmosphere. An absolute vacuum does not exist, or at any rate cannot be produced, and in air reduced to the degree of rarity which we have just mentioned there still exist myriads of gaseous molecules passing over in straight lines distance relatively considerable, and endowed for this very reason with new properties recently discovered by Mr. Crookes.

The illustrious inventor of the radiometer, making his own an expression employed by Faraday as early as 1816, has given the name of "radiant matter" to that matter which still exists in those spaces which we have been accustomed to consider as empty, but which are not so in reality. By some brilliant experiments which he made in the month of August last year at the meeting at Sheffield, and which he has just repeated at Paris before the faculty of Medicine, and at the Observatory, with the help of Mr. Salet, Mr. Crookes has established the properties of radiant matter, thus penetrating into a region hitherto completely unknown, making the limits of things that are known touch upon those that we are ignorant of, and which we shall perhaps never understand. In the statement we are about to try to make, we shall be deprived of the aid of the beautiful experiments, by which Mr. Crookes astonished and delighted his audience. We shall endeavour, therefore, to reduce this abridgment to terms so simple that everyone may understand.

When an electric spark leaps between two conductors it furrows the air zigzag-fashion, like a small flash of lightning. We have, now, a tube inclosing very rarefied air, and terminated at its two extremities by two metallic wires hermetically sealed into the glass, and by which an electric discharge may be made to pass. Under these circumstances it is no longer an electric spark that is seen in the tube; the latter becomes wholly illuminated, and the light will be variously coloured, according to the nature of the rarefied atmosphere that the tube incloses. This is what is called a Geissler tube.

For a long time physicists have noticed that around the negative pole there exists a dark space, whilst the rest of the tube is luminous. Now Mr. Crookes has ascertained that this space increases in length in proportion as the air is rarefied, and he has been led to believe that its length represents exactly the length of the free path of the molecules. As those which dart forward, strongly excited, from the negative pole, meet with but few, if any, molecules in the whole extent of the obscure space, no light darts forth; a light only appears when the electrified molecules strike against each other, or against the sides of the tube itself. To this last may be given dimensions such, that after having produced a vacuum of a millionth of an atmosphere, the molecules, almost entirely free from the shocks of their neighbours, dart from the negative pole right to the extremity of the tube, this length representing the distance of free path. This is what is called a Crookes tube.

While the current of electrified molecules cross it, there appears on the sides of the containing vessel a greenish light—chiefly on the side of the negative pole—the glass has become phosphorescent. Under these conditions other bodies become still more luminous than glass. It is especially the case with the sulphide of calcium, whose phosphorescence was discovered twenty years ago by M. Ed. Becquerel. In connection with this, a beautiful experiment is to project the electrified molecules upon a diamond which then emits a greenish yellow light. Ruby shines with a bright red, and as it is made of that white earth called aluminium, and which can be precipitated from alum if the electric discharge is sent through a Crookes tube inclosing this aluminium, it also gives out a bright red light.

Radiant matter is propagated in straight lines, like light itself. The electrified molecules separate from the negative pole at a normal to the surface, and if to this pole is given the form of a little concave mirror, the molecules can be concentrated to a focus, beyond which they diverge anew; but when the atmosphere of the tube is very rarefied, no light marks the passage of these novel rays; the sides of the tube opposite the negative pole alone are lit up at the place where the molecules, flying before the pole in a right line, strike the glass. When there is placed in the path of this current of radiant matter a little screen, such as a leaf of aluminium cut into the form of a cross, the shadow of this cross will be projected on the opposite side of the tube, because the molecules, arrested in their rectilinear course, can no longer excite the parts of the glass situated opposite the screen, while the neighbouring parts will continue to be exposed to the molecular shocks, and will be illuminated. But a curious circumstance is that the impression that the glass receives, and which renders it phosphorescent, diminishes in intensity with the duration of the experiment. If, then, the cross is turned round, so as to unmask the parts of the tube on which it projected its shadow, these parts, receiving in turn the molecular shocks, will be illuminated more than the others, which seem already fatigued, and the little cross will stand out luminous from the bottom of the tube.

This torrent of electrified molecules, which are precipitated in right lines from one extremity of the tube to the other, can be made to deviate from their path by the action of a magnet. Mr. Crookes employed an ingenious artifice to make this deviation visible. He arranged one of his tubes so that the molecular stream should just touch a phosphorescent screen placed longways, and on which will appear a luminous line; this was visibly bent by the action of a magnet applied at the middle of the tube.

If it is true that they are really material molecules that are thus impelled in a right line, they ought to exercise mechanical power in the direction of their propagation. Their course is sufficiently long for this effort or pressure not to be transmitted instantaneously in every direction, as takes place in gas at the ordinary tension. This is precisely one of the most characteristic properties of radiant matter, and Mr. Crookes has shown it by means of various and ingenious experiments.

In one of his tubes he placed longitudinally little rails, on which he disposed a little wheel, with vanes, so that the stream of molecules of radiant matter could melt the vanes in the upper part of the tube.

At the moment of the discharge, the wheel commences to revolve, and flies before the negative pole, impelled by the molecular current, and it retraces its path immediately the electric current is reversed. Let there now be placed before such a wheel a screen, and on this screen let there be concentrated, by aid of a little concave mirror, forming the negative pole, the currents of radiant matter, in such a manner that they can no longer touch the vanes, and the wheel will rest motionless. But, by the aid of a magnet, turn aside the stream towards the upper part, and the radiant matter will meet the vanes, no longer protected by the screen, and will immediately impress upon the wheel a movement of propulsion.

Mr. Crookes employed the radiometer to complete his beautiful demonstration. Every one has seen the arms of this instrument revolve, like a little windmill, turning backwards in a glass globe, in which the air has been rarefied. It is the direct action of the wind which turns the arms of a windmill. In the radiometer, on the contrary, the arms turn from the effect of a recoil, which is easy to explain. Each of them receives the impression of the calorific rays upon one of its faces, covered by a substance that is absorbent, and susceptible of being heated more than the other. The molecules of air, which rebound after having struck against this warmer face, tend to make the arm recoil, like the jet of water makes the arm recoil in the hydraulic tourniquet. The arm that seems to fly before the calorific rays turns, in reality, because it is repelled by the molecular current which moves from one of its surfaces. But, for this effect to have place, it is necessary for the atmosphere of the globe to be very rarefied. At the ordinary pressure, the distances of free path are so short, and the molecular collisions are so numerous, that the excess of pressure of the particles that start from the warm face is communicated instantaneously from molecule to molecule, to the entire gaseous mass, and is propagated in all directions, so that the opposite face of the arm receives at the same instant an equal and opposite impulse to that of the warm face. The arm then remains at rest, and the radiometer does not revolve in a gas at the ordinary pressure. This delicate instrument is indeed well-named; after long discussion on the appearances it presents to us, physicists now recognise that they are not the calorifique or luminous rays of the ether, but rather the gaseous molecules of the rarefied atmosphere itself, which put it in movement. In other words, it is the radiant matter which is emitted in some manner from the warm face, and which causes it to revolve. It can be put in movement by electrified radiant matter, if, as Mr. Crookes has done, a radiometer is placed so that the metallic faces of the wings form the negative pole, and are placed at a certain distance from the positive pole. When the discharge is passed, different effects are produced, according to the degree of rarefaction of the air.

At a pressure of a few millimetres of mercury, a halo of violet light shows itself on the metallic surfaces of the arms; as the pressure diminishes, the dark space of which we have spoken above makes its appearance before the arm and the light, and recedes in proportion as the rarefaction augments. The rotation commences as soon as it extends towards the borders of the glass, and becomes very rapid when it touches it, a new proof that there exists a correlation between the degree of rarefaction, the extent of dark space, and the properties of the residual gas.

In this electric radiometer the molecules of air which flee from before the negative pole repel the arms because the distances of free path have become sufficiently considerable for the pressure not to be able to be propagated instantaneously in all directions. It is the principle of the ordinary radiometer, with the difference that the gaseous molecules are electrified; in fact, they are in a particular state of excitation, as if a new force were added to that force which the molecular movement represents. It is then necessary to keep in mind the intervention of electricity in these beautiful experiments of Mr. Crookes, and also the influence that it may exercise on the properties of radiant matter.

Among other properties, one of the most curious is relative to the transmission, or, rather, the transformation of the molecular movement, of which we have just spoken.

Stopped or deadened, it is converted into heat, and this projection of the electrified molecules sent forward with force against the sides of the tube, determines not only the phenomena of phosphorescence of which we have already spoken, but also a sensible heating of the tube. Mr. Crookes has shown this disengagement of heat by a striking experiment. By the help of a concave mirror, he concentrated a molecular current on a little piece of platinised iridium; this almost infusible metal was at first raised to most active incandescence, and melted when the intensity of the discharge was augmented.

It is the physical properties of radiant matter that we have just made known, and the properties are the same, whatever be the chemical nature of the gas submitted to experiment. At a low pressure, hydrogen, carbonic acid, or atmospheric air, show the same phenomena of phosphorescence, of magnetic deviation, of heating; only that these phenomena commence at different pressures. But, curiously, in this state of extreme tenuity, when radiant matter seems to take upon itself some of the properties of the ether, or of radiant energy, the molecules yet preserve their individuality, and their peculiar character: carbonic acid continues to be absorbed by potash, the vapour of water by phosphoric anhydride, hydrogen by the metal palladium, and oxygen by carbon, which it burns. The permanence of these chemical properties has been made use of to carry the rarefaction of the gas to a degree unknown till now. Thus in tubes in which the air has been reduced an excessively feeble pressure, this air can be replaced by water vapour, and this may be absorbed in its turn by a substance absorbent of water, such as dry potash, or phosphoric acid. It is by employing means of this kind, that Mr. Crookes has been able to produce a vacuum which he reckons at the twenty-millionth part of an atmosphere.

But is it true that the effects of which we have spoken are due to a projection of molecules, and could not the electric discharge itself produce them? The eminent physicist has himself foreseen this objection, and has answered it. It is known that two bodies charged with the same electricity repel each other, whilst two currents of the electric fluid attract when they are propagated in the same direction, as our immortal Ampère has shown. Now Mr. Crookes has shown that two currents of radiant matter which are propagated in the same tube and in the same direction are mutually repelled; they are, therefore, formed by a transport of electrified matter, and one repels the other because they are of the same name. It is known also that in spaces where the vacuum is carried to the extreme degree we have mentioned, the electric spark refuses to pass, so much is it true that electricity, under all its forms, is allied to matter. We may say of it with more reason what Goethe said of light, "it is engendered by matter, and with matter it will perish."

But, is it possible to admit that these tubes, exhausted to the millionth of an atmosphere, yet incloses so many particles? Yes; they contain a number so prodigious that the imagination stands confounded.

By the help of considerations drawn from the theory of gases that we have explained at the beginning of this study, this number can be calculated. It has been—very approximately, without doubt—for in calculations of this sort, it is always necessary to make use of certain hypothetical data.

According to the most competent authorities on this matter, a bulb of glass of a diameter of ·135 metres incloses more than septilion of molecule! A septilion! This is a million multiplied three times by itself; it is unity followed by twenty-four noughts; and if you divide this quantity by a million, the quotient will represent the number of molecules of air contained in the bulb in question after the air has been rarefied to the millionth of an atmosphere. This quotient is a quintilion; that is to say, a million multiplied three times by itself; unity followed by eighteen noughts. Was I not right in speaking above of innumerable legions of molecules, and has not the mind some trouble to conceive such immensities, as well as to figure the unheard-of smallness of material molecules?

A final experiment of Mr. Crook's brings to the light all the difficulty, but all the grandeur also, of his conceptions. Here is the same bulb we have just been considering; it is exhausted to a millionth of an atmosphere. By means of a powerful spark we can pierce the side, and the opening thus made is so small that to perceive it the eye must be armed with a strong lens. But through this imperceptible opening the exterior air in going to rush into the bulb, and if we suppose (a supposition much under the reality, and which is here made only to give an idea of these immensities) that in a second there could enter a hundred million molecules, do you known how long a time it would take for this little bulb to fill entirely with air at the ordinary tension? Would it be an hour, a day, a year, an age? No; it would be almost an eternity; and supposing the experiment had commenced at the time when our solar system was constituted, it would not be finished when the sun, the abundant but not inexhaustible source of heat, light, and force, should have cooled down and become extinct. These thoughts and these words are those of Mr. Crookes. I desire to leave the reader under their impression.

* Translated from the *Revue des Deux Mondes*, Feb. 1, 1880, by Edmund P. Toy.

Science.

Se Am Sup — No 240

Aug 7 1880

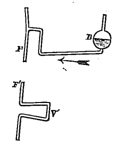
ON AN IMPROVEMENT IN THE SPRENGEL PUMP.

By Professor O. N. Rood, of Columbia College.

In this notice I propose to indicate very briefly the nature of an improvement that I have lately made in the form of the Sprengel pump, which enables the experimenter easily to obtain a vacuum as high as [illegible] or [illegible], reserving the details of manipulation, etc., for more extended notice hereafter.

(1.) The improvement consists, first, in an arrangement by means of which the mercury, instead of being at once introduced into the pump, passes beforehand through an exhausted bulb, B, thus freeing itself in great measure from air and moisture. It afterwards passes through a nearly horizontal tube, finally reaching the fall tube, F, as shown in the diagram.

(2.) The second part consists of what amounts to an almost theoretically perfect fluid valve, which prevents the



air that has passed out of the fall tube from returning into it; this is accomplished by merely bending the fall tube as indicated at V. As for the rest, the pump is contrived so as to be free from stop cocks and grease.

By inclining the pump somewhat, the bulb can be exhausted once for all, as matters can easily be arranged so that when the atmosphere is allowed to enter the pump, the exhaustion of the bulb remains intact.

The action of this pump is very rapid, two hours or less sufficing to reduce the vacuum from [illegible] to [illegible], the total capacity of the pump being 100 cubic centimeters.

The exhaustion in these experiments was always accomplished by mechanical, not by chemical means; chemical substances being introduced solely for the purpose of drying the air. In the total absence of all such substances I have obtained a vacuum as high as [illegible]. The means of measuring these vacua and other details will be given as soon as a set of experiments that are being made on the [illegible]er of the fall tube is finished.—*Am. Jour. of Science.*

Menlo Park Scrapbook, Cat. 1052

No. 36. "Motograph"

This scrapbook covers the years 1878-1881 and contains clippings about the telephone, along with a few items about the microphone. The spine is labeled "Motograph, Telephone, Audiophone." There are 144 numbered pages.

Blank pages not filmed: 38-144.

Molograph

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36

Vol. XLII.—No. 2. [NEW SERIES.] Scientific American Sc. Am NEW YORK, JANUARY 10, 1880. [$3.20 per Annum. [POSTAGE PREPAID.]

THE TELEPHONIC CENTRAL OFFICE SYSTEM.

It is difficult to conceive of an invention more marvelous than that which enables persons to converse with each other without regard to the space that separates them; and it is not only wonderful, but deeply interesting to the student of science, as it involves several of the most prominent physical discoveries of modern times. It is a monument of persevering and difficult study and experiment. From being a mere scientific curiosity, universally believed to be of no practical value, it has now become an important factor in the daily business and social life of this and other large cities.

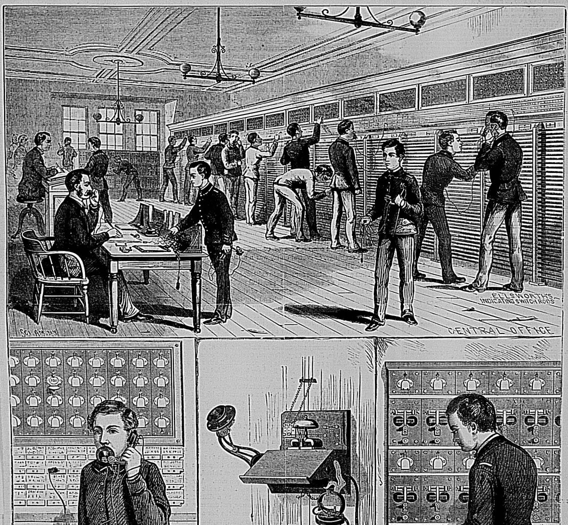
The uses to which the telephone is already applied, its future and its possible applications, will be considered in another place, the object of the present article being to afford the general reader an idea of the details of the arrangement and working of the central office system, which increases the usefulness of the telephone manyfold.

We have chosen for illustration as an example of this system in its perfected form, the Merchants' Telephone Exchange, located at 198 Broadway, and controlled by the Gold and Stock Telegraph Company of this city.

The telephone shown in the lower central figure in the accompanying engraving scarcely needs description, its construction and the details of its operation having been repeatedly described in these columns. In brief, the adjustable arm carries an Edison carbon button transmitter, connected with the primary wire of an induction coil concealed beneath the desk. A receiving telephone, which is connected with the line wire, hangs upon a switch at the opposite end of the desk. Removing and replacing the telephone operates the switch. Above the desk there is an ordinary single-stroke electric bell, and below it are two cells of Leclanché battery.

This telephone is one of many, each of which is connected by a single wire with the central office, the interior of which

[Continued on page 22.]



THE MERCHANTS' TELEPHONE EXCHANGE NEW YORK CITY.

2

THE TELEPHONE CENTRAL OFFICE SYSTEM.

[*Continued from first page.*]

is represented in the larger view in the engraving. Each person having the use of a telephone connected with the central office is called a subscriber, and his wire entering the office is connected with a small switch—a jack-knife switch; just below his name, and by this switch an electrical communication between the line and one of the annunciators above the switch is established or broken.

The arrangement of a telephone line in its normal condition is as follows: One wire from the subscriber's local battery is grounded; the other connects with the push button seen at the side of the desk. When this button is pressed the current from the local battery passes through the line wire, through the switch at the central office, through the magnet of the annunciator to the ground. The effect of the passage of the current through the annunciator is to release the little cover concealing the number of the subscriber's wire, permitting it to drop and expose the number. On seeing the number, the switchman connects his portable telephone with the subscriber's line, by inserting the plug at the end of the flexible telephone cord in the jack-knife switch. This operation not only connects the switchman with the line, but it also breaks the connection between the subscriber's line and the annunciator. The switchman's telephone being already connected with a battery and induction coil, and in condition to talk over the subscriber's line, he says to the subscriber, whom we will call A: "Well, A; what will you have?" A then says: "Connect me with B (say) at 25 Wall street."

The switchman then connects A's jack-knife switch with one of the long horizontal bars seen below; switches and turns the bar slightly, to indicate that it is occupied. He then goes to B's jack-knife switch; inserts one end of a flexible cord in the switch, and taps on a long brass strip connected with the central office battery, thus sending electrical impulses through B's line wire, ringing B's bell, when B removes his receiving telephone from its switch, and listens while the switchman connects B's jack-knife switch with the same horizontal rod that is connected with A. He then removes A's connection from the rod, and tells A "All right; go ahead," when the conversation between A and B proceeds. It takes only seconds to do what has required minutes to describe.

The boys attending the switches become expert and rarely make mistakes, although it is difficult to see how anything could be done correctly amid the din and clamor of twenty or thirty strong voices crying, "Hello! hel-l-o, A!" "Hello, B!" "What will you have?" "Who?" "Which?" "What?" "A-l-l right," and so on. It seems anything but orderly and systematic; but, nevertheless, it is the very embodiment of order and system. There are no less than six thousand calls per day; yet there is no delay, no mistakes, no trouble, save from the occasional breaking of a wire or the crossing and interference of one wire with another.

An idea of the activity of a telephone central office may be obtained from the larger view. The actual condition of things is far from being exaggerated.

It doubtless will be asked, How is it known at the central office when A and B have finished talking? The clearing out relays shown in one of the lower views, and at the farther end of the office in the upper view, indicate this. These relays, which are of comparatively high resistance, are each arranged to work a local circuit in which there is an annunciator representing one of the switch rods.

Each horizontal switch rod is connected with one of the relays, and all of the relays are grounded. Now A, having begun the conversation through the telephone, must indicate when it is ended; therefore, upon hanging up his receiving telephone, he pushes the button four or five times, working the relay, and consequently the annunciator connected with it, indicating that whatever is connected with the horizontal switch rod whose number corresponds with that of the annunciator, may be removed, and the switch rod may be used for C and D, or any one else.

One desk, seen at the right of the larger engraving, is the chief operator's desk, and the line-men, whose business it is to rectify troubles, get their orders at this desk.

There are upwards of 600 wires entering this office alone, and it requires over a thousand cells of battery to work this maze of wires.

Persons desiring to avail themselves of this means of communication subscribe to certain conditions, which require, among other things, the payment of a monthly rental, and the observance of the rules of the company. Men are then sent from the central office to place the telephone and battery, and to run from the subscriber's telephone to the central office a wire, supporting it at intervals by poles and fixtures as in the case of telegraph lines. The line and the instrument are kept in order by the company. Any imperfection in the action of either reported to the chief operator's desk at the central office receives immediate attention, men being sent out at once to find and remedy the trouble.

An alphabetically arranged list of subscribers is furnished with each telephone, and as new subscriptions are made, supplementary lists are furnished to all subscribers.

Among the recent improvements in telephone exchanges is the portable switchman's telephone, which is clearly shown in the lower left-hand view in the engraving, and the switch rods, shown in the same view, and also in the larger one. The latter are the invention of Mr. T. G. Ellsworth, the manager of the central office. They certainly save a great amount of labor, and prevent confusion and trouble.

The telephone, like many other modern inventions, needs to be used to be appreciated. It is wonderful enough that we are enabled to talk to persons in all parts of this great city, but when we can talk without difficulty with persons in neighboring cities, it becomes even more wonderful and interesting. The lines which connect New York with Newark run under the North River. Those that connect New York and Brooklyn are suspended from the East River bridge towers. The wires may run underground, under water, or high in air.

The large and rapidly-increasing number of telephone lines indicate the growing popularity of this means of communication, and we confidently expect at no distant day to see it almost universally adopted for business and even domestic purposes. Already the wires extend in every possible direction from the central office, and fairly darken the sky in some localities. The Gold and Stock Telegraph Company have in this city three exchanges similar to the one we have described, connected with each other, and, with the central office systems, several of the adjoining cities. Jersey City, Newark, and Orange, N. J., and Brooklyn, N. Y., are so connected. Yonkers, and, in fact, all of the other important cities surrounding New York, will undoubtedly be telephonically connected with the metropolis before the beginning of another year. We understand New York and Philadelphia are soon to be connected in this way. The convenience of such means of communication is thoroughly appreciated by business men, whose operations are confined to a few hours, and whose time is valuable. The SCIENTIFIC AMERICAN has constant proof of the utility of this invention, as there is scarcely an hour in the day that the telephone in the office is not used in communicating with some one, either in this or one of the adjacent cities.

The operation of this telephone will be understood by those who are familiar with the first electro-chemical telephone. The vibration of the diaphragm of the transmitting instrument varies the contact between the carbon and the two electrodes, so that a varying current is sent through the primary of the induction coil; this of course produces a secondary current of varying intensity in the secondary wire of the induction coil, which being in circuit with the secondary wire of the induction coil of a distant instrument produces a current in the tertiary wire wound around the secondary coil. The tertiary current passes through the chalk cylinder and the platinum-faced rubber, and as the chalk cylinder revolves, the friction of the rubber is varied according to the variation of the primary, secondary, and tertiary currents. The platinum-faced rubber is connected with the diaphragm, and the friction of the rubber is sufficient, when no current passes, to pull the diaphragm forward as the cylinder is turned; but when the slightest current is sent through the primary coil, the induced tertiary current transforms the frictional surface of the chalk into a frictionless surface and the diaphragm springs back. All this describes a single vibration of the diaphragm, thousands of which are required for the utterance of a single sentence. It is not essential that the current should be broken to produce the effect in the receiver. It is probable that an absolute break never occurs in the ordinary use of the telephone.

An ordinary call bell is adopted in this system as a means of giving an alarm.

This telephone is unrivalled for loudness of speech, and an electro-magnet is not required in its construction.—*Scientific American.*

THE LONTIN ELECTRIC LIGHT ON THE METROPOLITAN RAILWAY.

ON Monday evening, the 6th inst., at the invitation of Mr. Myles Fenton, General Manager of the Metropolitan Railway, a number of the representatives of the metropolitan press were present at the Aldersgate Street station of the Metropolitan Railway, to witness some experiments with the Lontin Electric Light. The system of Electric Lighting has been carried out by the *Electric Generator and Light Company*. The generator is that known as the "Lontin." The principal advantages claimed for this machine being, "The low speed at which it works," "The ready division of the light," and "The production of alternate currents."

The Lontin machine works at a maximum speed of 400 revolutions, whereas those hitherto employed in public lighting are worked at from double to treble that rate. The great advantages of low speed are the enormous reduction of wear and tear, of risk of accident and of over-heating.

The light may be very much sub-divided. As many as 12 lights have been placed on one circuit. It has been shown practically that by the machine it is possible to give a larger number of small lights, and, so far as experience has hitherto gone, whatever loss there may be in illuminating power is much more than compensated for by the convenience of

Cosmopolite Jan. 1881.

CINCINNATI electricians have succeeded in solving a most difficult question. By a new invention a circuit automatic repeating system for the transmission of messages to any distance has been provided. By its means, as ascertained by experiments carried on in New York and Philadelphia, the vibrations of the articulate human voice can be conveyed from New York to San Francisco with the same ease with which they are conveyed from one part of a city to another.

3

The Blake Transmitter.

To the Editor of the Scientific American:

It is somewhat remarkable that the friends and admirers of Mr. Edison take such great pains to prove to the world that he is the inventor of every electrical instrument and contrivance which turns out to be of value.

Not satisfied with the signal defeat which Mr. Edison sustained in the great microphone controversy in Europe, where the leading scientists, without exception, supported the claim of Professor Hughes, that the microphonic action is totally different from the principle which Mr. Edison has always claimed as the basis of his carbon telephone, viz., "the property possessed by some substances of moderate conductivity of having this power modified by pressure," although even this cannot be regarded as his exclusive property, as it was discovered as early as 1856 by the Count Du Moncel, and described by him in his "Exposé des Applications de l'Electricité," and also used by M. Clerac in 1865—not satisfied with this, I repeat, an attempt is now made to induce the public to believe that Mr. Edison is also the inventor of the only really successful microphonic transmitter ever produced. I allude to that invented by Mr. Francis Blake, of Newton Lower Falls, Mass., and described in your issue under the date of November 1.

Wherein the similarity between the Blake and the Edison transmitters lies, it is difficult for one acquainted with both to say, save in the fact that both are used in combination with an induction coil, the secondary circuit of which is a part of the main line.

I have examined Mr. Prescott's account of Mr. Edison's inertia telephone, and find it totally different, both in action and principle, from any microphone.

It appears, however, from the article in question that Mr. Edison's latest transmitter, described also in the SCIENTIFIC AMERICAN a few weeks since, is also like the "old invention," in principle. If so, it is a query why the Western Union Company did not bring out this superior instrument instead of the carbon telephone, when the latter was beaten everywhere by the Blake transmitter. The fact really is that the Western Union tried to imitate the Blake transmitter at different times since its introduction, a year since, and could never make the imitations work, simply because the Blake transmitter has a few technical points on which its success depends, and which are only known to the electricians of the National Bell Telephone Company.

Mr. Prescott states in his book, and it is found to be true in practice, that although many substances may be used as a conducting medium for varying resistances in the Edison transmitter, lampblack is the best; per contra, lampblack is not used in the Blake transmitter at all, the substance used being invariably very hard gas carbon, besides which Mr. Edison himself states in his patent 203,016, that unmixed carbon is not adapted for use in his transmitter.

The article we have alluded to as in your last issue, in its second paragraph states that there is "nothing delicate or fine about the construction" of the Blake transmitter. In the third paragraph we find the words, "this casting supports two delicate springs, etc." One of the main features in this transmitter is the delicacy of the adjustment obtained by means of the casting, which is perpendicularly across the inside of the diaphragm, and the screw in its lower end. In conclusion, I desire to say that no caviling spirit dictates these remarks, but simply a desire for justice to the Blake transmitter, its inventor, and perfecters.

Boston, October 29, 1879. T. D. LOCKWOOD.

2

THE TELEPHONE CENTRAL OFFICE SYSTEM.

[Continued from first page.]

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An idea of the activity of a telephone central office may be obtained from the larger view. The actual condition of things is far from being exaggerated.

It doubtless will be asked, How is it known at the central office when A and B have finished talking? The clearing out relays shown in one of the lower views, and at the farther end of the office in the upper view, indicate this. These relays, which are of comparatively high resistance, are each arranged to work a local circuit in which there is an annunciator representing one of the switch rods.

Each horizontal switch rod is connected with one of the relays, and all of the relays are grounded. Now A, having begun the conversation through the telephone, must indicate when it is ended; therefore, upon hanging up his receiving telephone, he pushes the button four or five times, working the relay, and consequently the annunciator connected with it, indicating that whatever is connected with the horizontal switch rod whose number corresponds with that of the annunciator, may be removed, and the switch rod may be used for C and D, or any one else.

One desk, seen at the right of the larger engraving, is the chief operator's desk, and the line-men, whose business it is to rectify troubles, get their orders at this desk.

There are upwards of 600 wires entering this office alone, and it requires over a thousand cells of battery to work this maze of wires.

Persons desiring to avail themselves of this means of communication subscribe to certain conditions, which require, among other things, the payment of a monthly rental, and the observance of the rules of the company. Men are then sent from the central office to place the telephone and battery, and to run from the subscriber's telephone to the central office a wire, supporting it at intervals by poles and fixtures as in the case of telegraph lines. The line and the instrument are kept in order by the company. Any imperfection in the action of either reported to the chief operator's desk at the central office receives immediate attention, men being sent out at once to find and remedy the trouble.

An alphabetically arranged list of subscribers is furnished with each telephone, and as new subscriptions are made, supplementary lists are furnished to all subscribers.

Among the recent improvements in telephone exchanges is the portable switchman's telephone, which is clearly shown in the lower left-hand view in the engraving, and the switch rods, shown in the same view, and also in the larger one. The latter are the invention of Mr. T. G. Ellsworth, the manager of the central office. They certainly save a great amount of labor, and prevent confusion and trouble.

The telephone, like many other modern inventions, needs to be used to be appreciated. It is wonderful enough that we are enabled to talk to persons in all parts of this great city, but when we can talk without difficulty with persons in neighboring cities, it becomes even more wonderful and interesting. The lines which connect New York with Newark run under the North River. Those that connect New York and Brooklyn are suspended from the East River bridge towers. The wires may run underground, under water, or high in air.

The large and rapidly-increasing number of telephone lines indicate the growing popularity of this means of communication, and we confidently expect at no distant day to see it almost universally adopted for business and even domestic purposes. Already the wires extend in every possible direction from the central office, and fairly darken the sky in some localities. The Gold and Stock Telegraph Company have in this city three exchanges similar to the one we have described, connected with each other, and, with the central office systems, several of the adjoining cities. Jersey City, Newark, and Orange, N. J., and Brooklyn, N. Y., are so connected. Yonkers, and, in fact, all of the other important cities surrounding New York, will undoubtedly be telephonically connected with the metropolis before the beginning of another year. We understand New York and Philadelphia are soon to be connected in this way. The convenience of such means of communication is thoroughly appreciated by business men, whose operations are confined to a few hours, and whose time is valuable. The SCIENTIFIC AMERICAN has constant proof of the utility of this invention, as there is scarcely an hour in the day that the telephone in the office is not used in communicating with some one, either in this or one of the adjacent cities.

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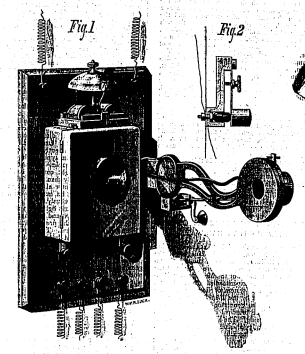
of Professor Edison's earliest and best telephones or microphones. It is exceedingly simple and does not require frequent adjustment, while it is equally as sensitive as existing forms of transmitter. The details of its construction will be understood by fig. 2. A vulcanite arm is secured to the centre of the mica diaphragm by means of a small bolt, which is connected with one pole of the battery by a piece of metallic foil or very thin copper wire. The head



of this bolt is platinum-faced, and sunk deeply in the vulcanite arm, the same cavity containing also a piece of carbon pencil, such as is used for electric candles. The carbon fits the cavity loosely and is rounded at both ends. Its outer end is pressed by a platinum-faced spring secured to the outer end of the vulcanite arm. The spring carries at its free end, exactly opposite the piece of carbon, a brass weight, and the pressure of the spring upon the carbon is regulated by the small set screw. A wire or piece of copper foil, connecting with the spring, completes an electrical circuit, which includes the primary of an induction coil contained by the rectangular box. The secondary wire of the induction coil is connected with the telephonic line, and a tertiary coil which envelopes the secondary is connected with the rubber, and chalk cylinder of the receiving instrument. Below the transmitter box are two keys, the right hand one being used for signalling, the left hand one for completing the tertiary circuit when a message is received.

The cylinder of the receiving instrument is made of precipitated chalk solidified by great pressure. The fluid now used to saturate the chalk is a dilute solution of hydrogen disodic phosphate: Professor Edison has found by a long series of experiments that the solution employed must be that of an alkali or the phosphate of an alkali, and the hydrogen disodic phosphate is found to be superior to all others.

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In conclusion, I desire to say that no cavilling spirit dictates these remarks, but simply a desire for justice to the Blake transmitter, its inventor, and perfecters.

Boston, October 29, 1879.

T. D. LOCKWOOD.

Cosmopolitan Jan. 1881.

CINCINNATI electricians have succeeded in solving a most difficult question. By a new invention a circuit automatic repeating system for the transmission of messages to any distance has been provided. By its means, as ascertained by experiments carried on in New York and Philadelphia, the vibrations of the articulate human voice can be conveyed from New York to San Francisco with the same ease with which they are conveyed from one part of a city to another.

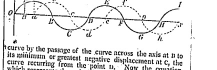
4

RESEARCHES ON TELEPHONE VIBRATIONS

Nature Dec 25 187[illegible]

DR. RUDOLPH KONIG, the well-known constructor of acoustical apparatus, has recently brought before the Physical Society of Paris a research of the highest interest, upon the difference of phase which exists between the vibrations of a transmitting and a receiving telephone. In a paper published more than two years ago, Prof. du Bois-Reymond discussed the conditions which determine the intensity and the phase of different sounds transmitted telephonically; and from theoretical considerations deduced the conclusion that sounds of low pitch suffered greater loss by transmission than shrill ones, and that every simple vibration was retarded in phase by a quarter of an undulation. The former of these actions would produce an alteration in the timbre of the voice as received at the end of the line: the latter effect would remain unappreciated by the ear, since the retardation of phase was the same for waves of all periods. More recently Helmholtz has attacked the question in a paper in the *Annalen* of Wiedemann ("Telephon und Klangfarbe"), and, with a theoretical treatment of the question based upon somewhat deeper analysis, has deduced the results that all sounds are weakened by transmission in almost a constant proportion irrespective of their pitch, and that the difference of phase between the vibrations of transmitter and receiver are very small. Dr. König has endeavoured to put these conflicting speculations to the test of experiment, and with marked success.

It may be well, perhaps, to indicate the elementary considerations which led du Bois-Reymond to predict the existence of this hitherto unobserved difference of phase. The currents by which sounds are carried from the transmitter to the receiver in the Bell telephone are induction currents, excited in a coil of insulated wire by the vibrations of the iron diaphragm in front of the permanent magnet which serves as a core. The intensity of these induced currents is greatest when the vibrating diaphragm is moving with the greatest velocity. But the maximum *velocity* of the diaphragm does not occur at the moment when the *displacement* of the diaphragm is greatest. To non-mathematical readers this fact may be explained by reference to the movements executed by a simple pendulum. As the pendulum swings backwards and forwards the "bob" comes absolutely to rest at the moment when its displacement to one side or the other is the greatest, and it moves with the greatest velocity when it passes through the "point of rest" mid-way between its two extreme positions. Mathematically, the matter is equally simply stated. The displacement of a body executing a simple harmonic motion is determined by an equation of the form $u = a \cos \frac{2\pi t}{T}$, where the values of u pass through a regular series of maximum and minimum values as t increases. These successive values are geometrically represented by the heights of the ordinates of the well-known harmonic curve or *sinusoid*, the distances along the horizontal axis O x being proportional to the times. Thus the telephone diaphragm originally at rest begins to move towards the magnet under the influence of the voice. The displacement, which at the origin is nothing, increases until at A it becomes a maximum. Owing to its elasticity the diaphragm flies back, and passing rapidly through its point of starting suffers a displacement in an opposite sense. These movements are graphically represented on the harmonic



curve by the passage of the curve across the axis at B to its minimum or greatest negative displacement at C, the curve recurring from the point D. Now the equation which represents the *velocity* of the moving point will be obtained from the equation of the displacement by differentiating with respect to time. This gives us an equation of the form—

$$\dot{u} = -\frac{2a\pi}{T} \sin \frac{2\pi t}{T} = \frac{2a\pi}{T} \cos \left(\frac{2\pi t}{T} + \frac{\pi}{2}\right),$$

which is, neglecting the constant coefficient of amplitude, geometrically represented by another harmonic curve of identical form, but shifted on so that it begins at a point a, or a quarter of the length of the curve O O from the origin. In this second curve the heights of the ordinates represent the varying velocities of the diaphragm, the velocity being nothing at a when the displacement at A is a maximum, and being at a maximum at b when the diaphragm in flying back passes through its point of rest or has no displacement. Now of these two curves the former corresponds in phase to the movement of the diaphragm of the transmitting telephone, while the second curve corresponds to the variations of velocity, and therefore of the current transmitted, and consequently also corresponds to the motions of the diaphragm of the receiving telephone. Hence it is easy to understand that there exists a difference of phase of one-quarter of an undulation between the movements of the diaphragms of the transmitting and receiving telephones, which will be either a retardation or an apparent acceleration of phase according to the sense in which the transmitted currents traverse the coil of the receiving telephone. These considerations apply only to the telephone of Bell or its modification by Gower, in which the vibrations of the transmitting diaphragm generate the current. They do not apply to the transmitters of Edison and Hughes, which merely regulate the current. In these instruments the strength of the current is proportional to the *displacement*, not to the *velocity*; hence there is no retardation of phase.

The memoir of Helmholtz, which, by introducing certain considerations respecting the mutual inductive actions exercised upon one another by the individual turns of wire in the coil of the telephone, arrived at a somewhat different conclusion, and was principally devoted to the question of the timbre of the transmitted sounds. The previous researches in physiological acoustics of this distinguished physicist had shown that differences of phase affecting individual tones of a compound "clang" do not produce any effect which the ear can detect. This important law the present writer has, however, shown elsewhere to be true only when one ear receives the sound, and to hold no longer in the case of binaural hearing. The equations of Helmholtz indicated the unexpected result that the difference of phase between the vibrations of transmitter and receiver was a quantity so small that practically it might be altogether disregarded, and he arrived at the conclusion that all sounds were transmitted by the telephone with an equal proportionate degree of intensity independent of their pitch, and therefore with unaltered timbre. Here again, however, the writer of this article has shown that the relation between the thickness and diameter of the vibrating diaphragm affects the distribution of the magnetism induced in it by the magnet, as to whether it is lamellar or radial in character, and that this distribution has influence on the timbre of the sound emitted by the receiving telephone, the notes of higher pitch being better given by the disk in whose magnetisation the lamellar distribution preponderates, while the lower ones are better given with a preponderating radial magnetisation. The whole question of timbre of the emitted sounds requires further careful study.

The experiments which M. König has executed entirely confirm the *à priori* reasoning of du Bois-Reymond as to the existence of a difference of phase. Instead of using two vibrating diaphragms, Dr. König takes two tuning-forks accurately tuned to unison, each of them being placed in front of the magnet of a telephone whose disk has been removed, and which are united in the usual manner by wires. The first of the forks being set into vibration with a violin-bow, the second immediately begins to vibrate. The phase of each of the forks is next observed. This has been done in several ways: firstly, by direct comparison of each fork in turn with the vibration-microscope; secondly, by applying the well-known optical method of Lissajous, compounding together the two vibrations rectangularly by throwing a ray of light on to small mirrors attached to the two forks, and reflected from one to the other and then on to a screen. The figure thus produced exhibited unmistakably a difference of phase of an exact quarter of an undulation. A further experiment on compound tones was made with the same general arrangements; two forks, differing by three octaves, being made to take up, one as transmitter the other as receiver, sounds whose higher vibrations were eight times as rapid as the fundamental tone. Here again the difference of phase experimentally found for the higher tone was one quarter of a vibration.

Incidentally two very important facts have been observed by Dr. König. In experimenting he found that a tuning-fork, vibrating in front of the magnet of a telephone *whose circuit is closed*, comes to rest in a much shorter time than the same fork vibrating freely away from the telephone; also that this weakening of the sound is greater in proportion as the distance of the fork from the pole of the magnet is smaller, and also is greater for small amplitudes of vibration than for large ones. These results are not without interest in their bearing upon Mr. Edison's recent attempt to construct a dynamo-electric machine, in which the moving parts should be attached to a large vibrating tuning-fork instead of to a rotating axis. Doubtless the inventor's idea was to get rid of the friction accompanying rotation; for, as the vibrations of the tuning-fork are very nearly simple harmonic motions, and as the simple harmonic motion is the only type which can be propagated without loss by friction through a body, the motions of whose parts are coincident in phase, it might be anticipated that there would be less waste of energy in a "harmonic" engine than in a rotatory one. The important fact however remained behind that by far the greatest part of the work of driving a dynamo-electric machine was not spent in overcoming friction, but in doing the work of moving closed conductors across a magnetic field, a work which, to produce an equal amount of current, requires equal power, whether the motion be one of rotation or of "harmonic" vibration. Many years ago Foucault demonstrated the reality of this resistance to motion by spinning his gyroscope between the poles of an electromagnet; and with a Gramme machine, and also with a Holtz machine, the increased effort necessary to sustain rotation when work is being done is a familiar fact. Dr. König has now demonstrated the existence of a similar phenomenon in the case of the vibrations of the tuning-fork, which comes much sooner to rest when it is doing electrical work than when it is doing no work.

SILVANUS P. THOMPSON

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THE WONDERFUL PHONOGRAPH.

A Pleasant Exhibition at the Boys' High School by J. J. Sprenger.

J. J. Sprenger, formerly of this city, who has recently returned from Europe, after having delivered about two hundred and forty lectures on Edison's latest improved phonograph, in connection with exhibitions of the machine itself, gave a very satisfactory exhibition of this marvellous instrument at the Boys' High School shortly before noon to-day. The machine is erected on a stand with a gearing which works with a weight, causing the cylinder to revolve with precisely the same motion when the sounds are reproduced as when they are placed upon the foil. Mr. Sprenger prefaced his entertainment by asking the boys to excuse any murdering of the King's English in his explanations, as he had been lecturing in German so long he had gotten out of practice in the English tongue. He then started the instrument and sang into it, "Home Again, from a Foreign Shore," which tones were reproduced much the same as the singer's natural voice. One of the pupils sang, "Mary had a little Lamb," and the machine also sang it in return. A number of other exercises were gone through with, and the machine did not fail to do its part.

The entertainment was closed by Mr. Sprenger placing upon the machine a cylinder which he had brought from Berlin, which contained a trumpet solo—"Up Comrades, to Horse," and a German song, "On the Green Strand of the Spee," which were very sweetly turned out by the machine.

During the entertainment Mr. Sprenger fully explained the mechanical operations and the scientific principles of the instrument, and he was heartily applauded by the boys at the close.

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PHYSICAL SOCIETY, LONDON.

"On Some Physical Points Connected with the Telephone." By Mr. W. H. PREECE.—This instrument may be employed both as a source of a new kind of current and as the detector of currents which are incapable of influencing the galvanometer. It shows that the form and duration of Faraday's magneto-electric currents are dependent on the rate and duration of motion of the lines of force producing them, and that the currents produced by the alteration of a magnetic field vary in strength with the rate of alteration of that field; and further, that the infinitely small and possibly only molecular movement of the iron plate is sufficient to occasion the requisite motion of the lines of force. He pointed out that the telephone explodes the notion that iron takes time to be magnetized and de-magnetized. Mr. R. S. Brough has calculated that the strongest current employed in a telephone is [illegible]th of the CGS unit. Mr. Preece explained that the dimensions of the coil and plate depend on the strength of the magnet, but the former should always consist of fine wire and be made as flat and thin as possible. The adjustment of the position of the magnet (as near as possible to the plate without touching) is easily effected by sounding a vowel sound *ah* or *o* clearly and loudly; a jar is heard when they are too near together. After briefly enumerating the attempts which have been made to improve the instrument, he mentioned the various purposes to which it can be applied. In addition to being useful in the lecture room in conjunction with several well-known forms of apparatus, it forms an excellent detector in a Wheatstone bridge for testing short lengths of wire, and condensers can be adjusted by its means with great accuracy. M. Niaudet has shown, by employing a doubly wound coil, that it can be used to detect currents from doubtful sources of electricity, and it is excellent as a means of testing leaky insulators. Among the facts already proved by the telephone may be mentioned the existence of currents due to induction in wires contiguous to wires carrying currents, even when these are near each other for only a short distance. Mr. Preece finds that if the telephone wire be inclosed in a conducting sheath which is in connection with the earth, all effects of electric induction are avoided; and, further, if the sheath be of iron, magnetic induction also is avoided, and the telephone acts perfectly. A great number of experiments on the use of the instrument on telegraphic lines were then described, from which it appears that conversation can be carried on through 100 miles of submarine cable or 200 miles of a single wire without difficulty with the instrument as now constructed. The leakage occurring on pole-lines is fatal to its use in wet weather for distances beyond five miles. An interesting series of telephones was exhibited, and by means of one of very large dimensions Mr. Preece showed that the current produced by pressing the center of the plate sensibly affects a Thomson galvanometer, and that the motion of the needle ceases in a remarkably instantaneous manner as soon as the pressure is removed, a necessary condition in order that the receiving-plate should accurately reproduce the motions of the sending-plate.

In the discussion which followed—

Mr. R. Sabine suggested that the failure of all attempts at improving the instrument by increasing its dimensions might be due to the *damping* action of the permanent magnet on the plate, the strain on it being proportional to the size of magnet, and rendering it less sensitive to the sonorous waves.

Mr. Coffin pointed out how interesting it would be if, instead of employing a receiving instrument, the currents could be communicated directly to the auditory nerves.

Prof. Adams explained the relation subsisting between the character of the vibrations of the disk and the character of the electric currents to which they give rise.

MISCELLANEOUS.

Benjamin Smith, a Utica machinist, has invented an attachment signal for the telephone. It consists of a sort of target, and, every time a call is made, a red disk makes its appearance. If the party signaled is out, he will know of the call on his return. The invention has been patented. Engineering News Dec 13 1879

When it is considered that if this mischievous method of trying to gain the credit of an invention is tolerated, no man's original work will be safe, since it is in the power of any upstart to dispute it by fictitious proofs of this kind, it will be admitted as a working principle that only *publication* to the world should determine the authorship of an invention. We are far from meaning to imply that the American scratch claims in question are not genuine; thus far we believe they are, but the system is a pernicious one, and there is no saying to what evils it might lead if it be not nipped in the bud.

BLAKE'S MICROPHONE TRANSMITTER.

The form of microphone designed by Mr. Francis Blake of Preston, Massachusetts, and recently introduced into this country by the Telephone Company as a transmitter for working their Bell telephone lines, is, perhaps, the most successful practical microphone which has yet been put together.

In all, or nearly all the microphones hitherto constructed one of the contact pieces is kept in a fixed position, while the other, being free to move to some extent, is constantly held in contact with this fixed piece, and is pressed against it with greater or less force by the vibrations of the diaphragm with which it is connected. In using an instrument of this form it has been found necessary to adjust the initial static pressure between its contact pieces or electrodes with great delicacy and care, in order to secure such a variation of resistance between them under the vibrations of the diaphragm as will enable the current to reproduce in a receiving instrument the sounds which fall upon the transmitting instrument. When such an adjustment has been secured it is easily disturbed by slight causes, such as a change in the temperature of the instrument or a trifling movement of some of its parts in relation to other parts.

By Mr. Blake's arrangement the proper adjustment is, however, easily secured, and is not liable to be disturbed in the practical use of the instrument. Both electrodes are supported in such a manner that they can move freely with the diaphragm. One of them may be attached directly to and be supported by the diaphragm, although it is preferred to support it in contact with the diaphragm from an independent support. The other electrode is so supported as to move freely, but is made so heavy, or is so weighted, that by its inertia it will offer a resistance to the slight and quick vibrations of the diaphragm, which will give a varying pressure between the electrodes and a consequent change in the resistance of the circuit. This second electrode is so supported that the initial static pressure between the two will not be sensibly affected by a change of temperature within the ordinary range of temperatures to which such instruments are exposed. It is placed on the end of a spring whose other end is connected to a lever, by means of which the proper initial pressure between the electrodes and against the diaphragm is obtained.

To secure contact between the electrodes, independently of the pressure against the diaphragm, the electrode next to the diaphragm is supported upon a spring which exerts its pressure against the opposite electrode.

The following drawings fully illustrate the apparatus: Fig. 1 is a plan of the mechanism attached to the top or cover of the box containing the microphone. Fig. 2 is a section of the box and mechanism on the line x, x, Fig. 1, and shows one of the terminals for making connections with the exterior circuits. Fig. 3 is a transverse section of the said box and mechanism on the line x^1, x^1, of figs. 1 and 2, and showing the terminals for making connections with the exterior circuits. On each of these figures A represents the box or casing in which the microphone is enclosed; the latter being for convenience attached to the cover or top A^1. B represents a metal ring or frame for holding the mechanism of the microphone. It is screwed to the cover A^1, as shown, and has two ears B^1, B^2. On the inner surface of the ring B is a narrow ledge or lip b, fig. 3, on which the disc or diaphragm C is placed. This diaphragm is formed as usual of a thin iron plate. A lining of paper or other suitable material is placed between it and the ledge or lip, and it is held in place by two springs D, D, attached to the metal rim or ring B, with their free ends pressing upon the back of the diaphragm near its centre so as to hold it against the ledge. Thin pads of india-rubber a, a, are placed between the ends of the springs and the diaphragm. By this method of holding the diaphragm in place it is less liable to be distorted by a change of temperature than when held wholly at its circumference. The centre of the ring and diaphragm is opposite the orifice E, fig. 2, in the cover A^1, through which the sounds enter the instrument. On the other side of the diaphragm and at its centre is placed one of the electrodes. It is a small metal bar or hammer e, fig. 2^1, one end of which rests against the said diaphragm. The other end is brought nearly to a point and is in contact with the other electrode e^1. It is desirable that it should be formed of or plated with some metal like platinum or nickel which is not easily corroded. It may be attached directly to the diaphragm, but, as stated above, it is preferred to support it independently, as shown, upon a light spring c, which tends to press it away from the diaphragm and towards the opposite electrode e^1.

This method of supporting the electrode e ensures its contact with the other electrode under some circumstances which otherwise would be liable to separate them and break the circuit.

The electrode e^1 is fastened to a weighted spring d, supported on an adjusting lever F by which the tension of the spring is regulated. This spring must be stronger than the spring c which supports the electrode e, and from its greater strength it tends to keep the electrode e in contact with the diaphragm. It may be made of a piece of a common watch-spring, and carries at its free end a weight g heavy enough to check very greatly the rate of vibration of the spring. This weight may be of metal, which may serve directly as the electrode, but better results are obtained by applying to

H, at the point of contact with the other electrode, a piece of gas-coke, or a hard-pressed block of carbon h, such as is used in electric lighting. If the weight is a non-conductor, there must be a metallic conductor between the carbon or other electrode used and the spring or some other part of the circuit. The weight must be proportioned to the stiffness of the spring, a stiff spring requiring a heavier weight than a weaker one. The adjusting lever F, to an arm of which one end of the spring d is attached, is a stiff bar connected at one end by a stiff spring j to the ear B^1 of the ring B. The other end rests upon an adjusting screw G, placed in the ear B^2 on the opposite side of the ring. The spring j tends to force the lever F away from the diaphragm and against the adjusting screw G. The ear B^2, supporting the adjusting screw G, is drilled and slotted as shown in figs. 1 and 2, to prevent the screw from wearing loose.

The part of the lever F which comes in contact with the screw is inclined to the axis of the screw, as shown, so that when the screw is forced inward it will press the lever towards the diaphragm, and when it is withdrawn, the lever will, by the tension of the spring j, be forced away from the diaphragm. The outer end of the screw extends into a hole l through the casing, and is fitted to receive a key by which it can be turned to adjust the lever to a desired position.

The pressure between the two electrodes and against the diaphragm obviously depends upon the position given to the adjusting lever by the adjusting screw G, but it is evident that, as this pressure can be increased or diminished only by increasing or diminishing the tension of the spring d, the changes in the pressure by turning the screw will be much less rapid than they would be if the electrode were acted upon directly by the lever or the adjusting screw. Hence a proper adjustment of the initial static pressure between the electrodes can be much more easily obtained through the agency of the spring d than without it. It will also be seen that this pressure will not be sensibly affected by any slight change in the position of the electrodes which might arise from the expansion or contraction of any part of the apparatus under a change of temperature. On the other hand, it will be seen that if the diaphragm is thrown into the rapid but slight vibrations caused by sounds, the spring alone would yield to them so readily as to give but little change of pressure between the electrodes within the range of the vibrations, but by reason of the inertia of the weight, the tendency of the spring to follow the vibrations of the diaphragm will be checked, and a greater range of pressures between the electrodes will be obtained. At the same time, it will be readily seen that the changes of pressure will be very different from what they would be if the electrodes were supported rigidly and could not yield to the movements of the diaphragm.

An additional improvement is gained by supporting that electrode on the aforesaid light or independent spring, which keeps it in contact with the electrode e^1, for it not unfrequently happens, when the intermediate electrode is attached directly to the diaphragm, that a too rapid vibration of the diaphragm, or some other disturbance in its vibrations, will throw the outer electrode out of contact with the intermediate electrode, and thus break the circuit; being audible beyond the desired limit. A monthly rental is charged for the use of this system.

Now that the ice is broken, we anticipate that the telephone will be taken up with the customary energy of our countrymen, and we hope soon to see the whole of London, as well as other large cities, divided up into districts, each furnished with its central telephonic station.

ON LIGHTNING PROTECTORS FOR TELEGRAPHIC APPARATUS.

By WM. HENRY PREECE, Electrician, General Post Office.
(Read before the British Association.)

For many years it was not the practice in England to protect telegraphic apparatus from the injurious effects of atmospheric electricity because the damage done was so insignificant, and because the remedy was found to be worse than the disease.

But as telegraph systems increased—as the country became enveloped in one vast network of wires, it was found that the damage done became considerable, until, in fact, about 10 per cent. of the apparatus in use were in one year damaged.

Lightning protectors then became essential. Many forms were tried, based on the fact that when a discharge takes place through a non-conductor, such as dry air, at the moment of discharge the resistance along the line of discharge is practically nothing, and, therefore, all the charge is conducted away. According to Faraday, "the ultimate effect is exactly as if a metallic wire had been put into the place of the discharging particles." (*Researches*, series XII., 1406.) Most of those tried failed.

The survival of the fittest has been exemplified in the "plate" protector. In this form—one of the earliest introduced—one thick plate of brass is in connection with the earth, and another similar plate in connection with the line is placed above it, but separated from it by paper, or by insulated washers. The lightning, on entering the wire, bursts across the paper, or air space, in preference to passing through the apparatus, and thus escapes to earth.

An important modification of this plate discharger has been made by Dr. Werner Siemens, who, by serrating, or grooving with a pointed tool the opposing faces of the two plates at right angles to each other, converted them into a conductor, which was supposed to be one composed of an infinite number of opposing points. The remarkable action of points in facilitating discharge is well known, and their introduction into lightning protectors occurred very early in the annals of telegraphy, by Mr. C. V. Walker, F.R.S.

Messrs. Siemens' arrangement, very pretty in theory, never carried conviction of its value in the mind of the author, because protectors, so prepared, never singled themselves out as evidently superior to others that were not so prepared; and while the intersection of the grooves certainly formed mathematical points, they did not form physical or mechanical points, and it is upon the action of this

8

Manufacturer & Builder November 1879

Latest Telephone of Edison.

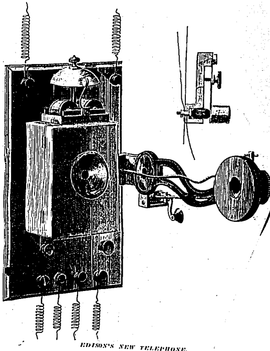
One of the most interesting experiments exhibited before the meeting of the American Association for the Advancement of Science, was that of Edison's latest improved electro-chemical telephone. It was attached to a stand in front of the platform, in the large room of the town hall, containing some 2,000 or 3,000 persons, and this telephone was found so unrivalled for loudness of speech that every person in the hall could hear what was said at the other end of the line, and transmitted to the telephone by an ordinary conducting wire. This is quite a feat, and an enormous step in advance of the Bell, Gray, or Phelps telephones, which require the observer to place his ear close against them, and even then the speech is not always distinctly heard.

The principle on which this telephone works is quite different from any of those mentioned, as the receiving instrument requires neither electric batteries nor magnets of steel or of coiled soft iron. The principle upon which it works is a variation of friction, which takes place when a conducting point is sliding over a surface, while an intermittent electric current runs from the point to the surface, or *vice versa*.

Edison discovered this principle a long time ago, and at first tried to produce by it the points and dots of the Morse alphabet, without using electro-magnetic attraction. He made a point which touched a revolving cylinder, and so adjusted that the friction of the revolving cylinder pulled it forward, overcoming the tension of a spring which held the point back; every time the current passed the friction between the cylinder and the point became very small—in other words, the current made the surface temporarily so smooth that the spring caused the point to slip back; when it slipped back a simple leverage produced a contact, making a point or a line, in proportion to the length of time the current lasted, while as soon as the current ceased the point was pulled forward again by the revolving cylinder. It should be understood that the whole extent of the motion of this point was only ¼ of an inch, or even less, which was quite sufficient to make the telegraphic dots and lines, a point being formed on the ordinary strip of travelling paper every time the current lasted only an instant, and a line in length in proportion to the time the current lasted.

In applying this idea to the telephone, Edison attached the point to the diaphragm, and when the cylinder is turned the friction is sufficient to pull the diaphragm forward; but when the slightest intermittent current is passed, the frictional surface of the cylinder is changed into a smooth surface in regard to the point, and the diaphragm pulls it back. It does this for every wave of the current, each of these therefore producing a single vibration of the diaphragm, and hundreds are required for every word. When no current passes, the point is pulled forward by the revolving cylinder, and the elastic diaphragm kept uniformly on the stretch; when currents pass, the diaphragm becomes able to pull the point backward as often as an electric wave passes, and this causes vibrations equivalent to the velocity and character of the waves.

Understanding the principle upon which to base such a telephone, the practical question was, What are the best materials for the cylinder and the point? After numerous experiments Edison found that precipitated chalk, solidified at great pressure, was the best material for the cylinder, and for the point a piece of platinum faced rubber. He also found that the chalk must be wet, and, after trying hundreds of solutions, he at last found that it was best to saturate the chalk with an alkali or its phosphate, and finally that the best solution of all was a diluted solution of hydrogen disodic phosphate.



EDISON'S NEW TELEPHONE.

In the adjoined engraving the receiving instrument is represented at the extreme right, and so hinged that it can be turned out of the way when not in use. It has a small crank (seen below) that is turned around when the reception of a message is expected; this crank is connected by an axis to the revolving chalk cylinder in the little receiving box seen at the extreme right; this box is also connected by the isolated conducting wires seen above the straight axle connected with the crank. The transmitter is the square box seen at the left, with its mouth-piece in front and the call-bell on top.

The details are represented in the small figure at the upper right-hand corner of our engraving. A vulcanite arm is secured to the center of the mica diaphragm by means of a small bolt, which is connected with one pole of the battery by a piece of metallic foil or very thin copper wire. The head of this bolt is platinum-faced, and sunk deeply in the vulcanite arm, the same cavity also containing a piece of carbon pencil, such as is used for electric candles. The carbon fits the cavity loosely, and is rounded at both ends; its outer end is pressed by a platinum-faced spring secured to the outer end of the vulcanite arm; the spring carries at its free end, exactly opposite the piece of carbon, a brass weight, and the pressure of the spring upon the carbon is regulated by the small set-screw. A wire or piece of copper foil, connecting with the spring, completes an electric circuit, which includes the primary of an induction coil contained by the rectangular box. The secondary wire of the induction coil is connected with the telephonic line, and a tertiary coil which envelops the secondary is connected with the rubber and chalk cylinder of the receiving instrument. Below the transmitter box are two keys, the right-hand one being used for signaling, and the left-hand one for completing the tertiary circuit when a message is received.

Talking Over Two Thousand Miles.

Under this caption was reprinted in the JOURNAL OF THE TELEGRAPH, of December 1st, from the *Bethlehem (Pa.) Times* an improbable statement that Mr. Robert Packer, "Superintendent of the Pennsylvania Railroad," while traveling in Nebraska, had conversed with his wife and friends at his home in Sayre, Pa., two thousand miles distant, by means of a telephone.

Tel. Journal Jan/80

Since its publication, the *Scientific American*, which also reprinted the statement, learns, it says, on good authority, that, though Mr. Packer's friends received his communication by telephone, it was not so sent by Mr. Packer. The message was sent from Nebraska to Mauch Chunk, Pa., by telegraph; thence it was telegraphed to the Sayre office of the Pennsylvania Canal and Railroad Company (of which Mr. Packer is superintendent), and from there it was transmitted to Mr. Packer's house by telephone—falling short of the newspaper report of the telephone's performance by some nineteen hundred and ninety-nine miles and a fraction.

The First Edison Loud-speaking Telephone introduced into Birmingham has been used to connect the Camp Hill Works of Messrs. Crichley & Co., stove, grate, and fender manufacturers, with their showrooms and offices in Cannon Street, Birmingham, a distance of about a mile and a half.

Ironmonger 22 Nov 1879

9

NEW RESEARCHES ON THE THEORY OF THE MICROPHONE.

By Dr. Julian Ochoswicz.

Two distinct hypotheses have been put forward to explain the phenomena which occur in the ingenious discovery of Mr. Hughes. The one, exclusively molecular, supposes dilatations and contractions of the molecules in certain partially conducting bodies, to take place under the influence of sonorous vibrations, in the microphone itself. *Changes of density* correspond to the increase or decrease of the resistance of the circuit, and, consequently, to a proportional production of sounds. This hypothesis bears a certain analogy to the phenomena which take place in selenium under the influence of light and radiant heat.

The other, partly molecular and partly mechanical, rests upon the discovery, made some time ago, by M. du Moncel, and according to which the increase and decrease of resistance are due to changes of pressure in the electrical points of contact. These changes being produced by the pressure of the vibrating air, there results an equivalence of causes and effects.

In basing my theories on experiments made with a very great number of microphones, since the first appearance of this discovery, I shall endeavour to prove that, if one of these hypotheses is entirely erroneous, the other is only superficially true.

In the first place:

1. When the carbon rod is immovably fixed by any cement, wax for example, without submitting it to any pressure, the microphone remains inert under the most powerful sonorous effects. This would be impossible if it acted by molecular action only and not mechanical.

2. The microphone can be placed in a tube of glass, lightly suspended by means of a fine wire, and the air exhausted in the tube without affecting its microphonic effects. It is evident that, in this case, the waves of air can have no influence upon the density of the carbon, they only act mechanically by shaking the whole apparatus.

3. It is impossible to construct a microphone of a single piece of solid carbon, presenting firm contacts, which do not prevent molecular influences, but which render impossible the action of sonorous waves, of contacts, and of shakes, on the current which traverses the carbon.

It appears to me, then, that we have these sufficient reasons for entirely rejecting the exclusive molecular theory.

Again:

1. The lateral pressure exercised on a compact electric conductor (metal, carbon, &c.) placed in a telephone, does not produce any microphonic action.

2. A longitudinal pressure exercised on the rod of a microphone by means of a thumb-screw, can modify within certain limits without altering the action of the apparatus. This is only the *timbre* which alters the intonation. But the same effect can be obtained without change of pressure, by the simple fact of changing the points of contact. If the pressure is augmented, the apparatus loses its sensibility at the same time that it loses its faculty of vibrating mechanically; but the single fact of an augmentation of pressure has no connection with any microphonic phenomenon. This experiment relates to a microphone with a membrane.

3. Apparatus can be constructed in which the pressure remains the same, and which nevertheless acts as a microphone. (See figure.) It is hardly rational therefore to consider pressure as the essential cause of microphonic phenomena.

It is, however, an accidental cause, for when the sonorous waves strike the movable part of the apparatus, the pressure which it exercises on the support changes; but this is not from the fact of the pressure causing the differences of resistance; it is from another fact, often parallel to the first, but which differs from it.

In order to understand this better, let us consider the apparatus in its simplest form, as shown by fig. 1.

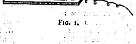


Fig. 1.

Two short pieces of wire, in circuit with the microphone and telephone, are stretched across one another as shown; the current passes at the point of crossing. It is *at this point only* that the microphonic action takes place. When one of the wires is caused to vibrate from any cause, a noise or very strong musical sound fills the room in which the telephone is placed. If the wires are good conductors the action of the apparatus has two phases: the current passes when one wire touches the other, it does not pass when the reverse is the case. There is then a *simple and complete interruption of the current*, and, in consequence, this microphone, like the transmitter of Reiss, like the singer of Mr. Pollard, &c., can only transmit simple sounds. This first category embraces all the microphones in which the contact is effected at a single point. I have obtained better results of the kind with a bladder membrane and sharp point. The electric communication was ensured by a little strip of tinfoil glued on the membrane. With a small bichromate battery the tune could be heard all over a room. Strictly speaking, there is in these simple apparatus certain graduations of action between the limits of full intensity and of complete rupture of the current, and one can understand that sometimes the *interruption is only partial. It is then the alteration of the points of contact* which plays here the principal *rôle. The intensity* of the sounds depends upon the greater or less number of these points; the number of successive interruptions of the same contacts determines their *pitch*, and the nature of the changes their *quality*. In fact, the successive and simultaneous combinations, periodic or non-periodic, of all these changes determine their *articulation*. It is sufficient to compare the traces of the words in the phonautograph, the logograph, and the phonograph to convince oneself that it is, in these apparatus, only a reduction of *quality* to quantity. I am even inclined to believe that this reduction is very simple, and that a series of combinations in times and in spaces of *three material points of contact* is sufficient to produce an equivalent to all our articulate sounds. It would be difficult to relate all the experiments and inferences which have led me to this supposition, but I give them for what they are worth, and now pass to the third category.

The principle of the change in the number of points of contact caused by pressure allows us to consider the different resistances of the microphonic circuit, and explains the action of the majority of microphones, but it does not explain all.

It is possible to construct, in fact, microphones in which no alteration of pressure will produce a variation in the numbers of points of contact, but which, nevertheless, work well.

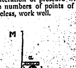


Fig. 2.

10

Suppose a little cylinder of carbon, a (fig. 2), fixed horizontally to a membrane, M M, and sliding on another small cylinder of carbon, b, movable about its axis. If the cylindrical form of these two pieces is perfect, the pressure and the number of points of contact remain the same. If this is not so, as would practically be the case, then the *rôle* played is different; it is *the* length of the route traversed by the current in the bad conductor. Whilst the membrane vibrates, its distance from the carbon b diminishes or increases, and there is then a change in the number of the points of resistance crossed.

It is this class of apparatus to which belong the liquid telephone transmitters of Gray, Bell, and Palet, where the change of resistance in the circuit results from a layer of liquid more or less thick, which is to be traversed by the current.

It is very difficult to separate the two principles one from the other, but it is possible to determine the preponderance of the one or the other, or still better their parallelism. Suppose, for example, that the two cylinders of carbon, a and b, were replaced by two plates of the same material, and that b remains immovable, the two actions would be equal and opposite. The same complication presents itself in the microphonic transmitter of M. Righi, where the metallic disc of the membrane plunges in the powder of plumbago mixed with powdered silver.—*La Lumière Electrique.*

American Inventor

The Telephone Abroad.

The disinclination to adopt American institutions not infrequently deprives the people in foreign countries of the benefit of facilities and conveniences which in the United States are regarded as indispensable. Our system of fire-alarm telegraphs which is here so generally and sucessfully introduced, has never, we believe, been adopted elsewhere, and the cumbersome and inefficient systems of notifying the existence and localities of fire are retained. The telephone was at once adopted and put to practical and extensive use here, while abroad, except in Germany, very little use has been made of it as yet.

The system of telephonic communication which has proved to be so popular, is just being introduced in England and France, but in every instance, we believe, due to American enterprise. It will no doubt require some time, even after they are established, to educate the public to use them to any considerable extent. Perseverance, however, will in time overcome unreasonable prejudices, and we shall probably within a few years see the telephone in use in all the great business centers of Europe. Their advantages are so obvious, and the necessity for prompt communication so pressing, that once introduced they cannot fail to meet with more prompt appreciation and practical adoption as localized institutions than has usually been the case with telegraphic improvements originating in this country.

Sci Am Dec 27 79

A NEW TELEPHONE.

In the telephone shown in the annexed engraving the inventor has made use of Jamin laminated U-magnets to secure great magnetic power with little weight. The ends of the magnet are cut off diagonally, and the poles are each surrounded with a helix of fine insulated copper wire connected as in an electro-magnet. Two of these magnets are attached to an elliptical hoop, which surrounds the head and supports

NOVEL TELEPHONE.

the diaphragms and ear pieces. Each diaphragm carries a light triangular armature, which fits the poles of the magnets and nearly touches them. The telephones are connected with each other and with the line. The operation is similar to the Bell telephone. The instrument shown in the engraving is arranged as a receiver to be used with any of the ordinary transmitters, but it may be arranged as a transmitter.

Mr. Andrew C. Hubbard, of Danbury, Conn., is the inventor of this telephone.

Oct 15 Telegraphic J.

Edison's telephone, of the form illustrated on another page, is giving great satisfaction in France, where it has been tried at the Central Telegraph Administration and on several railway lines. The Administration experiments were undertaken at the request of M. Cochery, minister of posts and telegraphs, and they were made between Paris and Versailles, a distance of 13 miles, and on other shorter suburban lines. Although more than 100 sets of Morse and Hughes instruments were at work in the same room, and ordinary traffic was passing over the wires next to the telephone circuit, the Edison apparatus is said to have done very well. On the Northern Railway, M. Lartigue, the engineer, has installed a loud-speaking telephone from Paris to Creil, a distance of 31½ miles; another, *viâ* St. Quentin, a distance of 40 miles; and a third from Paris to Amiens and returning to Creil, a length of 142 miles. On the first two lines the vocalisation is all that could be desired, but on the longer one it is feeble, and speakers require to raise their voices, and sometimes to repeat, in order to be heard. On the Eastern Railway several shorter lines, as from Paris to Meaux, a distance of 25 miles, have been fitted with these telephones successfully.

THE TELEPHONE IN FRANCE.

SPREAD OF THE SYSTEM—THE GOVERNMENT DEPARTMENTS TAKING HOLD OF IT—FUSION OF THE RIVAL COMPANIES.

Herald Nov 24 1879 PARIS, Nov. 7, 1879.

The war which threatened to break out between the three telephone companies (all American) seeking a foothold in Paris has been nipped in the bud by a compromise which will doubtless be as much for the interest of the public as for that of the companies themselves. To go back a little, the success of the Gower telephone as described in the HERALD of July 16 led to renewed activity on the part of Mr. Edison's representatives and also to the development of a third party under the lead of several gentlemen from Chicago, the latter seeking to employ forms of telephones already introduced by the Bell Company in the United States. Having granted a concession to run wires to the Gower Company the government found itself under some pressure to do the same for the others, and finally did so, expressing a hope at the same time that some way of uniting the several interests would be found. This has now been reached, and a visit to the large and elegant quarters fitted up by the Gower Company shows that the introduction of this latest American novelty is fairly under way. The facts and figures are of interest as illustrating the progress of American enterprise abroad. The new combination is entitled The General Telephone Company—Edison, Gower and other systems. The honorary directors are Thomas A. Edison, of Menlo Park, N.J., and Frederic A. Gower, of Providence, R. I., It was intended to include the name of Professor Bell, but this was found inexpedient, because the Bell telephone patent has been declared invalid in France owing to previous publication of the principles of the instrument in this country.

The capital of the concern is fixed at 10,000,000f., of which about one-half is devoted to the purchase of the Edison, Gower and other interests, and the rest to construction and maintenance. The capital is stated to be all subscribed and the shares are already held at a premium. The actual management of affairs is in the hands of a board of directors, with an executive committee, of which Mr. Cornelius Roosevelt, of New York, is a member. The central office is located at the headquarters of the Gower Company, No. 66 Rue Neuve des Petits Champs, where active preparations are in progress.

THE METHOD OF OPERATIONS.

The premises occupy the upper floor of a spacious building and comprise ten rooms, about fifteen feet square, a reception room 30 by 30, and an operating room 40 by 20. Half the smaller rooms are devoted to offices and the rest to Mr. Gower's laboratory and private apartments. The operating room is divided along its walls into compartments, on the system of the French telegraph offices, with a central switch board for connecting wires together, and a desk in the middle of the room for the chief operator. It is finished in American hard pine, and the yellow tint of the wood is already crossed with wires in every direction. The estimated capacity of this room is two thousand lines, and some six hundred of these are already secured by the union of the telephone interests. The subscriptions include the leading journals, bankers, physicians, theatres, hotels and so on, quite upon the American plan. M. Emile de Girardin has already an Edison telephone from his house near the Arc de Triomphe to the Avenue de l'Opéra, while the Rothschilds, the Crédit Mobilier, the Prefect of the Seine, the Minister of Posts and Telegraphs, and a long list of lesser notabilities in the Paris world have installed the instruments of Mr. Gower. The office of the NEW YORK HERALD in the Avenue de l'Opéra will naturally be among the first to adopt the system and will offer its fullest advantages to those having business to transact there as well as to the habitués of its reading rooms. Mr. Gower proposes one or more special wires for the HERALD service so that information can pass without delay between the HERALD office and the telephone centre at all hours. The facts connected with the telephonic system are familiar enough to the New York public, but to the Parisian mind it still savors of wild fiction that an American in Paris wishing to find a friend's lodging place should step into the HERALD office and in ten minutes be able to make inquiries regarding it of all the principal hotels; or without leaving his easy chair secure places at the theatre, make appointment with a friend, ascertain if the American steamer is arrived at Havre and thus transact his business generally. The idea is still too startling, and people are found who subscribe to the system with express provision that it shall first be proved a practicable means of communication. But the projectors of the system go on with their plans, and the uniform of the messengers of the "Téléphone Gower" is already to be seen here and there on the boulevards.

11

USES OF THE SYSTEM IN FRANCE.

Aside from the "district system," so familiar in America, there are several interesting uses of the telephones peculiar to European life. In Paris every house, public or private, has its *concierge* or janitor on guard at the entrance, while but few have any prompt means of communication from the *concierge* to the tenants on the floors above. Speaking tubes are a costly luxury and bells are of limited application. Even in a hotel like the Continental, where bells and tubes have been made a study, it has been found that two of the Gower telephones put in, wire and all, in two hours, give greater satisfaction than a speaking tube which occupied two weeks in construction and cost twenty times as much as the telephones. Large concerns like the Crédit Foncier, the Crédit Mobilier, the Bourse and the Hôtel de Ville report the same experience. Let us take again that of the coast guard. As everybody knows, the western and northern coasts of France are provided with coast guard stations, within sight of each other and connected by telegraph with the nearest towns. At intervals, also, there are batteries and military posts, though the latter are more numerous along the eastern frontier. As a telegraph force at each of those thousand points is expensive, the government was inclined to welcome the advent of the telephone until it was found that it, too, required a battery and some electrical knowledge. But with the advent of the Gower telephone this last objection was obviated, for without the aid of a battery the instrument not only sounds a whistle like a distant fog-horn, but can be made to release a spring that starts a clockwork bell which will produce any amount of sound required. In the public telegraph service it was first thought that telephones would be of no great use in the presence of a well-organized system of "old-fashioned telegraphs," as Mr. Gower puts it.

THE TELEPHONE IN GERMANY.

But Dr. Stephan, the telegraph director of Germany, has put in operation some six hundred telephone stations, and France cannot afford to be behind in the progress made in this direction. Experiments show that for distances under twenty or thirty miles, where the wires are not numerous upon the same poles, the Gower telephone (which is, after all, only a highly developed form of the original Bell instrument) is practically effective for common uses without the aid of a battery. The Belgian government reports a satisfactory test between Brussels and Ostend, seventy-seven miles, but this is regarded as exceptional. So it follows that any village large enough to have a post office may receive its telephone for communication with the nearest telegraph station, and that without requiring any knowledge of the principles of the instrument on the part of those who use it, this last being an important feature from the European standpoint. The use of private telegraphs has never become common in France or Germany as it has in England, and is comparatively trifling to what is known in the United States. So the telephone now finds this field clear and makes known for the first time the very want which it supplies. For military purposes this latest scientific improvement has already taken a firm hold. It has been found that a cavalryman can hang a Gower telephone upon his saddle bow, strap a reel of wire upon his back, and run out a kilometre (three-fifths of a mile) of telephone line, attach the instruments and begin conversation in sixteen minutes from the time of starting. A strong steel wire is used, and to test its strength batteries have been driven over it at full gallop without breaking the communication. On one occasion a file of soldiers was detailed to use the instrument steadily, eight hours a day for an entire week, without developing any weakness in the system. It is scarcely necessary to add that American inventive genius now holds a high place in French military estimation. And in this whole telephone business one of the facts most impressive to the European scientific mind is the freedom from any allegiance to theory characteristic of American invention. Theory and law in Europe are everything; in America it is the demonstrable fact that rules the situation. Professor Bell developed a speaking telephone and explained its theory, while Mr. Gower, his friend and pupil, produced a form of the instrument of which Professor Tyndall said, with a smile, that "no theory could have led to these conclusions." And so long as this striking difference exists we may expect to see American inventors pointing out the way to fresh employment for the surplus millions of European capital.

PROGRESS OF THE TELEPHONE IN FRANCE.—Three telephone companies have been formed in Paris; they have now been consolidated, and a capital of 10,000,000 francs paid in, half of which is devoted to buying the patents and the interests of the three old companies, and the other half for expenses of offices, wires, apparatus, etc. Six hundred lines are already in operation, and others are in course of construction.

Manufacturer & Builder

12

The English Mechanic

AND

WORLD OF SCIENCE AND ART.

FRIDAY, JANUARY 2, 1880.

THE TELEPHONE EXCHANGE.

AS the Telephone Exchange has now become a reality, being actually at work in London and some provincial towns, a few notes upon details will not be without interest, especially as there has been some misconception as to the appliances adopted for the work of intercommunication by the telephone. In its simplest form the Telephone Exchange consists of a central office from which line wires extend to the offices or residences of its subscribers; but it is obvious that in such a place as London the central office may be connected with any desired number of local exchanges, each complete in itself, but having communication with all the other local offices through the central station. All that is needed is a multiplication of the appliances used for the simple exchange, and an explanation of the latter will, therefore, suffice for all purposes. In the central office of a telephone exchange, then, there is a switch-board for, say, every 30 subscribers, and an attendant who is continually on the watch for signals from the members of the exchange. The number of switch-boards will obviously depend upon the number of members, and clearly the number of subscribers to one switch-board, must depend upon the amount of talking that they wish to do. If all 30 subscribers want to communicate at the same time, the 30th will be getting impatient before his turn comes round, unless each member *is* limited to a few minutes' possession of the line; and *consequently* where such an arrangement will not suit, the alternative is a fewer number of lines to one switch-board. Each member of the exchange has a transmitting and a receiving telephone in his office, and each switch-board at the central station is similarly equipped. Along the upper part of the switch-board is a row of little metal shutters, which when they are closed cover up the figures representing the names of the subscribers; and along the bottom of the board is a row of metal-tipped pegs, which fit into holes made in the intervening space. Suppose now that member No. 1 wishes to be put into communication with No. 7, he rings the bell in the central station by putting his switch to the bell. At the same moment as the bell rings, the little shutter falls down and discloses the number of the member who wishes to use the line. The attendant then goes to the telephone and asks what is wanted, and on receiving the answer, in our supposed case that No. 1 wishes to speak to No. 7, he signals 7 by bell, and on obtaining attention informs him that No. 1 wishes to speak with him, and that he will put him in communication. That is effected by putting the metal pegs belonging to Nos. 1 and 7 respectively into holes in the centre line of the switch-board, which has the effect of connecting line No. 1 with line No. 7, and the two members of the exchange can now converse together without any fear of being overheard. The attendant puts up the little shutters, which being hinged at the bottom, fall over on to

the switch-board, and will now serve as a signal to him that the conversation is ended without having a special wire for the purpose. No. 1 and No. 7 having finished their business, signal that fact to each other by their bells, and at the same time the attendant is informed of the fact by the falling over of the little shutters. As a matter of precaution, he will probably call to one of the members before restoring the switch-board to its normal state, but the fact of the shutters having fallen will be considered as a sufficient signal for him to disconnect wires No. 1 and No. 7, and attend to the next applicant. The operations are precisely the same no matter how many local exchanges may be connected to the central one, but of course, just as the pegs must be shifted at the central station, so they must also be shifted at each of the central offices of the local exchanges. The instruments chiefly used are the Bell and the Edison telephones, or a combination of the two, the Bell being preferred for transmitting and the Edison for receiving. So far as merely receiving messages is concerned, it is easy to understand that the Edison would be chosen by many persons, for while it is necessary to place the Bell instrument to the ear, the Edison can be heard at a distance if clockwork has been provided to revolve the chalk cylinder. That, however, necessarily adds to the expense, and as a rule the instrument intended for occasional use only will need the hand of the listener to turn the crank attached to the chalk cylinder. For press purposes, however, and in places where long messages are frequently received, the cylinder will be rotated by clockwork or rather by a train of wheels and a weight. Experiments have recently been made with the loud-speaking telephone of Edison to test its suitability for transmitting messages between a reporter at the House and a compositor at the printing-office. A shorthand writer at one end of a line wire reading slowly from his notes can be understood and followed rapidly by an operator sitting at a composing machine, but until more practice has been made it would be premature to speak of the results as altogether satisfactory. With everything prepared, however, paragraphs have been set in type from the verbal message received by the telephone, and the plan is otherwise so advantageous in late work on newspapers that every effort will be made to develop it. Telephone wires will doubtless be laid on between the House of Commons and the clubs and the principal newspaper offices, for in the one case, information as to the progress of a debate can be transmitted as frequently as necessary, and in the other, the latest news—such as the result of a division—can be sent up to the very last minute before going to press. That could of course be done by telegraph, but the telephone is much simpler, quicker, and in the long run more economical. The present arrangement for telephone exchanges may be fairly regarded as crude and imperfect: improvements are sure to be suggested as the defects become apparent in continued usage, and we are therefore not too sanguine in believing that before many more years have passed the Telephone Exchange will become a recognised institution of a busy city, and the rent payable to the company one of the legitimate expenses of a business.

THE "Edison Telephone Company" have opened offices at Royal Exchange Square, Glasgow; and the "Telephone Company" at 72, Queen Street, in the same town.

Telegraph Journal Dec 1 1879

Detroit Post Tribune Jan 11 1880

MUSIC BY WIRE.

How Some of the Telephonists While Away the Dull Hours—Popular Appreciation of the Telephone—Work at the Central Office.

On Saturday night a POST AND TRIBUNE reporter climbed to the upper floor of the telegraph block on Griswold street, where the telephone exchange is located, and was ushered into the room by George Stockwell, a bright eyed young fellow who stands guard over the apparatus during the long hours of the night. When the success of the telephone was assured as a transmitter of the human voice it speedily took a popular hold upon the public. Business men at once saw that it would come into general use, and when the telephone exchange was established the most enterprising merchants gave it their patronage. Eventually nearly every leading business house in the city connected itself with the exchange and soon private houses followed their example. Under the new order of things a merchant can communicate with almost any part of the city without leaving his office.

The instruments are ranged along the wall at the exchange, and during the day there is an operator for each circuit. These operators are boys selected on account of their intelligence and the facility with which they are enabled to answer calls. The apparatus is so arranged that when a call comes in, the person calling is located by an annunciator similar to those in use in hotels. The operator responds with a "hello," and on ascertaining who the person calling desires to communicate with calls the party, and by adjusting a switch places them in communication. He then tells them to "go ahead," and when they have ceased talking "cuts them out." The busiest time at the exchange is between 3 and 4 o'clock in the afternoon, when there are many calls, and the boys are kept on the qui vive to answer every summons.

At night there is less business. The stores, banks and lawyers' offices are closed and the telephones are out of service. In response to the reporter's query young Stockwell said the newspaper offices were the principal callers at night. Occasionally there comes a summons for a doctor or undertaker with now and then a call for a coupe or district telegraph messenger.

"Perhaps you would like to hear some music," the young man suggested.

The reporter said he would, and the operator stepped to the instrument and quickly manipulated the key board. Back came the responsive click, click, and Stockwell said, "Will you give us some music?"

"Yes," was the response, "wait a minute."

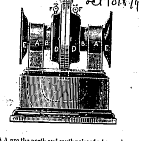
The reporter asked who were to furnish the music, and was told that Messrs. Griffith and Jamison, employes at the Michigan Central slip dock, two gentlemen who passed their leisure and whiled away the dull night hour with violin and mouth-organ. Placing his ear to the tube the reporter could distinctly hear Mr. Jamison tuning his violin at the dock a mile or two away. Then he heard him say to Mr. Griffith, "You play something while I finish tuning." In the meantime Mr. Hawley of the Russell house, J. W. Caldwell, the druggist corner of High street and Grand River avenue, and patrolman Spillane, the officer on duty at the district telegraph office were, at the suggestion of the reporter invited to enjoy the concert. Finally all were ready, and after Mr. Griffith had played a very pretty air on the mouth-organ he and Mr. Jamison entertained the listeners for several minutes with duets. Not only could the airs be plainly distinguished, but every note was heard just as distinctly as if the players were in an adjoining room. At last the performers announced that they must go to work, the listeners thanked them for the entertainment and all bade each other good night.

13

DUPLEX TELEPHONE.

[16289.]—I NOW proceed to describe my duplex telephone referred to in the account that I gave of certain experiments with a phonograph. The principle is that of subjecting a single diaphragm to the action of a magnet and coil on each side of it, and *vice versâ*, to affect two magnets and their coils by the one diaphragm. The instrument as constructed is shown in the figure.

English Mechanic oct 10 1879



A A are the north and south poles of a horse-shoe magnet. This magnet is in reality double, and the ends near the poles are bulged out so as to embrace short pieces of soft iron tube marked B B. On the inside ends of these tubes are slipped the usual bobbins containing the wire coils. These cannot be seen, as they are inside the circular box D. This box is in two halves screwed together with the diaphragm between them. The outside ends of the tubes carry mouth-pieces E E of the ordinary form or nearly so. You thus speak through these two pieces of tube which, by being embraced by the magnets, become magnetised themselves, by induction. The wires of the two coils are connected to the binding screws, of which there are of course four, though only the two nearer ones F F are visible in the figure. Several interesting experiments have been already made with this instrument. It was, in fact, with this that the phonograph was used as described in my former letter, though not quite in its present form.

If one magnet and coil be properly coupled up to the other so as to bring both into action, it is found that the loudness of the voice at a distant (ordinary) telephone is much greater than when only one coil is used.

If two persons speak or sing simultaneously, one into each mouth-piece, the diaphragm will respond to both sets of vibrations, and both voices will be heard at the distant telephone. So two people at the same time can hear words received from the single distant telephone.

Again, by coupling an ordinary telephone A with one coil of the "duplex," and another B with the other coil of the duplex (there being no direct connection between the wires of A and B) conversation can be easily carried on between A and B. This would be naturally expected, as the diaphragm receives and "passes on" the vibrations, but in appearance it looks at first sight rather odd. I propose, as soon as I have time, to make experiments with a battery introduced into one of the circuits, also with the microphone as part of the arrangement. Should I obtain any new or interesting results I will communicate them.

Plumb-bob.

Priority in Telephone Matters.

Dr. Cushman, an able electrician, of New Lisbon, O., experimented twenty-five years ago with various kinds of telephones. He was recently interviewed in regard to his experiments, and the result, as published in the *Youngstown* (O.) *Vindicator*, again shows that nothing is more incorrect than to attribute the invention or discovery, as it now stands, entirely to any one individual. In regard to Dr. Cushman's claims, we extract from the paper mentioned the following statement made by him:

"In the year 1851 I was engaged in getting up some apparatus to protect telegraph instruments from the effect of lightning, when I discovered that I was receiving a sound, as of peeping frogs some several miles distant. This led me to look into the matter, and between that year and 1855 I got up some experiments with practical results. In fact, in 1855 and 1856 we made practical use of what may now be called the electro-magnet telephone. I did not get articulation as well as it is now obtained by Bell and others. My apparatus was rude and cheap, and I used different kinds of heads or diaphrams.

"In those early days and years of telegraphing we did not have time to stop and talk to reporters, as now. I find, however, in an old scrap-book, an attempt to give a description of a system gotten up by myself, of reporting trains upon railroads. This was by using the whistle and bell at different points on the road. In this way each locomotive would report itself. I was about to say that the only thing the newspaper man was right in, was the manner in which I constructed lines in this reporting system—the magnet, with metallic diaphram enclosed in a box with ground wire line, and all that goes to make the Bell telephone, but in a rough state. In 1855 we used the same in principle, making such a practical use of it as to establish our claim as an original discoverer, provided no one had made use of the same prior to that date. The law does not compel a person to patent what he invents *or discovers; but on the other hand* it is a good defence to an action for the infringement of a patent, that the thing secured by the patent was not originally discovered or invented by the patentee, but had been in use anterior to the supposed discovery of the patentee. Neither would a mere change in form or proportion, or substitution of mechanical means or equivalents, in any one or all the elements producing the same result, constitute a substantial defence within the meaning of the patent law. In fact, in order for a plaintiff to recover for a violation of his patent, it must be shown that he was the original inventor in relation to every part of the work. The use we made was not mere experimenting.

"There has been a large number of patents issued on telephones. The Patent Office has had quite a harvest. The old stethescope, with a dried bladder drawn over the end and a string tied to the other, forming a string line from the house to the barn, as far back as 1834, has not escaped one or more claims among the batch issued."

To the above we may add that we found a description of a telephone in the German scientific journals in 1864. This was a form intended to convey musical tones, namely, the pitch and rhythm of sounds correctly. We had several of these instruments constructed, and experimented with them about that time in the Polytechnic Club of the American Institute. We made several improvements in the diaphram, and other details, and on two occasions read a paper respecting these improvements before the American Association for the Advancement of Science, and refer further, in this regard, to our back numbers, namely, page 129 of our May number, 1869; page 84, April number, 1877; and page 85, April number, 1878.

Dr. Cushman also expressed an opinion in regard to the success of the telephone companies now being organized in several localities in the United States as well as abroad. His opinion is so sound that we think no one will contest it. He says: "A good and useful application of the telephone, properly managed, if they start right, get arranged correctly, and do not undertake too much, will in practice be useful; but if they get confused in trying to use too many instruments upon one line, patrons will after a little become dissatisfied and lose confidence, and neglect to use the instrument, and the system will die out of use in time. On the other hand, if they are properly organized and trained, the instrument holders will succeed. However, time and experience will develop more upon the subject." Manufacturer & Builder Jan 1880

THE EDISON LOUD-SPEAKING TELEPHONE.

The Birmingham Daily Post

Some interesting experiments were made yesterday in Birmingham with Mr. Edison's telephone. The instrument was fitted up at Messrs. Critchley and Co.'s show room in Cannon Street, and was connected with their works in the Coventry Road, about a mile and a half away. A long conversation was carried on through it; the voice of the speaker at the further end being most distinctly heard by several gentlemen standing in the Cannon Street room, at a considerable distance from the telephone. Directions as to details of work were given and repeated, fractional numbers were transmitted and were also repeated, in order to show that they were understood, and on closely approaching the instrument, even the faintest whisper was heard with perfect clearness. The general conversation was conducted in an ordinary tone, sometimes with rapidity of utterance, and now and then specially complex sentences were employed; in each variety of test the result was the same—the person stationed in the Coventry Road heard, understood, and answered what was said to him just as if he had been no further away than the other side of the room, instead of being a mile and a half distant. Had he been ten miles away, we are told, he would have heard and answered with equal facility. It is obvious that such a method of communication—simple, instantaneous, and free from liability to error—must be of great value to business men and others who desire to have unrestrained and immediate intercourse with those who are associated with them; and we are not surprised to learn that the Edison telephone is coming quickly into use in London and in some of the larger provincial towns. A company has been formed in London to work the invention, in conjunction with Mr. Edison; and branches, we understand, are being arranged in other places, including Birmingham. As the instrument now being shown in Cannon Street embodies the latest improvements made by Mr. Edison, an explanation of its principle and a description of its mechanism will not be unacceptable to our scientific readers. The scientific principles upon which the invention operates are entirely original with Mr. Edison. They are twofold, in that a different one is employed in the transmitter from that in use in the receiver. The transmitter operates upon the principle of varying the strength of a voltaic current, by the varying pressure of the sound waves upon a piece of carbon constituting a portion of the circuit. Mr. Edison having discovered that carbon had the property of varying its resistance to the passage of an electric current in proportion to the degree of pressure exerted upon it. This principle forms the basis of the telephone transmitter now in use by the telephone companies of America, and it was by virtue of it alone that the telephone there attained such wonderful commercial success, there being now upwards of 40,000 of them in practical use. The receiver—that is, the apparatus for reconverting the electric wave into sound—is based upon the principle of converting, by means of the electric current, a constant friction into a variable one. The *modus operandi*, which is exceedingly simple, may be thus described. A tympan, or diaphragm, of mica is held in position on the face of a vulcanite case, about four inches in diameter, being clamped firmly at its edges. Attached to the centre of this tympan and within the case is a metal bar about two inches long, standing at right angles to the tympan; the free end of this metal bar rests upon a small cylinder of chemically prepared chalk, and is made to bear upon it with considerable pressure, by means of an india-rubber buffer placed immediately above. The chalk cylinder is rotated by means of a small crank which projects outside the case; when the cylinder is rotated the friction between it and the end of the metal bar is sufficient to force the tympan, to which the bar is attached, out of its true plane, or, in other words, to put it under tension somewhat analogous to a musical string. The electric waves, set free from the battery at the transmitting end by the action of the voice upon the carbon, and which therefore accurately represent the sound waves in their varying intensity, are made to pass through the metal bar and chalk cylinder, and effect in their passage at the point of friction a variation of the friction in the exact ratio of their intensity. It will thus be seen that the tympan is constantly endeavouring to regain its normal position, and succeeds in doing so only in proportion to the degree of neutralisation of the friction effected by the electric wave. That is to say, it is made to vibrate in harmony with the voice at the transmitting station, and consequently to contribute to the air at the receiving station precisely that form of motion given to that at the transmitting station, necessarily producing the same sound. The active principle, it will be seen, is the utilisation of the power of the hand at the receiving station to reinforce the electric current, thus permitting a much more decided vibration of the tympan than is possible in other telephones, since in them the electric current is compelled alone to perform the physical work of vibrating the tympan. The practical result of the device is the reproduction of the human voice at the distant station in something like its original compass, thus obviating the necessity for holding an instrument close to the ear. As we have already said, the means above described act perfectly: the distant speaker, if we did not know him to be far off, might be supposed to be actually close at hand. Every word comes full, clear, and distinct; the tone may be loud or low at pleasure: the utterance may be rapid or deliberate—every inflection and intonation of the speaker's voice is instantly reproduced, with such fidelity that the result constitutes a true miracle of science. Not only so, but the speaker may address a single auditor or an assembly at pleasure: he has but to raise his voice or to lower it, and the sound is either confined or diffused—the Edison telephone, the operators being miles away from each other, will faithfully convey a secret, a speech, or a song. We may add that Mr. Johnson, who is in attendance to explain the invention, and to show its wonderful capabilities, was an assistant of Mr. Edison, and that he will be glad to give illustrations and explanations to persons who are interested in the matter.

PROGRESS IN SCIENCE AND THE ARTS.

General Science. Engineering Journal

Edison's Electro-Chemical Telephone.—Mr. Edison is reported to have lately improved his carbon telephone so much that, in conjunction with a magnetic receiver, it far surpasses, for power and clearness of articulation, every other instrument thus far constructed. In the description of the apparatus just received, it is explained that, although the carbon telephone possessed points of superiority over other systems, its power was limited to the capabilities of the receiver with which it was connected; and until the present improvement had been perfected and applied, no receiving telephone had been introduced that would do justice to the capabilities of the carbon transmitter. The improvement referred to is described as consisting of the application of the principle of the "electro-motograph" (an earlier invention of Edison's) to the construction of a telephone receiver; and the result is affirmed to be a remarkable increase and improvement in the power and qualities of the instrument. It is said to be quite unnecessary to go near the instrument to hear messages, as they are delivered in a loud, clear tone, audible in any part of the room; indeed, it is declared to be difficult to distinguish any difference in distinctness of articulation between its utterances and those of a person engaged in conversation. A full description of this important improvement will be found in the last issue of the *Scientific American*, to which we refer our readers for details.

A New Acoustic Telephone.

American Inventor Dec 1879

Mr. E. D. Finch, of Stanton, Mich., has for some time experimented with acoustic telephones, and noted the faults connected with the ordinary string and diaphragm instruments sold so largely throughout the country. It is well known that in the use of the acoustic telephones, a great difficulty lies in the way of success from the fact that they can be used only a short distance, and even then in attaching them to short lines, the sounds emitted are so weak and indistinct, coupled with the fact that they change the sound of the voice beyond recognition, it might well be said that there is no successful acoustic instrument yet on the market. Mr. Finch, noting these defects, set to work with the view of securing, first, distinctness in the receiving instrument, and second, capacity for operating on long wires. As a result of this study he has shown us instruments of his make which differ from those heretofore made. The first object was to experiment in the direction of the size of the diaphragm. This he found to be most serviceable if made in size not to exceed six or seven inches in diameter; smaller than this produce poorer results. Next came the question of material; it was found, after repeated tests, that a silk or linen diaphragm answered the purpose to the best advantage. It was in the arrangement of this diaphragm that the greatest skill was required. The perfect instrument shows a linen diaphragm seven inches in diameter; stretched across this diaphragm are a number of wires radiating from the center and attached to the line at the central point of the diaphragm; these wires are on that side of the diaphragm nearest the operator. The object of the radiating wires, as explained by Mr. Finch, are, first, to give strength to the line wire in its connection, and secondly, to absorb more of the sound waves of the voice and communicate the same to the line wire. Two of these instruments have been tested here under our supervision, and we find that they work admirably in every respect.

Telegraphic Journal

EDISON'S LATEST TELEPHONE.

oct 15 1879

SINCE the first appearance of Professor Edison's electro-chemical telephone it has passed through a succession of changes until it has finally assumed the compact and convenient form shown in the accompanying engraving. The form, however, is not the only change. In the first electro-chemical telephone, it will be remembered, the chalk cylinder was supplied with moisture by a movable roller which dipped in the exciting fluid and supplied it with moisture. This movable roller is now dispensed with, and the chalk cylinder is enclosed in a vulcanite box, seen at the end of the movable arm. The cylinder, when once moistened, remains in that condition for an indefinite period, as the box is practically air-tight.

The small shaft that runs parallel with the iron arm extends through the side of the box and carries the chalk cylinder. Upon the opposite end there is a small pinion moved by a worm, the crank of which is turned by the finger. The diaphragm of the receiving instrument is covered by the front of the box, excepting a small central portion which is quite sufficient for the exit of the sound.

The arm which supports the receiving instrument is jointed so that it may be raised vertically out of the way when the telephone is not in use.

The transmitter, fig. 1, is contained in the stationary rectangular box; its mouthpiece projects slightly, and the diaphragm, which is of mica, is supported by a metal frame and springs inside the box cover. This transmitter is quite different from the carbon transmitters now so largely in use in America, and it will be new to many of our readers; but it is one

14

16

THEORY OF THE MICROPHONE.—Prof. Julian Ochorowicz considers the chief causes of the action of all possible forms of microphone to be a mechanical movement of its parts, a change in the points of conductivity, and a change of resistance—three essentials which result from one another. He holds that there is no increase of sound by the microphone, as usually understood. All sounds are weakened by the microphone, and are transmitted only when the source of sound is in direct contact with the microphone or its stand. The microphone is less an instrument for transmitting sound than for transforming mechanical movement into sound. The intensity of a sound is, therefore, directly proportional to the energy of the mechanical movement accompanying the sonorous waves, or, as a necessary consequence, to the changes of resistance in the microphone. The distinctness of articulate sounds transmitted by the microphone is in inverse proportion to their intensity; for a loud sound tends to interrupt the current completely, and thus to prevent the transmission of articulate sounds. This is the chief hindrance to increasing at pleasure the loudness of the sound. The loudness of the sound is also dependent on the strength of the current. Electrician Oct 11 1879

Manufacturer & Builder

The Audiphone. Jan/80

Several exhibitions have been given of late showing how much deaf and dumb persons may be assisted in hearing by the use of an instrument called the Audiphone, by which sound is conveyed through the medium of the teeth and auditory nerve. The inventor of the audiphone is Mr. Richard S. Rhodes, of Chicago, who is very deaf. The instrument was suggested to him about two years ago, by the discovery that on placing his watch against his teeth he could distinctly hear its ticking, though unable to do so upon the usual application to the ear. After a year's work he perfected the instrument. It closely resembles a black fan; it consists essentially of a diaphragm of hard rubber, very thin and elastic, about a foot square, with rounding corners and a neat hard-rubber handle. When in use a silken cord draws down on the inside the top of the diaphragm, presenting a convex surface to the speaker. In this position the upper edge is pressed firmly against the interior edge of the upper teeth, and the sound falling upon this surface is conveyed to the auditory nerve.

At a recent exhibition in Philadelphia, a young man seventeen years old, who has been deaf since he was nine years old, and who could answer vocally questions asked by the sign language, was brought forward. When the audiphone was adjusted to his teeth, Mr. Rhodes asked his name in a loud voice. The boy evidently reaped a new experience, for his face lighted up with a smile. "I heard it, but I don't know what it was," he said.

At Hartford, Conn., two ladies sang a duet, with piano accompaniment, before the children in the Deaf and Dumb Asylum, and the children, on being asked how many heard it, three-fourths of them raised their hands; but upon being questioned, they generally asserted that they heard the piano, but could not hear the voices. The "laughing song" manifestly pleased some of the children.

[38150.]—Telegraph or Telephone.—The telephone is a very handy instrument for communicating over such distances as three miles or so. More so, even than the "A B C" instrument, as any person can use it that can speak and hear. It simply consists of a switch-board at each end of line-wire, with a call-bell fixed to each, and a battery for ringing same, and, when rung, the person present approaches telephone, which is resting on switch-holder, and the act of raising telephone to speak or hear throws batteries and bells out of circuit, and puts itself in; communication can be carried on as distinctly as if the person spoke through a speaking-tube 100 feet long. The probable cost of laying line-wire would run about £10 to £16 per mile, according to locality.—G. W., Liverpool. English Mechanic Oct 10/79

[38150.]—Telegraph or Telephone.—In your case I should recommend to employ A. B. C. telegraph instruments.—T. WIESENDANGER.

[38150.]—Telegraph or Telephone.—"Wanderer's" best plan would be to get a good reliable work on the construction and maintenance of telegraphs; that would probably give him all the information he desires. A very good work of the sort is one by Preece and Sivewright, "Text-Books of Science—Telegraphy"; but "Wanderer" may know of even better. I can safely say it would cost a good round sum, 18 poles to the mile being the lowest possible estimate, and 15s., or so a pole, insulators, wire, and cost of putting up the line, and a battery-power of 10 Daniells cells. A telephone would be by far the better mode of conversing; cheaper too; but it would be a great expense for one man to bear, and perhaps not satisfactory after all.—W. A. Y.

[38150.]—Telegraph or Telephone.—For so short a distance the telephone would work well, and, being the easiest for every one to work, would, I should think, be the most useful to you. You could, I believe, by an annual payment, have a wire from the office to your house. Get the "Postal Guide" (6d.), and you will find all the information you require as to fixing and rental of wire and instruments.—W. J. LANCASTER.

Scientific Recorder

Another Audiphone.

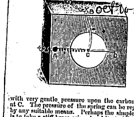
The audiphone, Jan 7/80 constructed by Professor Graydon, consists of a small electro-microphone, to the center of the diaphragm of which is attached a cord, which may be of any length, and to the other end of which cord is attached a small piece of wood. The manner of working the instrument is simple, and can be briefly described as follows. The deaf person takes a firm hold of the piece of wood between his upper and lower teeth, and the party desiring to converse with the deaf talks through the electro-microphone attachment at the other end of the cord, holding the cord taut. The theory advanced is that the sound is conveyed through the nerves of the teeth and the bones of the face to the auditory nerve, which, owing to some defection of the ear caused by disease is not approachable through the usual channel, thence to the brain. The instrument will only work, however, when deafness has been caused by disease. In case if paralysis of the auditory nerve it is useless. Some very interesting tests of the audiphone were made at the deaf and dumb department attached to the Third Intermediate School recently. Among others was one, a bright looking colored girl, who was entirely deaf. The professor talked to her at a distance of twenty-five feet through the instrument, and she repeated after him every thing which he said. Another was a little girl who had been deaf and dumb from birth. Using the mute alphabet she informed the teacher in charge that she could hear that one statement of the professor was made in a louder tone of voice than another, but that she could not understand what he said, never having been able to hear such sounds before. In some other cases, however, the pupils upon whom the instrument was tried said, in their mute language, that they were unable to distinguish any sound whatever. It is fair to presume that the instrument will, as have the telephone and microphone, be greatly improved, and that at no distant day it will be of great service to those afflicted by deafness.—*Cin. Gazette.*

A MICROPHONE FOR THE TRANSMISSION OF MUSICAL SOUNDS.

[16290.]—IN attempting to transmit musical sounds by the microphone, it is usually found that the sound emitted by the telephone has degenerated to a hoarse rattle, caused by the jarring of the movable part of the microphone. By reducing the play of the lever, or upright piece, this disagreeable effect may be diminished, but only at the expense of the sensibility of the instrument, which is then mute to the higher and softer notes.

The form of microphone described below is free from these objections, and, so far as I can tell, it transmits every musical sound, high or low, absolutely pure and unchanged. It may therefore be found useful for the accurate study of the sounds emitted by the diaphragm of the telephone. It consists of a deal box of a cubical form, about a foot high. It is open at the back and has a circular aperture in the front. A piece of guttapercha tissue is tightly strained over a wooden ring and fixed upon the aperture. In the centre of this diaphragm a small block of carbon is fixed connected by a fine wire with the binding screw at A. At B is another binding screw, and from it proceeds a light steel spring tipped with carbon, and bearing

Eng Mechanic



Oct 10 1879

with very gentle pressure upon the carbon-block at C. The pressure of the spring can be regulated by any suitable means. Perhaps the simplest way is to take a stiff brass wire, bend it at right angles and pass one end through a hole in the box at D, in which it slides stiffly. Its other end can then be made to bear with any required pressure upon the end of the steel spring. W. H. Snell.

Bampton-street, Tiverton.

[38306.]—Blake's Patent Transmitter.—This is a kind of microphone. It has an ordinary ferrotype plate diaphragm; pressing slightly in the centre is a small ball of platinum or other metal. It is about 1-16th of an inch in diameter, and is held in the middle by a spring. It looks like a small lead shot being forced half-way through a piece of steel spring. On the opposite side of the shot or ball is a carbon button. These are connected to the primary of an induction coil and a one-cell Leclanché. The secondary wire is of course connected to line and earth, to which are attached ordinary Bell telephones; it makes the latter instrument perfect. For instance, a gentleman whistled an air 50ft. from the Blake's transmitter, then suddenly left off, and his son, 1½ mile distance, immediately took that part up, and there were about 60 persons in the room, and they all heard the whistling quite plain, while I held a pair of Bell telephones in my hands. Singing could also be heard all over the room, and the tune distinguished but not the words.—GEORGE TOLMAN. Eng Mec

Telegraphic Journal Dec 15 1879

1531. "Apparatus for telephonic and microphonic purposes." JAMES WILLIAM THOMAS CADETT. Dated April 18. 6d. Consists of a series of microphones on boards or diaphragms, with connecting or coupling arrangements, permitting of arrangements being made to suit the electric power employed, and also the resistance of the line wire, telephone, or other receiver or receivers, and so forth.

17

On the Retardation of Phase of Vibrations transmitted by the Telephone.

By Professor S. P. THOMPSON.

DUBOIS-REYMOND predicted from theoretical considerations that a difference of phase, amounting to a quarter of a complete vibration, would be found to exist between the diaphragms of two Bell telephones, joined up in one circuit, the receiving telephone being a quarter of a vibration behind the transmitter. Helmholtz and Weber theoretically predicted only a small difference of phase. Recently König in a series of delicate experiments, effected an optical comparison by the method of Lissajous, of the vibrations of a pair of telephones, replacing the vibrating discs by tuning-forks armed with mirrors. The author has proposed the following method of observing. A pair of Bell telephones are suspended by wires of about a metre in length, so as to oscillate as pendulums, to frames so disposed as to avoid the possibility of any mechanical transmission of the vibrations. Below the point of rest of each telephone, and at some little distance from it in the plane of its swinging, is placed a steel magnet. After the lengths of the wires have been so adjusted that the telephones will swing in identical periods, one telephone is set swinging. As it alternately approaches and recedes from the magnet, the induced currents traversing the second telephone set it swinging. In every case the difference of phase observed amounted to one quarter.

In the case of those telephones which transmit vibrations by varying the resistance of the circuit, instead of varying the electro-motive force, there is no such retardation of phase produced in the ordinary electro-magnetic receiver. If, however, the current so transmitted is first passed through an induction coil, a retardation of phase of one quarter is produced, and in the case of several successive inductions the retardation amounts to an additional quarter for every additional induction. This remark applies only to vibrations of harmonic and quasi-harmonic type.

In the case of Edison's motographic or electro-chemical receiver, the velocities, not the displacement of the disc, are proportional to the strength of the currents received. Hence vibrations already retarded one quarter in transmission, as is the case with those of the carbon transmitter in conjunction with its induction coil, always used with this instrument, are restored to their primitive phase. The vibrations of this receiver therefore agree with those corresponding to the function of which the vibrations of the induction current are the derivate; that is to say, they agree in type with the primitive vibrations of whatever form. In the receiving telephone of Edison, therefore, consonantal sounds which depart widely from the purely harmonic type are better rendered than in a telephone which like that of Bell both retards the vibrations in phase and alters them in type. Tele. Jour. Sep. 15/79

Tel. Jour. Sept-15-1879

THE BATTLE OF THE TELEPHONE COMPANIES.—The Edison Telephone Company, fortified by the disclaimer to Edison's telephone patents, have stopped the India-rubber, Gutta Percha, and Telegraph Works Company (Limited) from making the Blake transmitter for the Telephone Company (Bell's). The Edison Company holds that transmitter to be an infringement of their patents, and they are determined to take steps against any other company making these transmitters. There is no especial merit in the Blake transmitter that its disuse should seriously inconvenience the Bell Company, since Crossley's or any other good microphone will answer just as well.

TELEPHONY IN GLASGOW.—The extended use of the telephone for commercial purposes has been provided for in Glasgow by the establishment of two companies, the Edison Telephone Company (Limited) and the Telephone Company (Limited), the former having its central offices in Royal Exchange Square, and the latter having temporary offices at 72, Queen Street. The Edison Company employ the Edison Loud-Speaking Telephone, while the other company use their own improved telephone. It is intended to form telephonic circuits, comprising places of business in and around the city, by means of which the various patrons of the companies will be brought into direct communication with the central stations, and with each other

14 18

REVUE DES TRAVAUX

RÉCENTS EN ÉLECTRICITÉ

Nov 1879

Sous cette rubrique nous indiquerons désormais dans chacun nos numéros, ce qui s'est fait d'intéressant en électricité dans la quinzaine.

Nouveau Téléphone de M. Edison.

Dans notre article du 15 mai sur les dernières découvertes en téléphonie, nous avons parlé du système de téléphone électro-chimique de M. Edison, lequel n'était qu'une modification de celui qu'il avait imaginé dès l'année 1877, et qui est décrit dans l'ouvrage sur le téléphone de M. du Moncel. Dans ce nouvel appareil, fondé sur le principe de l'*électro-motographe*, un cylindre de chaux se trouvait substitué à la bande de papier ; mais il fallait qu'il fût entretenu dans un certain état d'humidité qui n'était pas facile à obtenir d'une manière régulière. Dans le nouveau modèle, ce cylindre de chaux *peut rester sec*, ce qui est évidemment un avantage pratique. Mais, ce qui a été le plus modifié, c'est le transmetteur, que le *Telegraphic Journal* décrit de la manière suivante : « Ce transmetteur est contenu dans une boîte rectangulaire fixée contre un mur, et son embouchure n'a qu'une légère saillie. Le diaphragme est en mica et supporté par un cadre et un ressort métalliques placés à l'intérieur du couvercle de la boîte. Au centre de ce diaphragme est fixée, par un écrou métallique mis en communication avec l'un des pôles de la batterie, une petite équerre d'ébonite qui est creusée, devant l'écrou, de manière à former une cavité dans laquelle est introduit un bout de crayon de charbon à lumière électrique, arrondi par ses extrémités, et sur lequel appuie extérieurement un ressort de platine fixé au bout de l'équerre d'ébonite. A l'extrémité de ce ressort, sur la partie correspondante au point de contact, est *fixée une masse métallique pesante*, et la pression du ressort est réglée par une vis de réglage. Un fil conducteur adapté à ce ressort complète le circuit qui, comme dans les autres systèmes d'Edison, correspond au circuit primaire de la bobine d'induction appelée à réagir sur le circuit du récepteur. Celui-ci se trouve, en plus, relié à une troisième hélice qui enveloppe l'hélice secondaire de cette bobine, et c'est le courant ainsi fourni qui traverse le cylindre de chaux du récepteur. Sous la boîte du transmetteur se trouvent deux clefs, l'une qui sert à envoyer des signaux Morse, comme dans son premier système, l'autre qu'on presse au moment de la réception de la dépêche et qui joue le rôle de commutateur. »

Ce système de transmetteur n'est, par le fait, qu'un microphone, semblable à beaucoup de ceux qui ont été déjà décrits, auquel on a ajouté *la masse métallique* qui a produit de si étonnants effets dans les expériences de M. Ader. Il est vrai que ce dernier n'avait employé la masse pesante que pour le récepteur, mais il pourrait bien se faire que les effets avantageux que cette masse produit, puissent s'appliquer à la transmission comme à la réception.

Pour obtenir la suppression de l'humidification du cylindre de chaux, M. Edison emploie de la chaux solidifiée à une grande pression, et imprégnée d'une solution de phosphate de soude hydrogénée (*hydrogen disodic phosphate*). Il faut que la solution employée soit alcaline, et, suivant lui, un phosphate alcalin, tel que le phosphate de soude, est ce qu'il y a de mieux.

Le récepteur, du reste, qui est maintenant de très-petites dimensions, est fixé à l'extrémité d'un bras adapté perpendiculairement à la boîte du transmetteur, et se trouve relié à la manivelle destinée à faire tourner le cylindre de chaux au moyen d'une tige d'engrenage. Par cette disposition, le récepteur s'adapte naturellement à l'oreille de celui qui place sa tête contre le transmetteur pour parler.

Expériences nouvelles sur la théorie du Téléphone.

M. Percival Jenns, recteur de Saint-Jean dans la Colombie anglaise, a envoyé au journal *Nature* un résumé des expériences qu'il a entreprises pour reconnaître l'origine des sons dans le téléphone.

des phases de leur composition. Les vibrations des consonnes, au contraire, se distinguent mieux, car elles se séparent de plus en plus du type primitif, à chaque succession des actions d'induction.

« Dans le cas du motographe d'Edison, c'est-à-dire de son récepteur électro-chimique, la vitesse du déplacement du disque est proportionnelle à la force du courant reçu, et, par conséquent, les vibrations déjà retardées d'un quart de transmission, comme c'est le cas dans les transmetteurs à charbon réunis à des bobines d'induction (employées toujours avec cet instrument), reviennent à leur état normal. Les vibrations de ce récepteur sont donc du même type, non comme vibrations du courant induit (qui correspondent aux fonctions dérivées des vibrations primitives), mais comme vibrations correspondantes aux fonctions dont les vibrations du courant d'induction sont les dérivées; ce qui veut dire qu'elles s'accordent, comme type, avec les vibrations primitives de n'importe qu'elle forme d'appareils. Par exemple, dans le téléphone récepteur d'Edison, les sons des consonnes qui sont émises avec force et qui appartiennent au type harmonique, sont mieux rendues que par un téléphone qui, comme ceux de M. Bell, retarde la phase des vibrations et altère leur type. »

2497. TRANSMITTERS FOR TELEPHONES, *A. Marr.—Dated 21st June*, 1879. 6d.

The diaphragms are made of wood, and inside and near the centre are attached discs of solid carbon placed close to each other and connected respectively with the opposite poles of a voltaic battery or a magnetic current; the receiving telephone being in the circuit. The outer edges of the diaphragms are joined together by an angular piece of wood, and the space between, about ½in.—the carbon discs being about 1/16in. apart—is filled with powdered carbon. The Engineer [illegible]

Mining [illegible] Press March 6, 1880.

Are Telephones Telegraphs?

A somewhat singular discussion, involving the question as to whether telephones are telegraphs, has arisen in England, growing out of the fact of the connection of the Postoffice Department there with the telegraph. An application has been made for an injunction against the Telephone company to restrain them from discharging their functions, except under the Postoffice regulation in relation to the telegraph. After some considerable discussion it has been arranged that an injunction should not be taken, but that the defendant companies were to keep certain accounts until the hearing and final decision of the case.

The argument on behalf of the Postoffice is that telephones are telegraphs within the meaning of the act by which the latter inventions were committed to the charge of the Postoffice Department, and the Attorney-General represented it to be a serious grievance that the government, after spending millions on telegraphs, now found their monopoly interfered with by telephones, which, he submitted, were practically the same invention. The government had, therefore, he said, begun these proceedings by information in the Court of Exchequer.

It is reported, although this part of the question was not mentioned during the hearing, that they hope to be able to compel the telephone companies to take out licenses from the Postmaster-General, and pay royalties for doing so. The *Times* has an editorial on this subject, which concludes as follows: "The proposal to obstruct the development of the invention is one it would be impossible to defend. The fiscal argument is simply irrelevant. If the nation made a bad bargain in forgetfulness of the admitted commercial principle that few patents are worth more than three years' purchase of the receipts arising from them, the nation must bear the loss, however great it may be. It will not be diminished otherwise than apparently, by restricting the use of telephones. If any such restriction is sanctioned by the courts, it can scarcely fail to be removed by the direct intervention of the legislature. A tax upon telephones would be practically a tax upon knowledge. Any such imposts belong to the past rather than to the present or future."

Practical American March 1880

19

The Telephone to be Prohibited in England.

THE English Government is about to take measures practically equivalent to a prohibition of the telephone, or which at least will put a powerful check upon the extension of its use. There are no telegraph companies there, but the whole telegraphic business is under the sole government control, and combined with the post-office, while at every post-office there is a telegraph office also. The Post-office administration has found that the extension of the use of the telephone considerably decreases the revenues of their business, because when people can talk over the wire they don't want to send expensive telegrams or letters, with long delayed answers, and it has become a legal question if not the telephone is an infringement upon the government privilege of transmitting telegrams as well as letters.

We wonder if the British Government will give an example to the world of taking measures equivalent to a practical prohibition of one of the most important inventions of modern times, and do that in a country which boasts of its enlightenment and progressive tendencies.

P. S.—The above was written after a cable dispatch brought the news; since then the mail brought the papers, among them the London *Times*, which expresses opinions about it identical with those expressed by us.

Il serait difficile, écrit au *Times*, le directeur de la Compagnie des téléphones Edison, de donner une idée plus frappante des résultats que l'on peut obtenir avec le téléphone Edison que la simple citation du fait suivant. Le 8 novembre un monsieur, dont la maison avait été mise en communication avec le bureau d'échange des téléphones Edison, était allé en partie de chasse. Au moment de son départ le téléphone n'avait pas été fixé, bien que le fil eût été posé. Pendant son absence ce travail fut accompli et à son retour des lettres importantes lui furent lues, lettres auxquelles il dicta des réponses. Une conversation avec ses hommes d'affaires étant nécessaire, l'opérateur du bureau central établit une communication. Un important télégramme de New-York fut reçu et une réponse fut dictée assez à temps pour arriver à New-York trois heures après l'envoi d'Amérique du premier message. La plus grande partie du travail d'une journée en ville fut ainsi achevée en une demi-heure dans une bibliothèque.

Electrician [illegible] 2/1880

THE CHALK CYLINDER BATTERY.—Professor Barrett writes:—"When I sent my note to the Physical Society, announcing the production of an electric current by the friction of metal on a revolving chalk cylinder (the only case I know where friction, or, at any rate, the relative motion of two dissimilar conductors in contact, generates a continuous electric current), I was unaware that Mr. Edison had already made a similar discovery. I was first informed of the fact by Mr. Johnson, the electrician to the London Telephone Company. Although I see *The Electrician*, in common with most of the other English journals, every week, the announcement of Edison's discovery escaped me, and I should be glad if you would refer me to its record in your columns or elsewhere, and I will take care to make an immediate disclaimer in the matter." [Professor Barrett then, with some justice, goes on to comment on the remarks in our Note of last week. If we say this, we need say no more on the subject.—ED. *E.*]

14

20

Scrap book

THE EDISON TELEPHONE IN BOLTON.

Reprinted from the "Bolton Evening News," March 10th, 1880.

Since we had the pleasure of seeing and hearing the telephone at the offices of the Edison Telephone Company, in Exchange-street, the Company have considerably extended their operations, running wires to various places of business in the town, and have opened the telephonic exchange, both locally and in connection with the one in Manchester, thus enabling their subscribers to talk from their own counting-houses with those of their friends in Manchester. Before describing the ingenious manner in which this is accomplished, it may interest our readers if we describe the telephone as perfected by Mr. Edison, which we are able to do by the courtesy of Mr. G.W. Benson, the district manager. The transmitter, or speaking portion of the instrument, is made of carbon, which is obtained from the smoke of paraffin lamps. This is moulded into a circular form and placed between two metal discs of about three-fourths of an inch in diameter; these are fixed in the centre of a ring of vulcanite, and the whole is embedded in and surrounded by a circular iron case of three inches diameter. On the centre of the iron diaphragm is fixed a short tube of brass, which holds within it a projecting length of glass tubing; this and the screw opposite to it from the outside of the transmitter, press against the metal discs. To enable the voice to be directed against the centre of the discs, a mouthpiece is attached, into which the operator speaks, thus overcoming the defect in the "Blake transmitter," where the voice has to be some distance off and spoken in a loud tone, and thereby can not only be heard all over the room, but is liable to transmit other sounds and conversation. From the Edison transmitter a low, soft voice is heard with perfect distinctness, and, in fact, we are informed, the difficulty with new subscribers is that they speak too loud. The receiving portion of the instrument is, however, the distinguishing feature in the Edison telephone. The general one hitherto in use has been a magneto one, and to hear the voice needs pressing close to the ear, but the sound is so faint that it is not easy to hear, unless there is comparative stillness in the room, and when the wires are troubled by induction it is almost inaudible. To overcome these objections, Mr. Edison, after long and patent investigation and experiments, brought out his electric monograph receiver. Briefly described it consists of a cylinder of chalk about the size of a small cotton reel, which is mounted upon a spindle capable of being rotated by a small handle. Attached to the centre of a disc of mica is a brass strip faced with platinum, which projects over the chalk cylinder, and is made to press upon it by means of an India-rubber spring. The wires are so attached that the electric current is made to pass from strip to and through the cylinder at the point of contact. Upon turning the handle so as to rotate the cylinder outwards from the face of the disc, the friction between the cylinder and the strip draws the centre of the disc inwards, giving it a curved face. If an impulse of electricity be passed over the wire, the friction between the strip and the cylinder is destroyed and the disc regains its normal position. If a variable or undulatory current of electricity be transmitted through the instrument, the diaphragm is kept in continual motion by the constantly varying friction existing between the chalk and the platinum, dragging the diaphragm in opposition to its own elastic tension. So sensitive is this arrangement, that all the undulations produced by the human voice instantly produce their corresponding variations of frictional resistance, and the diaphragm reproduces, in a loud or magnified tone, words or sounds which are being uttered into the telephone at the other end of the wire, whether in a loud or soft tone, a whisper, or even a breath, so that although the Edison telephone is called loud speaking it is none the less soft speaking also. When the subscriber at a distant station in Manchester was asked to speak in his usual tone of voice, the words uttered were heard in the office in Bolton above the hum of conversation a few yards from the instrument, when, in a low tone, only a muttering was perceptible to the bystander though perfectly audible to the person listening at the instrument. At the top of the company's premises is the switch room into which the wires are brought from the various subscribers' offices and mills, and from the Manchester Exchange. Each switch board serves for 24 different stations, which is as many as one person can attend to at one time; but other boards will be added as required, and there may be any number of these in connection, so that any station on one board can be connected with any other station on another board. The board is a beautiful piece of mechanism, consisting of 24 brass strips, crossed by others at right angles; above are the indicators or shutters. Adjoining the switch board is the telephone for the use of the attendant, who sits in front of the board. Assuming that subscriber No. 5 wants to speak to No. 4, the person at No. 5 calls attention to the attendant at the Exchange by ringing his bell, and a shutter drops simultaneously disclosing his number. The attendant then inserts a brass pin into the switch board and thus connects his instrument with that of No. 5, who answers, "Connect me with No. 4." The attendant shifts the pin into a vacant portion of the switch board, and places No. 4's pin on the same line, and the two are then in direct communication. When they have finished talking they ring their bells and the shutters drop, the pins are withdrawn and they are disconnected. Thus subscribers can be instantly connected and disconnected, and any number can be connected up in couples, and be talking at the same time. If a subscriber wants to talk to a Manchester subscriber the operation is similar. For instance, No. 5, having finished with No. 4, wishes to talk to his Manchester warehouse which, in this case, is No. 3 on the Manchester Board. He has merely to ask for No. 1, *i.e.*, the Manchester Exchange, and on receiving a reply from there says, "Connect me with No. 3," and the two are in direct communication, although 15 miles apart, and talking through two switch boards. The whole is as simple as ingenious. Ease, rapidity, certainty, and privacy, are the great advantages of this system. A telegraphic message is wanting on these points, as it needs writing out, and perhaps in a way which cannot convey the exact meaning; sending to the office; transmitting by a skilled operator, interpreted often incorrectly, written out again, and then conveyed by a messenger to the abode or place of business of the receiver; opened and read, and passing under the eyes of at least two strangers; whilst in the new form of communication one person speaks to another as if in the same room, and receives his reply at once; and, if necessary, in perfect secrecy. The utility of this mode of communication is boundless. Gentlemen in business, who live out of town, can have their letters read to them from their offices, and dictate the replies or speak to a customer without leaving the breakfast room. The legal and medical professions will find it a great economy of time and money, consultations may be arranged or even take place at once between themselves and their clients, and a doctor in case of accidents can give directions before arriving at the house. Besides business and professional men, the various public offices, hotels, and livery stable keepers, and the main tradesmen will find it necessary to be connected with the exchange, for by its means our wives will order their household commodities, send for a cab, and learn it is *en route*, and will be able in a few minutes to arrange picnic, riding, musical, or even dinner parties. Mr. Benson tells us that some of the Manchester subscribers have informed him it paid for itself in one month.

21

THE EDISON

TELEPHONE COMPANY OF LONDON,

LIMITED.

The Manchester and District Telephonic Exchange.

SUBSCRIBERS TO THE BOLTON EXCHANGE.

Offices—8, EXCHANGE STREET, BOLTON.

(Head Offices: 15, Cross Street, Manchester.)

Messrs. BARLOW & JONES, LIMITED,	2, Portland St., Higher Bridge-st., Little Bolton
,, CREWDSON, CROSSES, & Co., LIMITED,	Rose Hill, Bolton
,, DAVIES & ECKERSLEY,	1, St. James' Square, Manchester
,, CROSSES & WINKWORTH, LIMITED,	Lever Street, Bolton
,, L. HANMER & SONS,	15, Cross Street, Manchester
,, GEORGE FRASER, SON, & Co.,	101, Portland Street, Manchester
,, DOBSON & BARLOW,	Kay Street, Little Bolton
,, EDEN & THWAITES,	Sharples, Near Bolton
,, LAWSON & ORMROD,	6, Silverwell Street, Bolton
,, TOOTAL BROADHURST, LEE, & Co.,	Daubhill, Bolton
,, JAMES SMETHURST & SON,	Bolton
,, HICKS, HARGREAVES & Co.,	Crook Street, Bolton
THE MANCHESTER & SALFORD BANK,	Bolton
Messrs. JOHN KNOWLES & SON,	Vernon Street, Bolton
,, MALCOLM ROSS & Co.,	Bolton
,, ORMROD & HARDCASTLE,	Flash Street Mills, Bolton

OVER

14

22

The Chalk Cylinder Battery.—Professor Barrett writes:—"When I sent my note to the Physical Society, announcing the production of an electric current by the friction of metal on a revolving chalk cylinder (the only case I know where friction, or, at any rate, the relative motion of two dissimilar conductors in contact, generates a continuous electric current), I was unaware that Mr. Edison had already made a similar discovery. I was first informed of the fact by Mr. Johnson, the electrician to the London Telephone Company. Although I see *The Electrician*, in common with most of the other English journals, every week, the announcement of Edison's discovery escaped me, and I should be glad if you would refer me to its record in your columns or elsewhere, and I will take care to make an immediate disclaimer in the matter." [Professor Barrett then, with some justice, goes on to comment on the remarks in our Note of last week. If we say this, we need say no more on the subject.—Ed. *E.*]

5009. Friction Telephones or Electro-Motographs, *J. Imray.*—Dated 6th December, 1879.—(*A communication.*)—(*Complete.*) 6d.

A cylinder of compressed chalk is soaked in an electrolytic solution, such as caustic alkali, to give conductivity. The axis of the cylinder is connected by gearing to an axis with a handle, by turning which the cylinder is rotated. On the periphery of the cylinder a blade attached to the diaphragm is pressed by a piece of wire acted on by a spring. The line wire is attached to the blade and the axis of the cylinder is connected to the earth. A pivotted lever carries a roller at one end which dips into a water reservoir, and the other end of the lever can be moved downwards, so as to raise the roller in contact with the cylinder and so moisten the latter.

Electrician—June 19 1880

2 May 15 1880 TH

THE TELEPHONE.

"EDISON" AND "BELL."

There are, among the multitude of sages who can be wise after events, many who see in Puck's boast, "I put a girdle round about the earth in forty minutes," a foretelling of telegraphic wonders by Shakespeare. In like manner, before common use shall drill the general mind as to the marvels of the telephone, now coming very rapidly into use in London, and England generally, there may be found among the crowd who cloak their inability to comprehend the greatness of modern inventions by the formula, "There is nothing new under the sun," some who will trace in the summoned "Genie of the Lamp" and Genie of the Ring" a proof that the Easterns understood the possibility of communicating over unknown distances by unknown and mysterious influences. It may be argued, indeed, and with some show of force, that "carbon" in the form of jewels was very largely associated with Aladdin's experiments, and that the truth in the bygone dream of the telephone in the "Arabian Nights' Entertainments" is proved by the received maxim that dreams go by the principle of reversion, for, while the carbonised jewels were "transmitted" to Aladdin, the carbon in its duller form is the transmitter—or, rather, a principal agent in the modern invention.

Leaving, however, these dreams and speculations for the idle and careless, we come to the great fact that to-day we have in London, in practical use, two systems of telephonic communication, and it has been our business to practically examine both the "Edison" and "Bell," with the view of laying the particulars before our readers, so as to enable them to judge of the advantages which this new system of communication has over all others. These advantages are manifold and self-evident, the first being that it enables principals in business to communicate *at once*, without the intervention of subordinates, and to learn at once, without the difficulties and delays of writing, the thoughts which they may desire to exchange. For instance, at present the editor of the daily paper, sitting in his office in London, in the discharge of his duty to the public, has to direct the "leaders" for the morrow's paper, and he can only do this on ascertained facts. These facts are transpiring in the Houses of Parliament two miles distant by carriage. The editor has the utmost need for consulting his chief of the staff at "the Houses" direct; but he can only do so by an immense loss of his valuable time in driving to the Houses, and in dashing through the labyrinths of the vast building. The "fierce heat" which beats about the daily newspaper press—that is to say, the stern necessity which exists for holding in the utmost secrecy the views which may be contained in the morrow's leader—compels the editor to throw aside the use of the telegraph in this case, for the use of the telegraph would require that he should open his mind clearly and distinctly to a mechanical subordinate, whose receptive faculties, perhaps, might be unequal to convey and reconvey the delicate touches which play about a political "policy." The telegraph has been and is a wonderful help; but it is not everything. Even where it is "laid on," as in newspaper offices, the clerks are the father confessors of their employers, and if they go out for "a smoke" in the intervals of work they may prematurely "let out" important facts where the unholy band of "London correspondents" to country papers most do congregate, and "London correspondents," by placing the country newspapers on a level with the town productions in the matter of late news, make themselves the deadliest enemy the London newspaper proprietor has to contend with. It is thus easy to be seen in what respects the London newspaper editor has for keeping to himself his "exchanges" of communications. As a contrast to the clumsy system of writing, or going in person to "the Houses," the editor can open his telephone and hold his direct communication—a system which, speaking from practical experience of daily newspaper work, we can say will lighten the labours of an editor of a daily newspaper, will lessen the "harass," and will keep his office secrets perfectly free from the dangers of "tapping." Then the counsel engaged in a case at Westminster will be able to be placed in communication with his solicitor at Chancery-lane; and law, if not justice, will be facilitated by the immediate personal communications between those who are watching and directing the same interests from different points. The merchant, in his counting-house, keenly sensible to all the ramifications of a vast business, will, by means of the telephone, have his affairs under the operation of his own eye. He will not need a correspondence to the great extent he is at present compelled upon to enter. The merchant class will, under the new system, be placed in direct and instant communication with those with whom they do business, and the wonderful change which will thus be wrought can only be foreseen by those who can take the trouble to "think out" the results which will follow on placing the ears and voices of the most important members of our busy community in instant and complete relation. To insurance offices the telephonic communications are clearly a necessity of which they must avail themselves.

We "wanted to know" all about the "Edison," and we travelled to the head-office, at 11, Queen Victoria-street, E.C. We found there a busy convocation of gentlemen, and the introductions were so rapidly performed that we can only guess, respecting the gentlemen we first saw, that they were Mr. Arnold White and Colonel Godfrey Twiss, the secretary and assistant-secretary of the Edison Telephone Company of London, Limited. We have no doubt about the next introduction, which was to Mr. E. H. Johnson, the chief engineer, a gentleman, we soon found, whose reverence for that high priest of practical invention, Mr. Edison, was only equalled by a knowledge of the instrument now being brought into working. We were "rushed," so to speak, from one apartment to another for our guide, philosopher, and friend on the occasion, while exhibiting that remarkable characteristic courtesy which is an importation from America, and contrasts so distinctly with general British brusqueness, was unmistakably in haste. It was evident that orders for telephonic communication were tumbling in, and that Mr. Johnson's mind was literally being wired at from at least a hundred different centres; so it is not surprising that his speech, like the Mary May of Hood's "Copper in the Air," should have been "full trotting," as if he had, like the interesting damsel after Mrs. Round's experiment in explosives, too much to tell before his death.

Mr. Johnson placed us before an Edison telephone, which, he stated, was in communication with various circuits, and one point of communication was at Norwood, over fifteen miles of wire. He drew our attention to the peculiarities of the instrument—in that the speaker through it, by the Edison system, is in direct contact with the two distinct parts—the "transmitter" and the "receiver"—the one transmitting the message from the speaker's lips, the other receiving the return message and pouring it into his ears, and, as it is, loud speaking, into the room where the instrument stands. The whole space occupied by the instrument, we may mention, *en passant*, is about that which would be occupied by one's hat upon the wall. Mr. Johnson explained to us the mechanical arrangements of the telephone, and he illustrated the action of the voice upon wires by drawing a straight line upon the wall, and thus described the voice as passing in waves over it after being received by the transmitter upon the diaphragm, and acted upon by Mr. Edison's carbon points and metallic discs. The "receiver" is conveniently close to the ear while the speaker talks into the telephone, and, in the space of the penny bun of commerce, contains Mr. Edison's special invention for the enlargement of the tone received. The receiver of the message turns a little cranked handle with his right hand, and this may turn to the right or to the left, or be changed in the circuit it may take, without causing any breakage or loss of message. The receiver has a diaphragm upon which the received message falls and is conveyed to the ear. Mr. Edison's latest improvement up to date is to place a cylinder of pure chalk, mounted upon a spindle, which is rotated by the cranked handle. Attached to the diaphragm, which is a disc of mica, is a brass strip faced with platinum, which projects over the cylinder, and is made to press upon it by means of a spring. The wires are so attached that the electric current is made to pass from the brass strip to and through the chalk cylinder at the point of contact—a point which is also the point of friction. When the handle is turned the cylinder is rotated outwards from the face of the disc, and the friction between the cylinder and the strip draws the centre of the disc of mica inwards, giving it a curved face. When an impulse of electricity is passed down the wire the friction between the strip and the cylinder is destroyed, and the disc regains its normal position of a true plane. When a variable or undulatory current of electricity is transmitted through the instrument, the diaphragm is kept in continual motion by the constantly-varying friction existing between the cylinder of chalk and the platinum, dragging the diaphragm in opposition to its own constant elastic tension. The simple mechanical arrangement thus presented is exceedingly sensitive to the smallest, as well as to the most rapid, of complicated variations in electrical intensity occurring in the transmitted current. It is so sensitive, indeed, that all the complex undulations produced by human articulation instantly produce their corresponding variations of frictional resistance, and the diaphragm reproduces to the ear of the receiver, in a loud and magnified tone, words or other sounds uttered or produced upon the diaphragm of the telephone at the other end of the wire. Mr. Johnson gave us this information in reply to questions which were addressed to him, and made it evident to us that he possesses as thorough a practical knowledge of all points connected with the instrument as a good seaman possesses of the compass.

"Now," said Mr. Johnson, closing the little door of the instrument, "I will ring the bell in the central station." He touched a little knob, and instantly came a ring. "That's the answer," he explained; and then, placing his mouth at the telephone, he called "Hallo, hallo!" (a contraction, we presume, of "Hail, ho, ho!) A reply, "Yes, sir. What can we do for you?" "Well, put me on to the store room."

There followed a little business conversation, and then Mr. Johnson placed us in conversation with a station at Norwood, which is fifteen miles off "by wire." "Do you have to pick out your words, or simply ordinary conversational tones?" we asked, before commencing to hold a conversation with an unknown gentleman at fifteen miles by wire, and, perhaps, eight as the "crow flies." "Oh!" said Mr.

23

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Johnson, "if a person 'mumbles' in his ordinary conversation and will speak in the telephone, his mode of speaking will be reproduced, only magnified in its peculiarities." (*Par parenthese.* Would some grace the giftie give some speakers the power to hear themselves as others—especially the Press—hear them!) We held a short conversation with Norwood; but, as our purpose was to listen and not to talk, we only spoke with the purpose of listening to the speaker at the other end. That he heard us was soon seen in the immediate compliance with our requests. The gentleman whispered, and words without tones—that is to say, with only breath forms—came back. Then we had a raised tone, and every word could be heard distinctly at several yards' distance from the instrument. The gentleman of Norwood gave us a song, and though we must confess, in candour, that the metallic rendering of the "human voice divine" was far from musical, yet the song could be distinguished in words, modulations of the voice, and in the various keys. The various sounds in a solo on the whistle by the human lips were also clearly and distinctly conveyed. Mr. Johnson informed us that it was quite possible to separate the metallic sound from the other, and to convey the harmony without what we may term the metallism by telephone—that, indeed, this had been done in America over long distances, an effect produced simply by the use of a wooden sounding-board in the receiver. The human voice could be reproduced perfectly through the telephone, if necessary; but he laughingly declined to pledge himself that Mr. Sims Reeves, for instance, could, by the telephone, be able to sing to a Crystal Palace audience by electricity while chanting at Albert Hall—that is to say, in such a manner as to be a commercial success. In general, the voice heard would be a new sound in the cosmos—the "telephonic voice," a distinct and clear voice, but still a voice with a certain amount of metallic or hollow sound.

We had proof of the telephone's efficacy in the transmission of sound—this being the middle of the day in the busy city of London, and yet, east, west, north, and south, with the rattle of trains, the rumble of vehicular traffic, and the multitude of noises, which, in the aggregate, may be heard in a hum miles distant from the city, the voice by telephone came back distinct and clear; and Mr. Johnson then gave us a few passages from the history of the instrument, first, as to the steps in the history of the conveyance of sound discovery by Mr. Edison; then the history of the receptive powers of a receiver, and then the history of the "receiver," the invention of which caps the whole, and makes the telephone a perfect instrument, blessing with the knowledge of an accomplished task "him who gives as well as him" who receives a message.

We then went into the "central exchange," where there are ranged lines of little brasses, like the coverings to the key-holes of large safes. Each of the little brasses represented, so Mr. Johnson informed us, a subscriber. There was a large quantity of material, looking like tangled fishing lines, behind the little brasses, and these were the telegraphic connections. At the tables were the "telephone voices," ready to answer any subscriber and place him in communication with any other subscriber. We had not been two minutes in the "exchange," before down fell one of the little brasses, displaying a number. A plug was placed in a hole below the brass, when the exchange voice asked, "What can I do with you, sir?" The voice of one of our metropolitan administrators, speaking as the head of a firm half-a-mile to the west, asked, "Have you made communication with Messrs. Blank and Co.'s yet?" The reply given, "Not yet ready, sir." "Thanks," was the response, "Good-day" being the closing words on our side, and that interview was closed. "That gentleman knows that we are placing up a telephone for others, and he wanted to know if all was ready," was the explanation given to us. While Mr. Johnson was speaking, down fell another brass. For an instant the "wire" of the receiver was communicating with No. 3. "What can I do for you, sir?" "I wish to speak to Mr. Blank, of Blank-court, Lothbury." "Yes, sir; you are connected," a point being inserted to another number. The point or peg so inserted in the little hole connected the two wires as effectually as if they were torn from the wall and twisted together, and the removal of the peg acting again as an untwisting of the wires. All these operations were quickly and quietly done. The operators, who are the medium of communication between the subscribers, have each a circuit, and their work, it can be seen at a moment's reflection, has been regulated by a perfect organisation.

The "Edison" Company has the Central Exchange at 11, Queen Victoria-street, and City branch "exchanges" at 77, Cornhill, 34, Eastcheap, and in Lonsdale Chambers, Chancery-lane, and at Westminster, while the same company is about to open exchanges on Holborn Viaduct, in Pall Mall, Southwark, Aldersgate-street, Regent-street, and Paddington. "Our great difficulty," said Mr. Johnson, "is to obtain permission to erect poles for the wires. We have obtained permission from some of the authorities holding rule over important public buildings, and we regard that as a great gain. We do not think that public opinion is wholly alive to the importance of telephonic communication; but the fact (stated by one of the company present respecting the introduction of gas) that the gas companies sent round people to ask if the gas should be laid on at the 'same time as next door had theirs,' a neighbourly jealousy which carried the day, shows that the public mind here has to be educated to a want. Our numbers are, however, daily growing. We have now about 460 persons daily calling at the Exchange wishing to be placed in communication with subscribers—that is to say, that subscribers have their time saved by their correspondents communicating with them directly by the telephone. Besides the number who daily call for business purposes, we have many who call to see the working. We did not practically commence until four months ago, so that we have not been yet long before the public in work, and we have here a printed list of the chief firms connected, being nearly 250 subscribers connected under the 'Edison,' so that we are progressing pretty rapidly."

We remarked that our practical experience in the working of the telephone system in America led us to think that the existence of two systems here would be injurious to both, or, rather, would lessen the ability of both to "go ahead" to the extent that an amalgamated company would, and it was acknowledged that two companies would not be so advantageous as one; but it was naively added that two were better than none. We sauntered out of the business-room, and as we went our conductor held that the "Edison" had great advantages over the "Bell," in the fact that the former gives no uncertain answer—that the magnified sound is an unquestionable advantage—that the system in transmitting the message will "largely neutralise the opposing inductive currents due to underground or adjacent telegraph wires," and certainly the fact of the loud-tone speaking of the instrument was amply demonstrated. We had a glance of some other Edison wonders, and we left the Victoria-street Exchange with the idea strongly predominant that Mr. Edison's friends have their faith in his inventive powers well founded, and that those who judge otherwise are of the class for whose backs Solomon said rods were made.

Now we come to the special consideration of the "Bell" telephone. We will at once say that we shall not touch by even so much as a word upon any matters which may be in dispute between the two companies working under the names of "Edison" and "Bell;" our purpose is only to lay before our readers the merits and advantages to be derived from the use of either, while in the interests of the public generally we cannot but express the hope that some means will be found to have telephonic communication cemented in London, at all events, by telephonic unison. On going to the head exchange of the "Bell," even if we had not the exact house before us in Coleman-street, we should have been able to pick out the "Exchange" from the forest of wires overhead. Some ancient artist, a few centuries ago, seems to have hit upon the particular spot where the chief "Exchange" stands as the very place whence the dead world was to be awakened to the sound of the trumpet—a rude representation in wood, of Scriptural interpretation, being placed over the disused burial-ground next door, and might be taken, by those who love auguries, as having foretold that the world, at present almost dead to the advantages of the telephone, would be from here awakened. Making our way to the first floor, we are introduced to Mr. H. F. Lewis, the acting general manager, who, in answer to our questions, states that the real working only commenced late last year, but that in London alone there were nearly 400 subscribers, and that the company was also at work in all the great towns. Mr. Lewis handed to us a double list of the subscribers, one being a list in which the subscribers are arranged in alphabetical order, for readiness of reference, with their telephonic number, and the other being as they stand in the order of the instruments. The company have exchanges in Coleman-street, Leadenhall-house, Leadenhall-street, Palace Chambers, St. Stephen's, Westminster. A large map of London stood on the wall, about four feet square, and the immense amount of business which may be done can be judged from the fact that, leaving out the line to Westminster, the communications made could be covered on the map by a man's hand. Mr. Lewis presented us with this statement:—

"Each subscriber has a wire from his residence or office, with the necessary instruments attached, to the telephone company's stations. A signal from the subscriber is answered by the operator at the central station, who instantly makes a connection with the wire of any other subscriber with whom communication is desired, and conversation can then be carried on with ease and privacy, without the possibility of any third person hearing what is passing. A signal to the operator intimates when the conversation is finished. There are no complicated or delicate parts in the instrument requiring any previous knowledge or care; and the words are not only heard clearly, but the voices of speakers can readily be recognised. For a fixed annual rental the company erect and maintain the wires and all requisite apparatus. The only charge for subscribers within a radius of a mile from the company's station is a subscription of £20 per annum, payable in advance."

The rules under which a telephone is held are as follows:—

"The undersigned lessee of telephones agrees to take good care of the same, and all fixtures connected therewith, and will not permit any one not a subscriber to use the instruments, and will not transmit messages for hire, or use the instruments upon any other line or at any other place except as herein specified, and at the expiration of the time for which this agreement is made will surrender the same to the telephone company, or its authorised agents, in as good condition as when received (ordinary wear alone excepted); and in default of payment as herein-below agreed, or in case of the violation of any of these conditions, the lease shall, at said company's option, terminate; and said company, or its authorised agents, shall have the right, and the lessee hereby gives them permission, to enter upon the premises wherein said telephones may be, and take possession of and remove said telephones and fixtures, and the lessee shall have no claim for the repayment of any moneys which may have been paid for rent or otherwise under this lease. In case either of said instruments is lost or destroyed, it is agreed that the lessee shall pay the lessor for each instrument so lost or destroyed, but the property in such instrument shall still remain in the lessor, and such payment of liquidated damages shall give no right to use such instrument. The company is to keep said telephones in good working order, and repair the same at its own expense, except when injured by the carelessness or neglect of the lessee or servants thereof, and is to have free access, at all reasonable times, to the instruments and premises where they are used, for the purpose of inspecting or repairing the same."

After receiving this information we were introduced to the engineer, who led us to the "switch room," as the apartment is termed where the connections are made. Here the subscribers' connections are shown on bars of double alphabets, and the connectors sit at four tables and "switch" on and switch off the subscribers on receiving the message. The transmitting telephone is on pretty much the same principles as the Edison—the difference being so nice that only an expert could appreciate it. The great difference between the two is in the "receiver"—that part which communicates the message to the ear. This, in place of standing out from the telephone, as in the "Edison," is attached by wire to it, and is held to the ear, when the message is heard by the receiver alone. The transmitter does not require, as in the "Edison," to have the mouth of the sender close to the mouth of the telephone; but the person may speak into it at a little distance, while the receiver of the "Bell" gives whatever advantage is derived from the message communicated being a private one, and communicated only to one ear. In this room we saw that the communication between the subscribers were received, and made as described in the "Edison" working, but in place of the little brass shutter falling to denote a message from a subscriber a disc falls, and the communication is made with a plug, which combines the wires of the communicating telephones. After admiring the order and organisation of the office, and expressing our hope that the great list of eminent merchants, firms, and offices would be increased to the full extent of the company's powers, we departed with the full resolve to spare ourselves from the plague of printers' devils in future by entering into telephonic communication with that part of the world which has been wise enough to find that to be without it is equivalent to being without the postage, telegraphic, and railway systems combined.

25

14 226

Nature June 17 1880

Mr. W. P. Johnson gives an account in the *Philosophical Magazine* of a new use of the telephone. It is sometimes necessary to grapple and lift a faulty cable, and if it lies in the water along with other cables of similar exterior make it has hitherto been impossible to decide, without cutting it apart, on the identity of the grappled portion. To avoid the obvious evil of having to cut and splice the cable unnecessarily, it is now suggested to employ the telephone on an auxiliary parallel wire in which the induction may be sufficiently strong to enable the electricians in charge to read the signals which may be sent into the cable, and so identify it.

ELECTRICITY.

Science July 17 1880

An interesting experiment which seems to have a bearing on the action of Edison's friction telephone, has been recently described by Herr Koch. When a plate of platinum or palladium is polarized by means of an electric current, the friction of these metals against a plate of moistened glass increases immediately. To measure the friction, Herr Koch uses the metal in the form of a hemispherical button, resting on the bottom of a glass cup, filled with pure or acidulated water. The button serves as pivot to a magnetic needle, which oscillates under the action of the earth; the decrease of the oscillations measures the friction of the pivot. Polarization is produced by the current of the Daniell element, one pole of which communicates with the metallic button, while the other terminates with a platinum wire entering the water of the cup. The polarization by hydrogen produces no effect, but polarization with the pole oxygenated is found very efficacious. The friction was increased, through this polarization, in the ratio of 2 to 3, and sometimes in that of 2 to 4. This increase of friction appears immediately the circuit is closed, and disappears immediately when the current is reversed; but it disappears slowly, like the polarization itself, when the circuit is merely opened. It increases with the electromotive force of the polarization by oxygen. Palladium behaves like platinum. Gold (18 carat) gave no effect.

REPORTING BY TELEPHONE.

Cincinnati Daily Gazette

How Late Speeches in the House of Commons are Dealt With by Modern Scientific Inventions.

From the London Times. June 9 1880

A new method of reporting the late debates of the House of Commons—those, namely, which are continued after midnight—has within the last few days been brought into operation in the office of this journal, and some account of the method employed will probably be of interest to the public. There has for sometime been a tendency among the most prominent public men to deliver their Parliamentary speeches at very late hours, and this, together with the dispatch of the first morning trains from the London termini an hour earlier than formerly, has placed great difficulties in the way of Parliamentary reporting. After about 1 o'clock in the morning, to produce in time for the early edition a full report of a speech, however important it might be, became a matter of extreme difficulty, and after 2 the record of proceedings became necessarily a mere abstract. But these difficulties seem now to be in a fair way to yield—sufficiently at least for all practical purposes—to the increased powers of work which have been afforded by the judicious application of modern scientific inventions. The first step in this direction must undoubtedly be ascribed to the increased rapidity of setting up type, which has been due to the employment of a machine as a substitute for the manual labor of the compositor. The most skillful workman, setting up type by hand, would not exceed a general average of about forty lines per hour, or a maximum rate of fifty lines per hour, during short periods of great pressure; but the machine, in which the types are brought down and placed in position by striking upon keys something like those of a piano or organ, enables a fair workman to attain an average speed of 100 lines an hour, even when composing from manuscript, which he has to read for himself; and this speed can be doubled, or nearly so, when the operator is assisted by a reader, and thus composes from dictation. The original form of the machine in use at this office was introduced here soon after the Franco-German war, and has ever since been undergoing such modifications in detail as experience has from time to time suggested, until it has now reached a state of very great efficiency. It has for some time been the custom to transmit the foreign intelligence from Paris, Vienna, and Berlin to this office by means of Hughes' printing telegraph, and to dictate the contents of the telegraphic slip to a compositor at the machine. By this combination remarkable facilities in dealing with late manuscript have been obtained, and it has been possible to carry on the work of type setting almost to the time of going to press; but the copy received from the House was necessarily somewhat delayed while the reporter transcribed his notes and in transmission. The compositor was compelled to lag behind the actual progress of the debate, and precious time thus lost at each step of the process mounted up in the end, to a considerable total.

At this stage in the history of the matter the telephone was brought into actual operation as a means of verbal communication between distant points, and the conductors of this journal formed a new connection between the House of Commons and the office, and placed one of Edison's loud speaking telephones at either end. The immediate result of this arrangement has been to bring the compositor at the machine into direct communication with the Parliamentary reporter at the House, and to enable the debates to be reported and printed from half to three-quarters of an hour later than had previously been possible. The notes made by the reporter can be read directly into the telephone receiver in a room adjoining the gallery, either by the reporter himself when relieved or by another person employed for the purpose, and the compositor, at his machine in the office, sits with his ears in juxtaposition with the other terminal of the instrument. The plan which has been found the most efficacious for the purpose of shutting out distracting sounds of other kinds is to place the disk of the telephone above and behind the compositor, and then to arrange two tubes, each with two trumpet shaped extremities, in such a manner that these extremities are applied at one end to the two sides of the telephone disk and at the other end to the two ears of the compositor. The compositor is also furnished with a speaking instrument, with a key for ringing a bell, and with a bell which is rung from the House; a simple code of bell signals, consisting of one, two, or three strokes, sufficing for the ordinary requirements of each message. The compositor announces by the bell that he is ready, receives a sentence, strikes the bell to indicate that he understands it, sets up the type with his machine, strikes the bell again for the reader to continue his dictation, and so on until the work is carried as far as time will allow. If there is any doubt or difficulty about the words, a bell signal will cause them to be repeated, or explanations can be sought and received by direct vocal communication. In this power, indeed, resides one of the chief advantages of the method, and one which ought to lead to greater accuracy than has ever previously been attainable. The names of people, places, etc., can be spelled out letter by letter if there is any doubt about them.

27

Electrician Apr. 10 1880

The Telephone and Deafness.—Some writers on science do not seem to know it has long been well understood that certain forms of deafness are partially remedied by receiving the sounds through the mouth. The ticking of a watch, which cannot be heard when the watch is placed against the ear, is audible when the watch is put into the mouth, and so on. The Milwaukee *Sentinel*, when describing the Elgin Acoustic Telephone, says:—"It is extremely simple and economical in construction." The article states:—"But the most wonderful test is the one which has been tried of getting at such a distance from the instrument that by no possibility can sounds be heard, and then taking the wire between the teeth. A person quite deaf can understand words spoken in a moderate tone, the effect being the same as follows from the use of an audiphone."

Engineering News. May 21. 1881.

THE ELECTROPHONE.

An experiment of great importance has just been made at Calais, France. Between that place and Dover, England, conversation has been kept up by means of a new kind of telephone called the electrophone, attached to the telegraph lines between the two places. The listener at Calais was able distinctly to distinguish not only the words of the speaker at the other end, but also to recognize the speaker by his tone of voice. During the time that the conversation was going on the wires were being used for the transmission of messages by telegraph, and that transmission was made without any interruption whatever. The inventor of the electrophone is of opinion that it can be used in connection with an Atlantic cable, and the success of his experiments so far seems to justify his belief.

Teléfonos.—Por cuanto se ha presentado don Tomas Alva Edison solicitando privilejio esclusivo para construir y usar en el pais unos aparatos telefónicos de su invencion; visto el informe de los peritos don G. R. Gopp y don C. L. Rowsell, y habiéndose cumplido con todos los requisitos que prescriben las leyes de 9 de setiembre de 1840 y de 1.° de setiembre de 1874;

Por tanto, vengo en espedir a favor de don Tomas Alva Edison patente de privilejio esclusivo por el término de ocho años para construir y usar en el pais dichos aparatos, tales como se encuentran descritos en el diseño y pliego de esplicaciones depositados en el museo nacional.

Los ocho años comenzarán a contarse despues de trascurrido uno, que se asigna al interesado para que ponga en ejercicio su industria.

Este privilejio no comprende el uso del aparato destinado a hacer sonar campanas, descubrir número y tablas cambiantes, por ser ya conocido en Chile.

Dada en Santiago de Chile, a 30 dias del mes de abril de 1880.—Pinto.—Domingo Santa Maria.

El Mercurio

Ensayo del teléfono.—Anoche las personas que habia en la oficina telegráfica trasandina de Santiago se han comunicado y conversado perfectamente por el teléfono con otras personas que estaban en la oficina central recien establecida en Valparaiso.

El señor Husbands ajente de la compañia del teléfono de Edison, hizo llamar a su esposa que estaba cerca de la oficina en Valparaiso. Habiendo llegado la señora, a invitacion del señor Husbands se puso a cantar el *Miserere* del *Trovador*, al fin de cuya pieza el esposo hizo dúo con su señora. Terminado el canto de la artista, que fué escuchado con mucho interes por todos los concurrentes de Santiago, el auditorio manifestó su satisfaccion con una salva de aplausos, a los que contestó la artista desde Valparaiso dando las gracias.

Todos los asistentes de Santiago y Valparaiso hicieron recíprocas preguntas, dándose las respectivas contestaciones. Uno de ellos, entre otros, llamó desde Santiago a la oficina de Valparaiso a un amigo a quien le habia remitido una encomienda. Acudió el amigo al llamado.

—¿Has recibido, preguntóle el amigo de aquí, la encomienda que te mandé el domingo?

—Sí, y en buena condicion, contestó el otro inmediatamente.

—Muchas gracias.

Y no hablaron mas a estilo de comerciantes.

Lo que se hablaba desde Valparaiso y hasta las risas de los concurrentes de la oficina de ese puerto, se oian claramente en todos los ámbitos de la oficina de Santiago.

Este ensayo del teléfono ha sido como una fiesta en celebracion del decreto espedido ayer por el gobierno en que se concede privilejio esclusivo a la compañia empresaria del teléfono.

Hai varias casas comerciales de Santiago que están ya dispuestas a valerse del teléfono para conversar sobre negocios al traves de 40 leguas, a ejemplo de algunas casas de Valparaiso que ya tienen establecidas ramificaciones telegráficas con la oficina central de ese puerto.

Asegura el empresario que una vez que esté bien establecida y corriente la línea, se oirá en Valparaiso el ruido de los carruajes que pasan por la calle cerca de la oficina de Santiago.

14 / 26 / 28

MINISTERIO DEL INTERIOR.

Diario Feb 8 1880

Por cuanto se ha presentado don Tomas Alva Edison solicitando privilejio esclusivo para construir i usar en el pais unos aparatos telefónicos de su invencion; visto el informe de los peritos don G. R. Gepp i don C. L. Rousell, i habiéndose cumplido con todos los requisitos que prescriben las leyes de 9 de setiembre de 1840 i de 1.° de setiembre de 1874;

Por tanto, vengo en espedir a favor de don Tomas Alva Edison patente de privilejio esclusivo por el término de 8 años para construir i usar en el pais dichos aparatos, tales como se encuentran descritos en el diseño i pliego de esplicaciones depositados en el Museo Nacional.

Los ocho años comenzarán a contarse despues de trascurrido uno, que se asigna al interesado para que ponga en ejercicio su industria.

Este privilejio no comprende el uso del aparato destinado a hacer sonar campanas, descubrir números i tabla cambiante, por ser ya conocido en Chile.

Dada en Santiago a 26 dias del mes de abril de 1880.

PINTO.

Domingo Santa María.

Eng. Mech & World Science. July 8, 1881.

A USEFUL MICROPHONE.

[18928.]—THE following details of a microphone will, I am sure, interest our various readers who have made this wonderful instrument a study. I do not claim for the instrument originality, but adaptation of the principle of the first microphone of Professor Hughes.

After many experiments, and patient trials of most existing forms of microphones, the one I describe will be found to have many good qualities. Commencing with the diaphragm, this is constructed of white or yellow pine 1-12th of an inch thick, and 5in. square; on the edges are glued two strips of wood about 3-16 thick, shaped like a bridge, about ¼in. at the middle, and tapering gradually at the ends; these are glued across the grain, and prevent the soundboard twisting, Fig. 1.

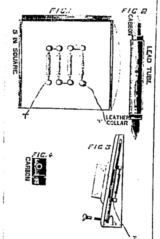
The carbon pencils (Fig. 2) are made from electric-light pencils, No. 2, obtained from Mr. E. Paterson, 76, Little Britain, and the pencil-holders from No. 5 pencil. The pencils are 2in. long, nicely filed to a point, and fitted into a small leaden tube (Fig. 2). The tube used for pneumatic bells answers well. Round the carbon is glued a collar of leather, which secures the lead in place, and acts as a damper in preventing the sound given by the carbon itself. This sound is heard if a small piece of carbon is struck, and is the cause of the metallic sound so often heard in microphones. The length of the lead tube should be 1in. and 3-16.

The pencil-holders are cut about 7-16 long, a hole drilled half-way through, and a groove cut round (Fig. 4). Four carbons are glued to the soundboard, and, when dry, the pencils put in place loosely by placing the remaining four carbons. A piece of thin copper wire, cleaned well, about No. 30, is placed in the front in the carbon holders, and twisted up, and a touch with soldering-iron afterwards makes all secure. On the opposite side of diaphragm is lightly glued a rubber ring, about 2¼in. in diameter, which rests when in box against the front, and the pressure regulated by a screw (see Fig. 3), filed to a square, and moved by a key. This rubber ring acts as a damper, and prevents noise and rattling.

The soundboard is fastened to the inside of the box by a leather hinge glued along the upper edge, and on a slip of wood, the thickness of rubber ring, a small spring presses at the lower edge of board, which keeps it close to the screw (see Fig. 3).

The soundhole in mouthpiece is 1in. in diameter, and the box made of well-seasoned mahogany, ¼ or ⅜in. thick, solidity being essential; the internal diameter of box about five inches and a half, leaving a space about a quarter of an inch all round board, except at upper edge, where the leather hinge is glued on.

When the adjusting screw allows the diaphragm to press lightly on front of box, the instrument is in order for speaking, and eight to ten inches distance gives first-rate results. The voice should be just as in ordinary conversation: music, such as violin, is beautifully heard through a telephone receiver.



The above is a description of a pair of instruments I constructed twelve months ago, and their behaviour is so good that, for the benefit of our amateur subscribers, I give you a description of this modified form of microphone.

Two or three Leclanché cells are sufficient for ordinary purposes. The microphone can be used well without induction coil, and can be fixed to any of the existing arrangements with switch and bell. The angle of microphone box, I should state, is from ten to twelve degrees. The ones I have constructed rest at 10°, and answer admirably.

Norwich. J. H. L.

29

Cette Compagnie des Téléphones, en plus des compagnies similaires américaines, a adopté plusieurs instruments nouveaux, entre autres le téléphone Gower, téléphone sans pile électrique, l'appareil de cet ordre le plus simple et qui présente les résultats les meilleurs.

Nous avons donné une description complète (*Science pour Tous*, année 1879) de ce téléphone, l'un des appareils dont la Compagnie des téléphones a acquis la propriété ... d'utiliser. Rappelons que cet appareil ... éphone ... prations ...

branches, et il paraît ... que les arbres ainsi ... plus chargés de fruits ... de fer ... découverte. ... ise aux

Cette précaution es ... et ra- ... que nous ne saurions ... nt. Mais pour le croire, et c'e ... léphone ... teuse que l'on peut ... nents du ... trera aux personnes ... mension ... si les résultats sont tant et à ... Pou une ... du son ... rle dans ... cet avan- ... le signal ... aux per- ... par son

avertir mutuellement, de s'appeler ... communiquer de vive voix. ... Gower est destiné à trouver des applications ... nombre de circonstances, notamment ... rées; aussi plusieurs compagnies de ... l'ont déjà adopté sur leurs lignes.

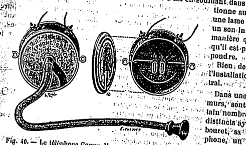


Fig. 40. — Le téléphone Gower. Vues extérieure et intérieure.

Avec cet appareil, nul besoin de pile, nulle dép... supplémentaire, nulle chance de dérangement parce ... dans un moment d'oubli on aura omis de rompre le ... rant, la communication terminée, et que la pile se ... épuisée.

L'appareil, accroché au mur comme un cartel ou rap... lant assez bien par sa forme celle d'un baromètre, ... roïde, est muni d'un porte-voix monté à l'extrémité d... tube flexible. C'est en soufflant dans ce tube que l'on ... tionne au poste correspond... une lame vibrante produis... un son intense et de la mê... manière que ce poste indiq... qu'il est prêt à écouter et à ... pondre.

Rien de plus curieux ... l'installation du bureau central.

Dans une salle, le long d... murs, sont aménagés un ce... tain nombre de compartimen... distincts ayant chacun son t... bouret, sa tablette, son télé... phone, un cornet acoustique ... pour renforcer en cas de be... soin les sons téléphonique... perçus par l'oreille, et fixé ... mur, un tableau commutateur, portant des numéros ... servant à établir les communications entre les correspon... dants. Le bureau central se trouve relié par des fils con... ducteurs ou fils télégraphiques, courant dans les galeries ... d'égouts avec le domicile de chaque abonné. Des em... ployés, mis à la disposition d'un certain nombre d'a...

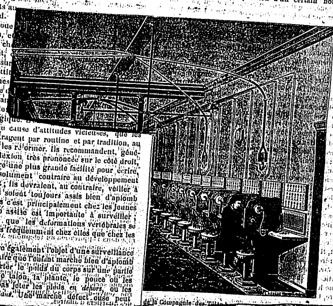
De l'att...

M. le Dr Dally ... ment intéres... sur l'attitude ... ble que toutes les pe... connaissent ce trava... à corriger ces attitu... la station assise, ... produit des effets au... remède plus tard.

La pesanteur joue ... des déformations, ... que possible les ch... la station debout, ... Nombre de voussu... sont dues à des atti... cause de migraines ... des yeux et même ...

C'est surtout da... cation que l'on do... d'hygiène pédagogique ... bien souvent une cause d'attitudes vicieuses, que les professeurs encouragent par routine et par tradition, au lieu de chercher à les réformer. Ils recommandent, généralement, une inflexion très prononcée sur le côté droit, qui donne peut-être une plus grande facilité pour écrire, mais qui est absolument contraire au développement régulier de l'enfant; ils devraient, au contraire, veiller à ce que les écoliers soient toujours assis bien d'aplomb sur leur siège. Mais c'est principalement chez les jeunes filles que l'attitude assise est importante à surveiller; on sait, en effet, que les déformations vertébrales se présentent bien plus fréquemment chez elles que chez les garçons.

La marche doit être également l'objet d'une surveillance active. Il est nécessaire que l'enfant marche bien d'aplomb et évite de faire porter le poids du corps sur une partie exclusive du pied, le talon, la plante, le pouce ou les orteils; il ne doit pas jeter les pieds *en dehors*, ou les ramener trop *en dedans*. Une marche défectueuse peut



... de la Compagnie des ...

ION GEAR.

Fig. 7.

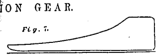
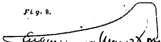


Fig. 8.



Engineering May 28 1880

REPORTING BY TELEPHONE.

WE quote the following from the *Times*: "A new method of reporting the late debates of the House of Commons—those, namely, which are continued after midnight—has within the last few days been brought into operation in the office of this journal; and some account of the method employed will probably be of interest to the public. There has for some time been a tendency among the most prominent public men to deliver their Parliamentary speeches at very late hours, and this, together with the despatch of the first morning trains from the London termini an hour earlier than formerly, has placed great difficulties in the way of Parliamentary reporting. After about one o'clock in the morning to produce in time for the early edition a full report of a speech, however important it might be, became a matter of extreme difficulty, and after two the record of proceedings became necessarily a mere abstract. The inevitable curtailment of the reports has been felt as a grievance by many members of the House, and has been one cause of the efforts recently made, by appointing Select Committees and otherwise, to get a better provision for the publication of the debates. But these difficulties seem now to be in a fair way to yield—sufficiently at least for all practical purposes—to the increased powers of work which have been afforded by the judicious application of modern scientific inventions.

"The first step in this direction must undoubtedly be ascribed to the increased rapidity of setting up type, which has been due to the employment of a machine as a substitute for the manual labour of the compositor. The most skilful workman, setting up type by hand, would not exceed a general average of about 40 lines per hour, or a *maximum* rate of 50 lines per hour during short periods of great pressure; but the machine, in which the types are brought down and placed in position by striking upon keys something like those of a piano or organ, enables a fair workman to attain an average speed of 100 lines an hour even when composing from manuscript, which he has to read for himself; and this speed can be doubled, or nearly so, when the operator is assisted by a reader, and thus composes from dictation. The original form of the machine in use at this office was introduced here soon after the Franco-German war, and has ever since been undergoing such modifications in detail as experience has from time to time suggested, until it has now reached a state of very great efficiency. It has for some time been the custom to transmit the foreign intelligence from Paris, Vienna, and Berlin to this office by means of Hughes's printing telegraph, and to dictate the contents of the telegraphic slip to a compositor at the machine. By this combination remarkable facilities in dealing with late manuscript have been obtained, and it has been possible to carry on the work of type-setting almost to the time of going to press; but the copy received from the House was necessarily somewhat delayed while the reporter transcribed his notes and in transmission. The compositor was compelled to lag behind the actual progress of the debate, and precious time thus lost at each step of the process mounted up in the end to a considerable total.

"At this stage in the history of the matter the telephone was brought into actual operation as a means of verbal communication between distant points; and the conductors of this journal, having obtained permission from the Metropolitan Board of Works to lay down the necessary wires in the subway of the Embankment, formed a new connexion between the House of Commons and the office and placed one of Edison's loud-speaking telephones at either end. The immediate result of this arrangement has been to bring the compositor at the machine into direct communication with the Parliamentary reporter at the House, and to enable the debates to be reported and printed from half to three-quarters of an hour later than had previously been possible. The notes made by the reporter can be read directly into the telephone receiver in a room adjoining the gallery, either by the reporter himself when relieved or by another person employed for the purpose; and the compositor, at his machine in the office, sits with his ears in juxtaposition with the other terminal of the instrument. The plan which has been found the most efficacious for the purpose of shutting out distracting sounds of other kinds is to place the disc of the telephone above and behind the compositor, and then to arrange two tubes, each with two trumpet-shaped extremities, in such a manner that these extremities are applied at one end to the two sides of the telephone disc and at the other end to the two ears of the compositor. The compositor is also furnished with a speaking instrument, with a key for ringing a bell, and with a bell which is rung from the House; a simple code of bell signals, consisting of one, two, or three strokes, sufficing for the ordinary requirements of each message. The compositor announces by the bell that he is ready, receives a sentence, strikes the bell to indicate that he understands it,

Nature May 27 1880

THE EDISON TELEPHONE.—Edison telephones have been installed at the Pic du Midi Observatory, and afford easy communication with Bagnères, a distance of 15 miles. The first experiment failed, owing to the cloudy and stormy intervening stratum of air, but with improved instruments every sound pronounced in the ordinary conversational pitch is distinctly audible.

SLIP

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Druggists circular Aug 1880

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The reporter, stationed in a room adjoining the reporters in the house gallery, reads from his notes directly into the instrument, sentence by sentence, and the compositor, with his type-setting machine at the *Times* office, sets up the matter as it is read, signalling the reporter when he has set up one sentence and is ready for the next. A simple code of prearranged bell signals suffices for intelligent communication between sender and receiver. The plan is stated by the *Times* to work very well.

Electrician Aug 7/1880

THE TELEPHONE.—A motion was made on Thursday morning, July 29, before Vice-Chancellor Malins, to restrain the United Telephone Company from issuing advertisements stating that they were taking proceedings against Mr. Louis J. Crossley, of Halifax, for infringement of their patent for carbon transmitters, pending legal proceedings which Mr. Crossley invited the company to take against him for infringement of the patent. The company are assignees of the Edison patent, and the day after the registration of assignment commenced proceedings against various parties. Mr. Crossley contended that his carbon transmitter, the "compound microphone," was no infringement of the Edison patent assigned to the company. After a short discussion the defendant company undertook not to issue the advertisements complained of, without prejudice to any question of the propriety of the proceedings which had been taken. Mr. Aston, Q.C., Mr. Philbrick, Q.C., and Mr. Macrory, instructed by Messrs. Philbrick and Corpe, 18, Austin Friars, appeared for the plaintiff; and Mr. Glasse, Q.C., and Mr. Cozens Hardy, instructed by Messrs. Waterhouse and Winterbottom, of Lincoln's-inn, appeared for the defendants.

Electrician June 19 1880

NEW TELEPHONES.

The recent amalgamation of the two English telephone companies (the Bell and Edison) is a matter of congratulation. By uniting they will change expensive and annoying warfare into mutual advantage, and occupy the field against all comers. The Edison transmitter, which is hitherto the best of all, will then be used in connection with the Bell receiver, which is likewise peerless of its kind, and the combination of these two instruments will be a benefit to the public.

The progress of telephone research has to some extent fallen off lately, but during last year there were one or two serviceable telephones brought out. Mr. Geo. M. Hopkins recently described an interesting transmitter of his invention in the *Scientific American*. The transmitter is fixed to a bracket, and stands vertically with its sound-collecting mouthpiece pointed in the direction whence the sound proceeds. The receiver, which is an ordinary Bell instrument, stands when not in use over a curved pendent resonator, the smaller end of which projects through the shelf of the bracket, and just enters the hole in the centre of the receiver mouthpiece.

Between the transmitter and receiver there is a small induction coil whose primary wire is connected with the local battery and transmitter. One terminal of the secondary wire of the coil is connected with the receiving instrument and line, the other terminal is grounded. The instrument is an ingenious form of microphone transmitter, and consists, as usual, of a diaphragm and mouthpiece to receive the speaker's voice, a carbon button attached to the under side of this diaphagm, and, pressing up against this button, is a light rod of fine carbon floated in a bottle of mercury. The carbon button is of ordinary battery carbon, the rod of electric light carbon. The bottle is a phial with a rounded bottom like an antique tear-jar. The circuit through this microphonic contact is made by means of a platinum electrode fused into the bottom of the phial so as to reach the mercury, and a wire making contact by means of a light spring with a leaf of copper foil lying under the diaphragm, and fixed between the latter and the carbon button. The current, therefore, passes by one wire, the foil, and carbon button to the carbon rod and mercury, thence by the platinum wire to the line.

The carbon rod is ¼in. in diameter and furnished with a round point, which is pressed by the buoyancy of the mercury against the under surface of the button, which is filed as plane as it can be. Hence the vibrations of the diaphragm, besides pressing the microphone contact, also dip the rod into the mercury, which forms a very equable fluid spring. The height of the telephone is about six inches.

The diaphragm, which is of mica, is rather stiff and firmly clamped in its chamber, the frame being of wood, well soaked in paraffin, or, better, vulcanite, so as not to be liable to warp.

The induction coil used with the instrument is of the ordinary form, two inches long, one inch in diameter, with a ¼in. core of No. 18 soft iron wire. The primary coil consists of ... covered copper wire, and the secondary of No. 36 ... quantity to fill the spool. One cell of Leclanché ... battery will work the transmitter, but two will ... volume of sound.

As to the efficiency of the instrument, it will bear ... with other transmitters, and in one or two points ... have a slight advantage. It will transmit speech cl... the speaker be within ten miles or as many feet from the ... Although a call bell may be used in connection with ... none will be required, as by saying 0-0-0-0 loudly int... piece a trumpet-like note is heard at the other end ... the receiver there, which, though not very loud, is ... attract notice in a tolerably quiet room. It would ... imagine, for Mr. Hopkins to add an efficient call to ... ment, and he would thereby greatly improve its effi... weak call is a decided disadvantage.

Another promising transmitter is the micro-tele... mitter by Mr. Hunnings, which was patented in ... since then been brought by degrees to a very efficient ... earlier form consisted of a diaphragm of ferrot... platinum or silver, and a disc of brass placed near ... the intervening space being filled with carbon p... 1-16 inch deep.

The circuit was made through the diaphragm and ... brass disc, and the whole was secured in a small co... wooden case. The carbon powder was preferably ... engine coke, and it was an essential feature that it sh... loose free state. The only difference, indeed, be... transmitter and Edison's is the looseness of the car... made it an agglomeration of microphone contacts.

The present improved form is mainly due to Mr. C... of York. It was recently exhibited at a meeting of th... Institution of Engineers, Middlesborough, with every ...

Its outward appearance is similar to that of the or... telephone, which is now so familiar to nearly everyo... resemblance stops there. The usual telephone mo... covered on the under side of the opening by a piece ... plated brass wire gauze, which forms a protection t... sheet of platinum foil, which now acts the part of ... diaphragm, and is in immediate contact with a very th... granulated coke, which fills a small posterior cavity ... with a brass plate at the bottom. The platinum f... nected to one terminal through a brass ring, and the ... is connected to the other terminal. The terminal ... passed through a hole down the centre of the handle, ... being screwed on to the central part.

In connecting it up for use a receiving telephone (w... be Bell's or other similar instrument) is, of course, r... each end of the line in addition to the micro-teleph... mitter, and also a battery of Leclanché or other cells. ... of this transmitter is, by the aid of the battery curr... increase the sound given out by the receiving teleph... make these instruments a practical success, and also to ... by its power the effects of induction from neighbour... this latter having hitherto prevented the use of tele... wires in the neighbourhood of others along which stro... currents may be passing. The success of Hunning... telephone in this respect is undoubted, and its clear ar... and power are very striking. The loose granulated cok... the two metallic plates is the secret of this success. T... waves cause more or less of the under surface of the d... to come into contact with the grains of coke, at ... time causing these particles to press more clos... each other, thus decreasing the amount of th... ance they offer to the passage of the voltaic ... through them by bringing more points into contact w... other, this action taking place in a greater or less d... accord with the amplitude of the vibrations of the plati... acting under the influence of the sonorous waves. The cont... this movement of foil and coke grains exercises over th... current renders the use of an induction coil, which is fou... so great a necessity with other forms of telephone transm... Edison's, Crossley's, and Blake's, to wit—quite unne... and by the use of a special form of receiver, which is ... gaging the attention of Messrs. Hunnings and Cox-Wal... effects of induction are hoped to be entirely elimina... experiments hitherto made by them in this direction giv... mise of ultimate success.

An automatic switch board, with call bell and ring... completes the outfit for each end of a line for te... purposes.

The instruments were successfully tried not long ago ... York and Darlington, a distance of about forty-five mil... wire used for the purpose of this test trial being one o... twenty of the ordinary telegraph wires which stretch fr...

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ION GEAR.

Fig. 7.

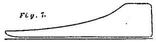

Fig. 8.

Engineering May 28 1880

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31

to pole along the side of the railway. The effects of induction were at times very powerful, but they did not prevent the easy and successful carrying on of conversation or the transmission of ordinary railway cypher messages between the two stations. The instruments exhibited at the meeting were connected on to the private wire of Messrs. Stevenson, Jacques, and Co., to their Acklam Works, where a set of similar instruments were placed. Conversation was then carried on for a considerable time with the Acklam office.

The microphone transmitter of Mr. L. J. Crossley is too well-known to require description here; but that gentleman has recently supplemented it by a new receiver which is an ingenious modification of Bell's. An electro-magnet of a square horse-shoe form has both poles presented to the underside of the diaphragm. One pole only is surrounded with a bobbin of insulated wire. The internal cavity is filled up with paraffin wax after the poles are adjusted by means of a screw to the proper distance from the diaphragm. This is to render the tone purer. The current is circulated through the bobbin, and the diaphragm is correspondingly attracted.

Another form is made having two of these electro-magnets side by side, acting on the diaphragm. The loudness of the sounds depends, of course, on the strength of the current; but six Leclanché elements give good results on a line nine miles long, when using the Crossley microphone for a transmitter.

At a recent meeting of the Royal Society a paper was read by Mr. Preece on some thermal effects of electric currents, in which he showed that extremely fine wires acquire and lose heat so rapidly, and are so sensitive to expansion from the heating, that, if inserted in the circuit of a microphone transmitter, they reproduce sonorous vibrations. Thus a mere sounding board or disc, and a fine wire, are all that are needed to reproduce speech with the same faithfulness that Bell obtains by electro-magnetic agency, Edison by electro-chemical agency, and Hughes by his microphonic principle.

A similar telephone has also been invented by M. Ader and Count du Moncel, and it will be remembered by our readers that at a recent meeting of the Society of Telegraph Engineers Professor W. E. Ayrton announced that he had just heard in Paris a remarkably simple telephone receiver, consisting merely of very fine copper wire bent into a curved form. If we remember rightly Count du Moncel had shown Professer Ayrton this receiver, and its principle would seem to be identical with that of Mr. Preece.

M. Ader has done some excellent work in telephony of late. The wire receiver is the natural outcome of his first telephone patented in this country last year. In this instrument a bar of iron was loosely encircled with a coil of wire, through which the vocal current flowed, and the molecular expansion and contractions of the bar gave out sound without a diaphragm. The next advance he has made is to dispense even with the bar, and make the thermal expansions and contractions of the wire itself give out sound under the action of the current.

Another form of telephone receiver was brought before the French Academy very recently by M. Ader. It is based on the principle that if a thin plate of iron or steel is placed before the poles of a magnet, it is much more strongly acted on by the poles when a second plate or armature of iron is placed behind it than when that second plate does not exist. This is easily proved by holding a spring in front of a horse-shoe magnet with its poles close together, so as to be attracted, but not sufficiently so to touch the poles. Then, on bringing up the armature behind, the spring will fly inwards to the poles.

The new telephone consists of a Bell receiver with a horse-shoe magnet and an iron diaphragm. Behind this diaphragm a second disc is fixed, having a hole perforated in its centre so as to permit the vibrating air to reach the inner disc. This telephone, through the exalting action of the rear disc, gives louder results than the ordinary Bell instrument.

HOW TO MEASURE THE SIZE OF WIRES.

By M. ROTHEN, Assistant Director of Swiss Telegraphs.

(Translated from the *Journal Télégraphique*.)

At first sight this question seems so simple that many readers might think that they could answer it at once. Yet it has already been productive of many discussions, propositions, and counter propositions within the last twenty years; and, quite recently, a committee formed of names distinguished in applied science was appointed to investigate it. The reason why the mode of indicating the size of wires is not so simple as it appears is that some wish to determine it by a line and others by a surface, in other words, some would take the *diameter* and others the *weight* as a basis of measurement. On the European continent the first method predominates; whilst in England, in the

Sc Am July 24 1880

Setting Type by Telephone.

The London *Times* contains an article describing the system of telephonic reporting adopted by that journal, in order to have the latest and fullest report of the speeches made in the Houses of Parliament. Permission having been obtained from the Metropolitan Board of Works to lay down the necessary wires in the subway of the Embankment, a new connection between the House of Commons and the *Times* office was formed, and one of Edison's loud-speaking telephones placed at either end. The immediate result of this arrangement has been to bring the compositor at the machine into direct communication with the Parliamentary reporter at the House, and to enable the debates to be reported and printed from half to three-quarters of an hour later than had previously been possible. The notes made by the reporter can be read directly into the telephone receiver in a room adjoining the gallery either by the reporter himself when relieved or by another person employed for the purpose; and the compositor, at his machine in the office, sits with his ears in juxtaposition with the other terminal of the instrument. The plan which has been found the most efficacious for the purpose of shutting out distracting sounds of other kinds is to place the disk of the telephone above and behind the compositor, and then to arrange two tubes, each with two trumpet-shaped extremities, in such a manner that these extremities are applied at one end to the two sides of the telephone disk and at the other end to the two ears of the compositor. The compositor is also furnished with a speaking instrument, with a key for ringing a bell, and with a bell which is rung from the House, a simple code of bell signals, consisting of one, two, or three strokes, sufficing for the ordinary requirements of each message. The compositor announces by the bell that he is ready, receives a sentence, strikes the bell to indicate that he understands it, sets up the type with his machine, strikes the bell again for the reader to continue his dictation, and so on until the work is carried as far as time will allow. If there is any doubt or difficulty about the words, a bell signal will cause them to be repeated, or explanations can be sought and received by direct vocal communication. In this power, indeed, resides one of the chief advantages of the method, and one which ought to lead to greater accuracy than has ever previously been attainable. The names of people, places, etc., can be spelled out letter by letter if there is any doubt about them.

Reporting by Telephone.

The method of reporting the debates in the House of Commons by telephone, lately adopted by the London *Times*, is thus described by that journal: A type-setting machine has for some time been used in the office, by which a fair workman can attain an average speed of 100 lines an hour, even when composing from manuscript which he has to read for himself; and this speed can be doubled, or nearly so, when the operator is assisted by a reader, and thus composes from dictation. Now the telephone has been brought into use in connection with this machine in the following mode. Having obtained the permission to lay down the necessary wires we formed a new connection between the House of Commons and the office, and placed one of Edison's loud speaking telephones at either end. The immediate result of this arrangement has been to bring the compositor at the machine into direct communication with the parliamentary reporter at the House and to enable the debates to be reported and printed from half to three-quarters of an hour later than had previously been possible. The notes made by the reporter can be read directly into the telephone-receiver in a room adjoining the gallery either by the reporter himself when relieved or by another person employed for the purpose, and the compositor at the machine, in the office, sits with his ears in juxtaposition with the other terminal of the instrument.

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Tel. Jour.

ON CURRENTS PRODUCED BY FRICTION BETWEEN CONDUCTING SUBSTANCES, AND ON A NEW FORM OF TELEPHONE RECEIVER.*

In a communicatio to the Royal Society of Edinburgh, of date January 6th, 1879, I showed that "electric currents were produced by the mere friction between conducting substances." The existence of these currents can be easily demonstrated either by a telephone or a Thomson's galvanometer. I have since found that these currents are, for all pairs of metals which I have yet tried in the same direction as the thermo-electric current, got by heating the junction of the same two metals. They are also, approximately at least, stronger in proportion as the metals rubbed are far apart on the thermo-electric scale—the strongest current, as far as I have yet observed, being got by rubbing antimony and bismuth together. These observations clearly point to a thermo-electric origin for the currents; but it is possible that they may be due partly to the currents suggested by Sir William Thomson as the cause of friction, and partly, also, to contact force between films of air or oxide adhering to the surfaces of the metals.

Having ascertained that these friction-currents are of some strength and fairly constant, I proceeded to make several kinds of machine for producing currents on this principle. One of them consists of a cylinder of antimony, which can be rotated rapidly, while a plate of bismuth is pressed hard against it by a stiff spring. When this machine is included in the same circuit with a microphone and a Bell telephone, the current got from it is quite sufficient to serve for the transmission of musical sounds and also loud speaking. The transmitter which I have found most serviceable in my experiments is made by screwing two small cubes of gas-carbon to a violin, and placing between them a long stick of carbon pointed at both ends, the points being made to rest in conical holes in the carbon cubes. The looseness of the contact is regulated by a paper spring. This forms an excellent and handy transmitter for all kinds of musical sounds, and also serves very well for transmitting speech.

Seeing that friction between metals clearly produces a current, it seems natural to inquire if the converse held good, that is, if a current from a battery sent across the junction of two metals affected the friction of the one upon the other. I have tested for this in a variety of ways, and the results obtained leave me in doubt whether to attribute them to variations in the friction or to actual sticking produced by fusion of the points of contact through which the current passes. The most noticeable effect is produced when one of the rubbing bodies is a mere point and the other a smooth surface of metal. This led me to make a modification of the loud-speaking telephone of Mr. Edison, in order to get audible indications of changes of friction produced by the passing of a variable current. It consists of a cylinder of bismuth accurately turned and revolving on centres. The rubbing-point is made of a sewing-needle with its point bent at right angles, and its other end attached to the centre of the mica disc of a phonograph mouthpiece. It is evident that this is only a loose contact, which can be perpetually changed. When this apparatus is included in the circuit with the violin-microphone and three or four Bunsen cells, the violin sounds, as was to be expected, are heard proceeding from the loose-contact, even when the cylinder is not rotated. They are increased, however, in a remarkable degree by rotating the cylinder slowly, so much so that a tune played on the violin can, with proper care, be distinctly heard all over an ordinary room.

With regard to the explanation of this effect, it is evident that electrolysis can in no sense come into play, as is supposed to be the case in Edison's instrument. I am inclined to look for the explanation rather in the direction of the Trevelyan rocker, although the circumstances are considerably different in the two cases. In the rocker we have the heat passing from a mass of hot metal through two points of support to a cold block, whereas, in the other case, the heat is only intense at the points of contact, the rest of the metals being comparatively unaffected. The variations in the current produced by the transmitting microphone must cause corresponding variations in the heat at the point of contact of the needle with the cylinder, and this again produces a mechanical movement of the pressing point, as well as of the air surrounding it, sufficient to give forth sound-waves. If such be the case the effect should be different for different metals, those answering best which have the lowest thermal conductivity and also the lowest specific heat. That this is really so is shown by substituting cylinders of other metals for the bismuth, all other things remaining the same. In this way I have compared lead, tin, iron, copper, carbon, and find that they all give forth the simple loose contact-sound when the cylinder is stationary, but that it is only with bismuth that there is any very great intensification of the sound when the cylinder is rotated. Now, by consulting the appropriate tables, I find that bismuth is a fraction lower than any other common metal in specific heat, while it is much below them all in thermal conductivity. This seems to bear out my explanation to a certain extent.

* Abstract of a paper read before the Royal Society of Edinburgh, by James Blyth, M.A., F.R.S.E., on May 3rd, 1880.

34

Money by Telephone.

"Say, miss," said a rather hard-looking customer to the young lady in charge of the central telephone office, one day last week, "say, miss, I'd like to talk with Mr. Joseph Snooks a moment."

The lady called Snooks and turned the instrument over to the guest.

"Hello, hello! Mr. Snooks!"

Snooks answered, and in the ensuing colloquy the lady could of course only hear the hard-looking customer.

"Snooks, old boy, I can't come up for that money to-day; I'm too busy."

"Eh?"

"No, can't get away."

"I know, but I'm sorry; I've got to meet Bruce about your affair."

"But I'd jeopardize all our interests. I positively can't come. Can you send the money down?"

"Down here."

"I don't believe she'll do it, will she?"

"No, I don't know her. She's a handsome girl with blue eyes and light hair. Know her?"

"I'll ask her about it. Wait, keep your ear there [miss, Mr. Snooks wants to pay me four dollars, and says for you to let me have the money. I'll ask again to make sure.] Snooks, did you mean for this fine young lady to pay me and charge it to you?"

"Don't hear you."

"Yes, yes, all right. [He says, miss, for you to take my receipts and let me have the cash. You are to put it in his telephone bill.] All right, Snooks, good-by, see you to-morrow," and he hung the mouthpiece on the hook.

"Fine fellow, Snooks," he continued, looking pleasantly at the manageress. "I never heard of sending money by telephone before, did you?"

"No," responded the lady.

"Perhaps you haven't the change handy?"

"Yes," said she.

"You'll trust Snooks, I persume," he went on in a faltering manner.

"Certainly," she replied, "if he says to let you have it."

"You don't think the telephone would lie, do you?"

"Assuredly not. I'll just ask Mr. Snooks."

"No, no. He's a sensitive man; he wouldn't like to have so much fuss over a small amount. Make it two dollars and I will give him a receipt on account."

"I'll pay anything Mr. Snooks says. I'll call him."

"Rather than bother him again, I'll make it a dollar. Give me a dollar—"

"But I perfer to call him."

"Miss," said the man, "don't go near the wire now. There's a cloud comming up. You're going to be struck by lightning. Rather than that, I'd take fifty cents, a quarter."

"Oh! I'm not afraid," and she approached the instrument.

"Keep away from that wire!" he howled, "don't call Snooks. He might be struck. If you don't care for yourself, have some mercy on his family. You needn't pay the amount at all. I wouldn't risk Snooks for all the money in Brooklyn."

"I shall either call Snooks or a policeman," said the girl firmly.

"Make it a policeman and I'll go for him myself," shouted the tramp, as he jumped over the rail.

And then she called Snooks, who had been swearing at his end of the wire in the hope of making some one hear him, and told him it was all right, she hadn't quite paid the money.

Mountain Voice

WHEATSTONE'S MICROPHONE AND RADIOPHONIC RESEARCHES.*

By Alex. Graham Bell.

In August, 1880, I directed attention to the fact that thin discs or diaphragms of various materials become sonorous when exposed to the action of an intermittent beam of sunlight, and I stated my belief that the sounds were due to molecular disturbances produced in the substance composing the diaphragm. Shortly afterwards Lord Rayleigh undertook a mathematical investigation of the subject, and came to the conclusion that the audible effects were caused by the bending of the plates under unequal heating. This explanation has recently been called in question by Mr. Preece, (p. 57, ante) who has expressed the opinion that although vibrations may be produced in the discs by the action of the intermittent beam, such vibrations are not the cause of the sonorous effects observed. According to him the aerial disturbances that produce the sound arise spontaneously in the air itself by sudden expansion due to heat communicated from the diaphragm, every increase of heat giving rise to a fresh pulse of air. Mr. Preece was led to discard the theoretical explanation of Lord Rayleigh on account of the failure of experiments undertaken to test the theory. He was thus forced, by the supposed insufficiency of the explanation, to seek in some other direction the cause of the phenomenon observed, and as a consequence he adopted the ingenious hypothesis alluded to above. But the experiments which had proved unsuccessful in the hands of Mr. Preece were perfectly successful when repeated in America under better conditions of experiment, and the supposed necessity for another hypothesis at once vanished. I have shown in a recent paper read before the National Academy of Science, that audible sounds result from the expansion and contraction of the material exposed to the beam; and that a real to-and-fro vibration of the diaphragm occurs capable of producing sonorous effects. It has occurred to me that Mr. Preece's failure to detect with a delicate microphone the sonorous vibrations that were so easily observed in our experiments might be explained upon the supposition that he had employed the ordinary form of Hughes microphone shown in Fig. 1, and that the vibrating area was confined to the central portion of the disc. Under such circumstances it might easily happen that both the supports A B of the microphone might touch portions of the diaphragm which were practically at rest. It would of course be interesting to ascertain whether any such localisation of the vibration as that supposed really occurred, and I have great pleasure in showing to you to-night the apparatus by means of which this point has been investigated (see Fig. 2).

* A paper read before the Philosophical Society of Washington, June 11th.

FIG. 1.

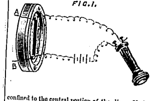


FIG. 3.

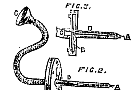


FIG. 2.

Eng. Mech. & World Science. July 8. 1881.

The instrument is a modification of the form of microphone devised in 1827 by the late Sir Charles Wheatsone, and it consists essentially of a stiff wire A, one end of which is rigidly attached to the centre of a metallic diaphragm B. In Wheatstone's original arrangement the diaphragm was placed directly against the ear and the free extremity of the wire was rested against some sounding body like a watch. In the present arrangement the diaphragm is clamped at the circumference like a telephone diaphragm, and the sounds are conveyed to the ear through a rubber hearing-tube C. The wire passes through the perforated handle D, and is exposed only at the extremity. When the point A was rested against the centre of a diaphragm upon which was focussed an intermittent beam of sunlight, a clear musical tone was perceived by applying the ear to the hearing-tube C. The surface of the diaphragm was then explored with the point of the microphone and sounds were obtained in all parts of the illuminated area, and in the corresponding area on the other side of the diaphragm. Outside of this area on both sides of the diaphragm, the sounds became weaker and weaker, until at a certain distance from the centre they could no longer be perceived.

At the points where one would naturally place the supports of a Hughes microphone (see Fig. 1) no sound was observed. We were also unable to detect any audible effects when the point of the microphone was rested against the support to which the diaphragm was attached. The negative results obtained in Europe by Mr. Preece may, therefore, be reconciled with the positive results obtained in America by Mr. Sumner Tainter and myself. A still more curious demonstration of localisation of vibration occurred in the case of a large metallic mass. An intermittent beam of sunlight was focussed upon a brass weight (1 kilogramme), and the surface of the weight was then explored with the microphone shown in Fig. 2. A feeble but distinct sound was heard upon touching the surface within the illuminated area, and for a short distance outside, but not in other parts. In this experiment, as in the case of the thin diaphragm, absolute contact between the point of the microphone and the surface explored was necessary in order to obtain audible effects. Now I do not mean to deny that sound-waves may be originated in the manner suggested by Mr. Preece, but I think that our experiments have demonstrated that the kind of action described by Lord Rayleigh actually occurs and that it is sufficient to account for the audible effects observed.

Nature July 28. 1881.

35

UPON A MODIFICATION OF WHEATSTONE'S MICROPHONE AND ITS APPLICABILITY TO RADIOPHONIC RESEARCHES[2]

In August, 1880, I directed attention to the fact that thin disks or diaphragms of various materials become sonorous when exposed to the action of an intermittent beam of sunlight, [1] and I stated my belief that the sounds were due to molecular disturbances produced in the substance composing the diaphragm (Amer. Assoc. for Advancement of Science, August 27, 1880). Shortly afterwards Lord Rayleigh undertook a mathematical investigation of the subject, and came to the conclusion that the audible effects were caused by the bending of the plates under unequal heating (Nature, vol. xxiii. p. 274). This explanation has recently been called in question by Mr. Preece (Royal Society, March 10, 1881), who has expressed the opinion that although vibrations may be produced in the disks by the action of the intermittent beam, such vibrations are not the cause of the sonorous effects observed. According to him the aërial disturbances that produce the sound arise spontaneously in the air itself by sudden expansion due to heat communicated from the diaphragm, every increase of heat giving rise to a fresh pulse of air. Mr. Preece was led to discard the theoretical explanation of Lord Rayleigh on account of the failure of experiments undertaken to test the theory.

He was thus forced—by the supposed insufficiency of the explanation—to seek in some other direction the cause of the phenomenon observed, and as a consequence he adopted the ingenious hypothesis alluded to above. But the experiments which had proved unsuccessful in the hands of Mr. Preece were perfectly successful when repeated in America under better conditions of experiment, and the supposed necessity for another hypothesis at once vanished. I have shown in a recent paper read before the National Academy of Science, April 21, 1881, that audible sounds result from the expansion and contraction of the material exposed to the beam, and that a real to-and-fro vibration of the diaphragm occurs capable of producing sonorous effects. It has occurred to me that Mr. Preece's failure to detect with a delicate microphone the sonorous vibrations that were so easily observed in our experiments might be explained upon the supposition that he had employed the ordinary form of Hughes' microphone shown in Fig. 1, and that the vibrating area was confined to the central portion of the disk. Under such circumstances it might easily happen that both the supports (A B) of the microphone might touch portions of the diaphragm which were practically at rest. It would of course be interesting to ascertain whether any such localisation of the vibration as that supposed really occurred, and I have great pleasure in showing to you to-night the apparatus by means of which this point has been investigated (see Fig. 2).

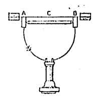
The instrument is a modification of the form of microphone devised in 1827 by the late Sir Charles Wheatstone, and it consists essentially of a stiff wire (A), one end of which is rigidly attached to the centre of a metallic diaphragm (B). In Wheatstone's original arrangement the diaphragm was placed directly against the ear, and the free extremity of the wire was rested against some sounding body, like a watch. In the present arrangement the diaphragm is clamped at the circumference like a telephone-diaphragm, and the sounds are conveyed to the ear through a rubber hearing-tube (C). The wire passes through the perforated handle (D), and is exposed only at the extremity. When the point (A) was rested against the centre of a diaphragm upon which was focussed an intermittent beam of sunlight, a clear musical tone was perceived by applying the ear to the hearing-tube (C). The surface of the diaphragm was then explored with the point of the microphone, and sounds were obtained in all parts of the illuminated area and in the corresponding area on the other side of the diaphragm. Outside of this area, on both sides of the diaphragm, the sounds became weaker and weaker, until at a certain distance from the centre they could no longer be perceived.

At the points where one would naturally place the supports of a Hughes microphone (see Fig. 1) no sound was observed. We were also unable to detect any audible effects when the point of the microphone was rested against the support to which the diaphragm was attached. The negative results obtained in Europe by Mr. Preece may therefore be reconciled with the positive

[1] Paper clx. in the *Transactions* of the Society, 1878. Vol. vii., pages 168.

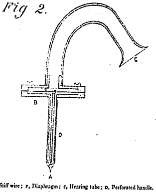
[2] A paper read before the Philosophical Society of Washington, D.C., 1881, by Prof. Alex. Graham Bell.

Fig 1.



A B, Carbon supports; C, Diaphragm.

Fig 2.



A, Stiff wire; B, Diaphragm; C, Hearing tube; D, Perforated handle.

results obtained in America by Mr. Painter and myself. A still more curious demonstration of localisation of vibration occurred in the case of a large metallic mass. An intermittent beam of sunlight was focussed upon a brass weight (1 kilogram.) and the surface of the weight was then explored with the microphone shown in Fig. 2. A feeble but distinct sound was heard upon touching the surface within the illuminated area and for a short distance outside, but not in other parts.

In this experiment, as in the case of the thin diaphragm, absolute contact between the point of the microphone and the surface explored was necessary in order to obtain audible effects. Now I do not mean to deny that sound-waves may be originated in the manner suggested by Mr. Preece, but I think that our experiments have demonstrated that the kind of action described by Lord Rayleigh actually occurs, and that it is sufficient to account for the audible effects observed.

Menlo Park Scrapbook, Cat. 1053

No. 37. "Lightning Protectors and Atmospheric Electricity"

This scrapbook covers the years 1873-1881 and contains clippings about lightning protectors and atmospheric electricity. There are 146 numbered pages.

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1053

Lightning Protection
and
Atmospheric Electricity
Lightning Canopy fy

37

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Notes.

A CURIOUS phenomenon has been observed on a property at Vernon, in France. Some five or six years ago, a garden planted with cherry-trees and gooseberry bushes was struck with lightning, a deep hole, about 10 centimetres in diameter, being made in the ground. Subsequently, everything died about the hole, the death circle becoming larger every year. It is now stated to be 7 metres in diameter, and has just reached a cherry-tree planted twelve years' ago, whilst some replanted gooseberry-bushes died in two years. The part the lightning has played in producing the phenomenon has not as yet been explained.

Tel Journal. Mar 1575

New Lightning Protector for Telegraph Lines (Lemasson System).—Among the different lightning protectors invented to protect telegraph lines, one of those most used is formed of two plates furnished with points and insulated from each other, one plate being traversed by the line current, and the other placed in communication with the earth. So long as atmospheric electricity is moderate the current goes through the first plate only, but when excessive it runs to earth through the points and the second plate. M. Lemasson proposes to render such a lightning protector of greater efficiency. He places a tube inside a conducting mass, provided with 100 transverse striates, and in immediate contact with earth. A cylinder communicating with the line occupies the centre of the tube, but does not touch it, and is provided with 40 longitudinal striates. By reason of the different direction of the striates, 4000 crossings are obtained,—uniformly distant ¼ a millimetre from each other,—and these crossings may be regarded as so many points. Hence, although measuring only 1 decimetre in length by 4 centimetres wide and broad, M. Lemasson's arrangement, though much smaller, is more efficient than that in ordinary use. An important addition to the apparatus is the insertion of a pipe (furnished with a stop-cock) to the air-space between the "tube" and the "conducting mass," so as to rarefy the air, and thereby diminish the resistance offered to the discharge of excessive atmospheric electricity.

BEECH TREES AND LIGHTNING.—It is a popular belief that lightning will not strike a beech tree. During a thunder-shower at Goshen, Mass., a beech and maple standing close together, received the electric bolt, which shattered the maple and passed into the earth through a prostrate hemlock tree lying near, which was stripped of its bark nearly the whole length. No trace of the lightning was left upon the beech.

The simple reason of this is that beachwood is not as good a conductor of electricity as other kinds of wood, for instance maple, and the lightning or electricity will of course always select the best conducting path to the earth. Feb 05. 1876

CENTRAL TELEGRAPH STATIONS.

THE great commercial capitals of the world, London and New York, have, within a very short period, been provided with Central Telegraph Offices which for extent and completeness are unequalled elsewhere. The Central Telegraph Station in St. Martin's-le-Grand, and the new offices of the Western Union Telegraph Company in Broadway, New York, may be regarded as evidences of an amount of progress such as has attended few institutions in our time. Less than thirty years ago the "system" of the late Electric Telegraph Company—or, to speak more correctly, the telegraphic system of the United Kingdom—consisted of a line to Nine Elms, and a small office at 334, Strand. Similarly, in 1846, a single wire was erected to an obscure office beneath the express offices at No. 16, Wall Street, New York, and two wires from Washington terminated in a small room over the Ferry-house in Jersey city, where three clerks easily—and not very continuously—performed the whole telegraphic business of the city of New York. We need not trace the progress of the Electric Telegraph Company eastwards until it acquired extensive offices,—first, in Founders' Court, Lothbury, and subsequently in Telegraph Street, Moorgate Street. Nor need we do more than simply mention the British and Irish Magnetic Telegraph Company, with its offices in Threadneedle Street, and the United Kingdom Telegraph Company, located in Gresham House. All three were eventually housed in the premises built by the Electric Company in Telegraph Street, and thence the next move was to the new Post-Office in St. Martin's-le-Grand. This event occurred on the 17th of January, 1874; and little more than a year afterwards—viz., on the 1st of February last—the Great American Telegraph Company moved to its new premises in Broadway, New York.

The American structure has been erected at a cost of more than two million dollars, and a considerable portion of this amount has been subscribed in England—chiefly in London, we believe. It is built of brick and granite, in what, with some latitude, may be designated as the French Renaissance style, the main idea in its construction being to reduce in appearance—by the proportions and the arrangement of the details—the great height of the building, as compared with its width or front. The building is said to be fire-proof throughout, wood having only been used for the doors, window-sashes, and the wainscoting. Most people are familiar with the appearance of our new Post-Office buildings in St. Martin's-le-Grand. Many regard them as being [illegible] of the Meteorological Society, has done good service in reading an exhaustive and able paper on the subject before the Society of Arts, and an admirable notice was given of it in the *Times*. Dr. Mann has supplemented this notice with an excellent letter to the leading journal on the precautions to be taken, especially with the tall zinc tubes now so largely used for chimney-tops. Mr. Preece had previously called attention, in the *Times*, to the danger of chimneys, lined as they are with soot, filled with ascending currents of heated air and smoke, and terminated

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THE TELEGRAPHIC JOURNAL.
VOL. III.—No. 55.

LIGHTNING.

THERE are indications that we may anticipate severe electrical disturbances during the coming summer. The winter has been unusually long and severe. Abnormal weather has occurred over most parts of the globe. Reports of severe thunder-storms reach us from the Cape and the antipodes. Exceptional conditions of this kind abroad usually presage similar conditions in England. "Coming events cast their shadows before." But whether the coming summer be above or below the average in lightning accidents, we are none the less bound to call attention to the fearful apathy and gross carelessness evinced in protecting buildings from atmospheric electrical discharges.

During two severe storms in England, in June, 1872, there were ten deaths and fifteen cases of injury to human beings; sixty houses struck, and fifteen burnt down; and twenty-three horses or cattle, and ninety-nine sheep, killed. Those accidents that are not recorded are innumerable. In large towns damage to property is more frequent than destruction of human life, but in the open country destruction of life is perhaps more frequent than destruction of property, unless we except trees, which are ruined in thousands every year, and unfortunately—from their size and growth—the finest suffer.

Lightning protection is therefore not only a necessity, but it is a source of satisfaction and comfort. It is difficult to comprehend the reasons why it is not more largely adopted. It is not its inutility—for the beneficial effect of lightning-conductors amongst our buildings and our shipping is incontestible. It is not its expense—for a house can be protected for a less sum of money than is required to bed out a parterre. It is not its difficulty—for any skilled workman or energetic landlord can do it with ease.

Dr. Mann, the President of the Meteorological Society, has done good service in reading an exhaustive and able paper on the subject before the Society of Arts, and an admirable notice was given of it in the *Times*. Dr. Mann has supplemented this notice with an excellent letter to the leading journal on the precautions to be taken, especially with the tall zinc tubes now so largely used for chimney-tops. Mr. Preece had previously called attention, in the *Times*, to the danger of chimneys, lined as they are with soot, filled with ascending currents of heated air and smoke, and terminated in grates, acting as lightning-conductors. If all such chimney-pots be connected with the water-pipes by galvanised iron ropes, and if all these pipes make good earth, a house is as safe from lightning as a collier in a mine.

All lightning-protectors should be constructed on proper scientific principles, and we have published in our columns many valuable papers on the subject. The great desiderata to be urged are—the employment of perfectly continuous metallic ropes or rods, the use of good earths, and the termination of the conductors in the air in points. A great fact to be remembered is, that joints, and earths, and points deteriorate, and lose their efficiency: they therefore require frequent examination and frequent renewal. Lightning-conductors require annual inspection and careful overhauling.

It is needless to point out to telegraphists the necessity of a good earth, for they all know that their circuits are unworkable without them; but it is lamentable to see the condition of the earths to the lightning-protectors of the steeples of some of our cathedrals and churches. The splendid new spire of Llandaff cathedral is positively in a dangerous condition from this cause. Nine out of every ten churches are in the same condition. Earth-wires are plunged into the interior of cisterns; they are leaded into stones; they are bedded in dry sand. One was carefully put into a glass bottle buried in the dry earth; another was coiled carefully into the interior of a wooden pail, in the basement floor of the house it was meant to protect. Every case of the inefficiency of lightning-protectors that has been examined has been proved to be due to the existence of such gross ignorance of the commonest principles of electrical science as is evidenced by the above cases.

The country is now overrun with telegraphs. Telegraphists are to be found everywhere. There is no difficulty in securing the advice and assistance of skilled men, and our churchwardens and church dignitaries would do well to call such experience to their aid. It is better to lock the stable door before the steed is stolen.

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Tel Jour Apl 1.78

INFLUENCE OF ELECTRICITY ON EVAPORATION.—M. Mascart has just communicated the results of his experiments on this subject to the French Academy of Sciences. Since atmospheric electricity has been known to exist, it has been supposed to owe its origin chiefly to the evaporation of water, and the experiments of Pouillet seemed to prove this supposition to be true. But more recent researches have cast doubts upon it. It was observed that in all the cases of violent ebullition in which electricity was developed by evaporation, there was always to be found small grains of solid matter projected upon the walls of the vessel; and these appear to have played an important part in the production of electricity, for, when care was taken entirely to exclude them, no electricity was produced. Again, the quantity of electricity furnished by gentle evaporation, was very feeble and inappreciable. M. Mascart's experiments had an opposite aim. They were intended to determine if electrification modified the evaporation of water. Accordingly, he arranged a set of small basins, containing water, or moist earth, under the conductors of a Holtz electrical machine, maintained at a high and constant potential. The basins themselves were connected to earth, as also were the other poles of the machine. The electrified conductors over the basin were in the form of a grating, which did not check evaporation, and were supported about 2 centimetres over the evaporating surface. The quantity of water evaporated by each basin was determined daily. M. Mascart found that electrification of the conductors accelerated the rate of evaporation whatever the sign of the electricity, and in some cases it doubled the rate. He also found, however, that slight variations of temperature completely masked the electric influence, and concordant results could only be obtained in a closed box regularly dried and kept in a cellar, where the temperature only varied form 4° to 6° during nearly a month. M. Mascart did not clearly determine the rates of evaporation under positive and negative charges; but he continues his experiments. However this curious effect of electricity be brought about, it seems to be appreciable only under very high charges. In connection with it, we may refer to the experiments of Mr. Cassamajor on the motions of camphor in electrified water, see TELEGRAPHIC JOURNAL, Dec. 15, 1877.

Tel Journal June 1.77

PROFESSOR LOOMIS, of Washington, who has closely studied electrical phenomena, claims to have communicated with an assistant twelve miles away, by means of an aërial current. The current was reached by flying kites a certain height at each point, the string used being a copper wire. When both kites had attained high altitudes, messages were sent and received at the distance mentioned by an instrument at the ground end of the wire, the only electro-motor being the atmospheric current between the kites.

DIMENSIONS OF LIGHTNING RODS.—The following results are published by Dr. Nippoldt of the Observatory of Paris. The existing errors with regard to the proper dimensions of lightning-rods are traceable to Kuhn's *Encyclopedia of Physics*, which gives the thickness for a conductor of iron 64 feet long as half an inch, and states that for other metals, such as copper or lead, the section ought to be proportional to the resistance of the metal.

The lightning conductor ought to fulfil two conditions:

1. To draw the current to earth.
2. To have sufficient sectional area to lead away the discharge without an injurious rise in temperature.

The elevation in temperature depends on the intensity of the current and the conductivity of the rod. Let W be the heat developed, J the intensity of the current, R the resistance of the rod; then

$$W = J^2 R. \quad (1)$$

Again, let l be the length of the conductor, g the cross-section to be found, s the density of the conductor, w its specific heat, r its specific resistance, M its mass, and t the temperature; then from the electrodynamic law it follows that

$$R = \frac{l}{g} r \quad (2)$$

and

$$W = J^2 . \frac{l}{g} r \quad (3)$$

and the mass M, which receives the total heat W, is raised to the temperature

$$t = \frac{W}{Mw} \quad (4)$$

and as $M = lgs$, by substituting this value in equation 4, we have

$$t = \frac{W}{lgsw.} = \frac{J^2 . r}{g^2 sw} \quad (5)$$

Temperature is independent of the length of the rod. The four metals employed as lightning conductors are

Metal.	Specific Heat.	Density.	Resistance.
Iron	0·1138	7·75	0·0986
Copper	0·0951	8·95	0·0162
Lead	0·0314	11·35	0·0199
Platinum	0·0324	21·54	0·0918

An iron conductor of 144 square millimetres ought therefore to be equalled by a copper conductor of 90 square mm., by a lead one of 320, and a platinum one of 156. M. Kuhn's gives the corresponding dimensions as 24 for copper, 230 for lead, 134 for platinum.

The resistance of copper (0·0162) given above is on the supposition that the metal is chemically pure. According to Dr. Mathiessen, the resistance is tripled if the metal contains ½ per cent. of iron. It is necessary to use copper containing not more than 2 per cent. of iron, and giving only one-fifth of the resistance of iron—that is, 0·0197 resistance instead of 0·0162.

The end of the rod should terminate in a platinum point two or three millimetres thick, having from three to seven square millimetres of section. A platinum point of this size will be heated from 2,000 to 500 times more than the rod itself, and if the passage of the current raises the temperature of the rod only 4° C. the platinum point will melt.

Tele Jnl Sept 15 78

ATMOSPHERIC ELECTRICITY AND PLANT LIFE.—According to M. Grandeau, atmospheric electricity is a powerful agent in the process of assimilation amongst vegetables. He says that plants defended from its influence have built up fifty or sixty per cent. less of living (azotic) matter than those exposed to ordinary conditions. The proportion of ash is higher, and that of water lower, in plants sheltered from the action of atmospheric electricity. The electric screen enclosing the plants experimented on was formed of four triangles of iron The plants were maize, tobacco and wheat; all other conditions were the same, but of the two specimens pitted against each other one was screened from atmospheric electricity and the other was not. The plants after being allowed to grow for several months, were then measured, weighed and analysed. All the experiments exemplify the above percentage in the most striking manner. The plants tested are tall, but low growing plants are equally influenced by atmospheric electricity. This fact may help to explain the absence of herbs under certain trees. It should also be mentioned that the total development of the plant is proportional to that of the azotic matter, as in growth, under normal conditions. M. Berthelot, in a subsequent note to the Academy on this subject, draws attention to the discovery made by him that free nitrogen united itself to organic matter under the action of electric currents not only from ordinary induction coils, but from feeble voltaic batteries; for example, five Leclanché cells: the proportion of nitrogen thus fixed in seven months on paper and dextrine being 1·92 thousandths, which will represent about 1·2 hundredths of matter analogous to the nitrogenised compounds of vegetables. It would thus appear that the slow, continuous action of feeble atmospheric currents on vegetation has a far more important bearing on agriculture than the formation of nitrous and nitric acid with their ammoniacal salts by the violence of the lightning flash.

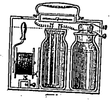
M. GRANDEAU, in a subsequent note to the French Academy, has supplemented the results given in the last note. By aid of a Thomson quadrant electrometer and water-dropping collector, he has measured the electrification under and in the neighbourhood of those large sheltering trees and bushes which appear to impoverish the soil beneath them. He finds that the potential beneath these trees is *nil*, while there is a sensible positive potential beyond the area which their foliage shelters These experiments of M. Grandeau show that it is not want of moisture, light, or heat alone, but want of electricity also, which renders the shade of dense trees so inimical to herbs and undergrowth.

Tel Jour Nov 1.76

A GALVANOMETER FOR TESTING LIGHTNING-CONDUCTORS.

THE preliminaries necessary to testing lightning-conductors are often troublesome, the apparatus required for it being rarely obtainable in handy and convenient form, though, indeed, little apparatus is required; merely a galvanic element, a galvanometer, and a sufficient quantity of insulated copper wire. The firm of Mittelstrass Gebrüder, in Magdeburg, have recently combined the essential parts in a galvanometer chest the arrangement of which (described in a recent number of *Dingler's Polytechnisches Journal*) is as follows:—In front the lid is fastened with two hooks. At the side are two binding screws

9



for attachment of copper wires. On the top is a sensitive galvanometer, the needle of which can be arrested with a screw. In the interior of the chest stand two glasses (see fig.), with equal width of neck, so that the glass-stopper in one may be readily transferred to the other, so as to close it. In the one glass is a suitable solution of bichromate of potash; in the other is the carbon and zinc element, from which spirals of wire proceed to the binding-screws as indicated. It is easy to lift the element out of the empty glass into the one filled with liquid, and so produce a current. In the third division of the chest is a roller with silk-covered copper-wire, which can be easily wound off, and, with the aid of a small handle, wound on again. Lastly, a binding screw serves for connecting the line to the wire-rope of the lightning-conductor.

Where desirable, the arrangement is so completed that only one turn of the conducting wire round the galvanometer needle is inserted, or all the turns; which can be done in a moment by turning a binding eye on the upper side of the chest. Lastly, on the under side of the lid may be introduced two resistance-coils of 1 to 10 Siemens' units, which, again, may be similarly inserted or excluded.

In testing a lightning-conductor the process is as follows:—1. The wire is unwound from the roller, drawn up to the roof, and the end of it wound about the point of the conductor. 2. The chest is opened, the element lifted over into the salt solution, the chest closed again, and so placed that the needle is still; then the binding-screw of the roller is connected with that of the chest with a piece of wire. 3. By means of the small binding-screw in the bottom of the chest a wire is connected with the lower part of the wire-rope of the lightning-conductor, and is brought to the second binding-screw of the chest. If there be perfect electric connection between the upper point of the conductor and the lower parts, the needle will be deflected. Should the deflection not occur, the place of interruption is sought for by connecting the lower binding-screw with the wire at successively higher points. 4. For investigation of the earth-conduction, the point of the lightning-conductor is excluded, by detaching the wire and connecting it with a neighbouring gas-chandelier, an iron spring, or an iron rod forced deep into the ground, and then the circuit is completed as before. The deflection of the needle will be greater, the more perfect the earth-conductor. Important advantage is here derived from the above-mentioned arrangements for insertion of the resistance coils, or only one or the whole of the galvanometer windings. After use, the element is lifted back out of the solution into the empty glass, and the galvanometer needle again arrested.

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Tel. Jour Oct. 1. 76

Note on M. Ducretet's Rheotome, with Constant Direction. By M. Cael.

M. Ducretet lately called attention to the resistance to passage of a current by aluminium forming the positive electrode of a voltameter; and thought the property might be utilised in telegraphy. M. Cael finds from experiment that the stoppage of the fluid by aluminium is not constant every moment, and the metal has not the *rôle* of a completely hermetic valve. Hence he does not see how the liquid rheotome can facilitate the problem of simultaneous transmission, or working of apparatus based on use of two currents. But it might replace with advantage the call by inversion of current used at all stations worked by derivation from the same wire. It would be more economical, and would isolate almost completely the station which had not to receive the call (so that weaker batteries might be used). By interposing the rheotome between the lightning conductor and the line, the consequences of derangement in bobbins of such apparatus would be considerably diminished.

Tel. Jnl. Mar. 1. 76

DESCRIPTION OF A LIGHTNING PROTECTOR ESPECIALLY ADAPTED FOR AERIAL LINES.

By J. E. Vaes.

A ring of metal (fig. 1) about $1\frac{1}{2}$ centimetres wide, and $2\frac{1}{2}$ centimetres in diameter, is cut in two. On one side the two halves are held together by means of a hinge, and on the other side they shut by means of a screw. This ring encircles a bobbin of hard wood, also cut in halves, and bored through its axis. The raised edges of this bobbin prevent the metal ring slipping off. In the interior of the ring is fixed a protecting point of alluminium, bronze, or platinum, which extends within a distance of one or two millimetres of the groove in the bobbin (figs. 2 and 3).

To apply the protector to a telegraph wire, the ring, and with it the two halves of the bobbin, (fig 3) are opened and placed on a wire of the same gauge as the groove in the wood. The ring and the bobbin are then closed with the screw, care being taken to pass under the head of the screw a copper wire covered with guttapercha, the other extremity of which is connected with a plate of metal attached to the bottom of the post, and making a good earth connection.

The lightning protector following all the vibrations of the wire, it is impossible that there can be a contact between the wire and the protecting point, and the point itself is excluded from atmospheric influences.

Remarks.

1. The diameter of the groove in the bobbin should be slightly smaller than that of the wire to which it is intended to be fixed.

2. To fill up the chinks that will always exist to a greater or less extent between the two halves of the bobbin, it is sufficient to introduce, before fixing to the wire, a thin layer of guttapercha or tarred cloth: these substances giving way to the pressure, fill up the chink entirely.

3. In case of rain, the lightning protector might give rise to derived circuits, owing to the short distance between the exterior of the metallic ring *a*, and the wire *b* (fig. 2). Several methods suggest themselves to remedy this defect. It would be insufficient to apply a coat of varnish to the metallic parts, it would therefore be better to lengthen the bobbin so as to increase its length on either side of the ring, or even to heighten the edges of the bobbin.

Another method consists in covering the wire with an insulating material for a distance of some centimetres on each side of the protector. That which appears the simplest, and at the same time the most effective plan, is to surround the lightning protector with a covering, thus removing it from the influences of rain. Owing to its small dimensions (the protector can easily be covered with the hand), the application of this last suggestion would not be difficult.

Fig. 1.

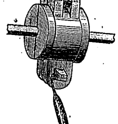


Fig. 2.

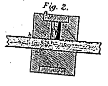
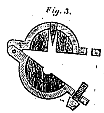
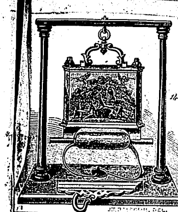


Fig. 3.





[20216.]—Ten-inch Plate Machine.—Base, 20 × 10 × 1½ thick; supports of broomstick well varnished. The axles of the plate are cemented on, and each has a small steel piece to run in brass bearings, which are screwed to the top rail. One of the axles has a wheel 1½ diameter turned on it, and the bottom rails carry a multiplying wheel about 5in. diameter. The rubbers are 2½ × 1½, stuffed with cotton-wool, and covered with chamois leather. They are carried by two pieces of mahogany, 3-16 thick, 6in. long, in which are drilled holes rather larger than the cross-piece which carries them. They are screwed to a piece of wood placed between them, which should be slightly smaller than the thickness of the two rubbers and the plate together. A wedge between this piece of wood and the cross-piece keeps all firm when working; a nut and bolt about halfway regulates the pressure. My conductor was made after the Winter model—wood ball, 5½in. diameter with 1½ brass ball projecting, fixed on a glass tube in a stand. This is separate from the machine, which is a disadvantage, but a cramp should be used to fix machine to the table. The collectors are made of three pieces of broomstick covered with tinfoil, and screwed together, one on each side of the plate. The ends should be rounded off, not covered with tinfoil, but some insulating cement, and connected to the ball by an iron rod. Brass tube is much the best to use for conductors on account of its strength and lightness. Solid metal bodies are no better conductors than hollow ones, as the electricity keeps entirely on the surface. In making an electrical machine I should advise "Economical" to keep as near to the Winter machine model as he can, as I consider it much superior to any other.—Owl.

[20219.]—Botanical Specimens.—Collect ...

World. Aug. 21, 1881.

Killed by Lightning.

[Philadelphia Press.]

Henry Davis, a colored laborer, was struck by lightning and instantly killed Monday afternoon while sitting in a chair in his brother-in-law's house, No. 1,710 Phillip street. The house is a three-storied brick building, and occupied by Henry Stevenson and his family. Davis, in company with his wife, had been paying a visit, and the group were all seated in a room on the first floor facing the street. Davis was in a chair tilted back against the wall between the door and the open window. About 5.30 o'clock rain began to fall, and the lightning was so severe that Stevenson got up to close the window. Just as he was about to return to his seat a vivid flash of lightning almost blinded him, and a loud report was heard simultaneously with the flash. The window frame was torn loose, and the plaster from the ceiling to within two feet of the floor was shattered and thrown down. A bluish, sulphurous smelling smoke filled the room, and when the frightened brother-in-law started to open the door he heard Davis exclaim: "Lord! what's that?" and noticed that his eyes were fixed on vacancy, and that a pipe which he had been smoking was lying on the floor. For a moment the whole party was so stunned by fright that not a word was uttered. The wife ran over to her husband and lifted one of his hands, but it fell limp and lifeless. He was dead.

11

ELECTRICAL LIFE TEST. Jan 77

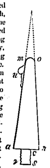
It is a well known fact that muscles contract under the influence of electricity, and it is long since experiments were first made in the stimulation of dead bodies by this means. Some curious phenomena have been obtained in this way. Recently, Dr. Kappeler, of the hospital of Münsterlingen, has added some new observations on the subject. He subjected twenty corpses to the action of various electric currents, and noted the rate of disappearance of the electric muscular contractility. In persons emaciated by long chronic maladies, this disappeared much more rapidly than in robust individuals, or those who had had acute maladies. It disappeared five quarters of an hour after death, at the quickest, and six and a half hours at the slowest. It is in cases where a rise of temperature is observed after death (which are not extremely rare), that the electric contractility persists longest. The importance of this sign of death is evident if we reflect that the contractions under electricity continue intact so long as there remains the least life. In the most prolonged faints, in the deepest lethargies, in all the varieties of apparent death, poisonings by carbonic oxide, chloroform, or narcotic substances, this valuable sign can be had at will, so long as real death is not a *fait accompli*. The fact of death, too, can be thus ...

[March 17, 1877.

EXPLOSIONS ON LIGHTNING ROD POINTS.

It is a well known fact that, if a metallic point communicating with the earth be presented to the conductor of an electric machine charged with positive electricity, the angle of the electroscope of the apparatus becomes small. The reason is that negative electricity escapes from the point as soon as developed, and serves to neutralize a quantity of the positive electricity of the conductor, no spark being produced. This phenomenon, as Professor Stroumbo, of the University of Athens, points out, is produced differently when the Holtz electric machine is used. If, while sparks are passing between the two balls of the apparatus, a third ball, having a metallic point attached to it, be taken in the hand and moved nearer one of the fixed balls, when the intervening distance becomes so small that the negative electricity of the point may escape the sparks at once cease. Yet, if the point be removed, they begin passing again between the two balls. This experiment can be repeated indefinitely. Now if the distance between movable and fixed balls above mentioned, at which no sparks pass, be gradually augmented, at a certain stage sparks will reappear between point and fixed ball. The conclusion from this is that, if the negative electricity of the point has great intensity, sufficient to enable it to escape from the point and pass over the interval, there will be no spark between point and fixed ball; but if the negative electricity of the point has not intensity sufficient to cause it to escape as soon as developed (the attraction then diminishing inversely as the square of the distance), there will be an explosion on the point itself, and electric sparks will occur constantly between the point and fixed ball, just as between the two balls of the machine.

During storms, the atmosphere is charged with enormous quantities of electricity, which, however, in their action should follow the same law as the smaller quantities produced in electric machines. If then a cloud, having positive electricity in determinate quantity, passes not too far away from the lightning rod point, analogous effects will take place. Then electricity developed by induction on the lightning rod will continue to escape at the point as soon as it gets there, and will go to neutralize the positive electricity of the cloud, neither thunder nor lightning being produced; but in case the same cloud were placed too far away, according to the experiments above detailed, an explosion might follow at the point of the rod, an intense heat would be developed, and the platinum point of the rod would be fused. This phenomenon occurred at the Royal Palace of Athens, where the platinum point was found melted, as shown in our illustration, which represents the rod in its full size.



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POINTED LIGHTNING RODS.

The important question as to the proper form of lightning rods occupied the minds of many savants some 75 years ago, and filled part of the scientific journals of that period. It has lately been renewed, and, as formerly, there are defenders and antagonists of the pointed rods. It is argued by the latter that the object of a lightning rod is not to attract the thunderclouds to the building to be protected, and induce discharges there; and it is claimed that long, upward-projecting lightning rods do this very thing, and that, although they are a protection in one sense, giving a ready path to the discharges, they become a source of danger by attracting the electrically charged clouds, and making discharges more frequent. Let us test this reasoning by the well known laws of electricity.

The amount of electric attraction depends on the extent of the attracting surfaces, and on their distance. If a series of clouds, say of a square mile in extent, floats over the earth's surface, these clouds being charged with positive electricity, they will induce, in that part of the earth's surface within the attractive influence, negative electricity. This charge will increase as the distance decreases, as the clouds follow the direction of the attraction; until at last, when the distance becomes small enough, an explosive discharge takes place, the stroke of lightning consisting in the simultaneous discharge of positive electricity from the cloud to the earth, and of negative electricity from the earth to the cloud. The manifestation of light and heat is the simple result of the neutralization of the two electricities, and will be greater in proportion as their quantity and intensity were greater.

Looking at the subject exclusively from this point of view, all that appears necessary is to provide a ready path to the electric discharge, such as a rod made of good conducting material, of sufficient capacity to be uninjured by the strongest current, and well connected with the ground, so as to establish at the moment of discharge a perfect communication between the cloud and the earth, which, previous to the stroke of lightning, were charged with opposite kinds of electricity. If we consider the function of elevated points on lighting rods, we find that Benjamin Franklin was correct when he recognized the gradual absorption or discharge of electricity as the main duty of lightning rods. Projecting points do not attract the thunderclouds; but elevated portions of the ground, as well as trees and houses, when in conducting communication with the earth, become charged by induction, and then exert attraction, whether there are pointed rods in the vicinity or not. The latter will, by their property of silent gradual discharge, serve to diminish the electric tension; and in place of being a source of attraction they will diminish this attraction, and take from the impending discharge a great deal of its violence.

We must, therefore, come to the conclusion that elevated points are desirable as upper terminals of lightning rods; and experience fully verifies this conclusion by practical results. One of the oldest instances took place in the tower of the cathedral of Siena, in Tuscany, which had been very frequently damaged by lightning. In 1776, a lightning rod was erected; but the people objected, and some of the priests called it an impious contrivance, invented by a heretic; but when it was found that the tower was rarely struck, and that once during a heavy thunderstorm the stroke followed the lightning rod without doing the least damage, the heretical contrivance came into proper esteem. The starlike terminations of some lightning rods are injurious. Faraday has proved that a single point discharges and absorbs electricity faster than a bifurcated or trifurcated terminal; if more points are added, still slower becomes the discharge, by their mutual interference; until at last, when the top is surrounded with an infinite number of points, a ball is the result, and the silent discharge ceases altogether.

But the upper pointed terminal is not the main part of the lightning rod; because it may be omitted altogether, although it is better to attach it. The main part is the ground connection; and as this is out of sight, it is often shamefully neglected. Much ignorance prevails in this respect also; hence it frequently happens that the electric current leaves the rod, to enter the house and pass off by the gas, water, or sewer pipes; and in its course it sometimes causes considerable damage. A connection with a water course, a well (not a cistern), or at least with the moist ground, is not imperatively necessary. If the soil is silicious and naturally dry, it is best to drive some pointed iron bars into the ground in such places as they are most likely to reach moisture, and connect all their upper ends with the conducting rod. The rule that requires a conducting surface equal to that of the roof to be protected, to be buried in the ground, given by some would-be authorities, has no foundation either in theory or practice. It is not the electric charge of a roof which has to be disposed of, but that of a cloud over it; and the latter has sometimes an extent of several square miles. All reported failures of lightning rods may be traced to defective connections, especially ground connections. Rods that are faulty from the outset are often made useless by subsequent neglect: as we found some years ago at the village of Gilboa, Schoharie county, N. Y. The church was situated on a hill, and quite exposed; the under end of the lightning rod, which in its upper end was connected with the spire, was pulled out of the ground, and lay on a pile of firewood in the rear of the church. If this church had been struck and burnt down, it might have been pointed out as an example of the utter uselessness of lightning rods.

A PARIS CHURCH DAMAGED BY LIGHTNING.—The little Gothic church of Kernaschen in the commune of Saint-Carade-Tregomel, built by Alain de Rohan in the fifteenth century, was lately nearly totally destroyed by lightning. The steeple was struck and fell through the roof, crushing in its fall fretwork and pinnacles, and doing much damage to the sculpture in the interior.

Tel Jour. Nov 1.77

13

TRANSMISSION OF OBSERVATIONS IN TIMES OF THUNDERSTORM.

THE establishment of a meteorological observatory on the summit of Puy-de-Dôme, and its telegraphic connection with the observatory of the plain, situated at Clermont Ferrand, have enabled M. Germain (says *Les Mondes*) to make, during very violent thunderstorms, tests as conclusive as interesting, as to the efficacy of the lightning-conductors used in telegraphy.

1. Those with multiple points would be at a maximum of efficacy, if, instead of consisting of two rectangular plates furnished with points arranged parallely, they were composed of two bands in spiral, so that the line and the earth might be opposite and in presence of each other over a large extent by means of the points.

2. Those based on the calorific properties of electricity are dangerous by reason of the frequent isolations resulting from fusion of the wire, or the bad communications which too delicate mechanisms form inopportunely with the earth. Thus, the telegraphic receivers are sometimes put out of use, the operators struck with lightning, and the line rendered useless at the moment most indispensable for the exchange of correspondence. The putting of the line to earth being the only state of inoffensive electric discharge, M. Germain first experimented with an instrument which realises this automatically at each lightning discharge, and restores the other state immediately after. These arrangements are simple and ingenious. Whereas, in the direct discharges, the protecting wire, breaking, allows a certain quantity of fluid to escape to earth; in the discharges by introduction, the movement is so rapid, that the wire has no time to redden and break.

Several leaves of gold were arranged on a metallic frame connected with the line, at a very small distance from each other, so that the fluid, reaching the extremity of the leaves, made them repel each other. This separation being made as small as possible, the line was connected to earth. The same powerlessness to prevent the passage of the fluid by introduction, through the telegraphic receiver, was demonstrated. Moreover, the heat of the leaves injured their elasticity.

M. Germain more successfully employed a system of coils, with three or four spirals of thick wire wound on a cubic centimetre of soft iron. A light armature connected with the line, and communicating now with the receiver, now with the earth directly, is attracted during the strong discharges. This system of coils, however, with differential action relatively to the ordinary coils of telegraphs, was found at fault. In a violent thunderstorm it happened that there was not enough electric quantity to produce the magnetisation, and that there was enough of potential to burn the fine wires of the telegraphs.

To suppress all these inconveniences, it was necessary to arrange that the line should be permanently in direct communication with the earth, and that the exchange of correspondence should take place all the same. This M. Germain realised. In the first coils he experimented with, each row of spirals of wire of the same size was connected, on one hand, with the line, and on the other, with the earth, so that the current branched into twenty spirals, where it passed in quantity, which was greater the smaller the spirals. The smallest spirals were found to be precisely the most influential by their proximity. The effects obtained by this system, on a short line, well insulated, showed a powerful magnetic force.

For longer lines, where derivations can be had, the coils employed are formed as follows:—Round a cylindrical sheet of very thin, soft iron, is wound screw-wise a small plate of copper, the larger sides of which are covered with an incombustible dielectric, while the smaller sides are bare. The bare part faces the surface of soft iron, but does not touch it. Several sheets of iron, and several rows of copper plates, are thus arranged concentrically. Their length varies according to the diameter. The entire coil is 12c. in length, and ·03c. in diameter. The magnetism is acquired by a polar plate, where the real poles of the armature meet the real poles of the electro-magnet.

From the experiments made it results that the magnetic force of each sheet is sensibly the same, and that all combine magnetically. The sums of the real spirals, whose number is very limited, form a number of spirals with action four times as great; this is one reason why the resistance may be considerably reduced without changing the effect produced.

M. Germain having found, on the other hand, that the resistance of conductors is inversely proportional to their surface, and not to their volume, has given the conductor of the coil the geometrical form which offers the greatest surface with the smallest volume. A thin sheet fulfils these conditions; it is easy to obtain, to cover, and to wind.

All the soft irons communicating with the earth, and all the bare spirals being opposed, at a very small distance, then, when electricity of high tension comes into the bobbin, not only does it find only two ohms of resistance, in place of 500 to 1,000 in other systems, but it can turn to the earth throughout all its course.

The dielectric is incombustible, that it may not be deteriorated by the small sparks which might pass in the interior.

With such a system, atmospheric electricity comes into telegraph stations with about the sixth, at the least, of potential; it finds a conductor seventy-five times less resistant, and consequently seventy-five times less susceptible of being heated. The magnetic effects produced are the same.

Such, in short, is the ingenious invention of M. Germain. And it has not remained at the stage of theoretic conception. For nearly six months employed in the correspondence between the observatory of Puy de Dôme and the town of Clermont Ferrand, it has acquired the sanction of a long practice. M. Germain has received numerous orders. At present, when observations at high altitudes are multiplying, it is important to be able to communicate permanently with the region of storms. In devising his coils and applying them to the Morse apparatus, M. Germain has rendered a great service to science, and overcome the chances of danger which threaten telegraphists in such circumstances.

14

Tel Jour Dec 1, 73

The Journal of the Franklin Institute. Vol. lxvi., No. 4.

Lightning and Lightning Rods.—A Letter from Mr. David Brooks.—My attention has been called to an article of Mr. Mott's on "Lightning and Lightning Rods," published in the August and September numbers of the journal, which contains many theories and notions at variance with those published by myself about a year since. Mr. Mott says: "Thus his Majesty's ship *Dictator* was struck and damaged by lightning at Martinique, in the year 1791, during fine weather and a clear sky." When effects are produced without cause miracles are wrought, and this is the latest recorded instance of a miracle. It is difficult to understand how any one who possesses any familiarity with the laws governing the propagation of the electric current, can believe that such an occurrence ever took place. "The return stroke often kills men and animals, or destroys buildings which are at the time at a great distance from the place where the direct discharge occurs." I have no hesitation in emphatically asserting that there is no such thing as a "return stroke" in an electrical discharge. There is a general inductive disturbance, or re-combination, whenever disruptive discharge takes place; but it is simultaneous with the discharge, and not an after result, and never "kills men and animals, or destroys buildings which are at the time a great distance from the place where the direct discharge occurs." In speaking of the effect and virtue of points over knobs or balls, my experiments show the very opposite of what he states to be true, and consequently I can neither appreciate nor subscribe to his remark or conclusion that, "Hence it (a point) may prevent a disruptive discharge which might otherwise occur." On the evening of the 4th of July, 1872, a thunder-storm passed over this city. Within the space of an hour over one hundred buildings were struck by lightning, or the effects of the lightning were noticed in over a hundred different places, leaving out many, probably a greater number, where the effect was unnoticed, or no damage produced. The discharges or flashes of lightning occurred as often as once per second during a portion of this hour. There were at least five thousand pointed rods in this city, and how much did they "produce an escaping current," or "prevent the accumulation of electricity," or neutralise the charged cloud?" Probably they did their level best, and prevented a discharge occurring oftener than once per second. The above example affords a practical illustration of the ability of points to silently discharge the accumulated electricity of the clouds, the earth, or the "return stroke," or the whole combined. Mr. Mott says "points are of vital importance before the instant of discharge arrives," and, he might add, of no account when they occur. "An improper termination of a lightning-rod is to connect it with the gas or water pipes of a city or village beneath the surface of the earth. Theoretically, it is the best possible termination; practically, one of the very worst," &c. Mr. Mott may connect a rod to earth in his way, and throw in any desired amount of charcoal. I will connect the same rod to a gas or water pipe, and then apply a current to the rod, and demonstrate that this current goes to the pipes in at least the proportion of a thousand to one. The author, further on, refers to Mr. Crosse's experiments, whereby he discharged fifty Leyden jars twenty times a minute, accompanied by reports "as loud as those of a cannon." This experiment was probably performed about the time the *Dictator* was struck, "during fine weather and a clear sky." I will only remark, in conclusion, that it would have been more satisfactory had the author adopted the phraseology of many parts of my paper without interpolations.

Tel Jour July 15, 76

A Victorian paper (B.C.) gives an account of some strange freaks of atmospheric electricity, during a recent thunderstorm. A lady residing next to a girl's schoolroom, heard a great crash in the building, and mentioned the fact to some friends. On entering it was found that the green baize doors near the entrance had been torn from their hinges, that the black boards lay on the floor, and that the lid of every desk, of which there were 144, was open and thrown back. Several of the lids had been torn from their hinges, others were partially so; but without exception every desk stood open, and some were half filled with water as if a bucketful had been dashed into them. The back door, like the green baize door, had been torn from its hinges and lay prostrate. The lightning evidently entered by the front windows, which were opened, and passed out of the back windows, which were also opened. Its course after leaving the building could not be traced. Had the accident happened two hours earlier, a dreadful tragedy might have occurred.

Elec News July 1, 75

Report of the "Commission on Lightning Conductors" Relative to a New Arrangement for Powder Magazines.—The new arrangement refers to the proposition of constructing air-shafts so as to place powder rooms in communication with the exterior air. The question asked by the War Administration of France was whether these air-shafts were sources of danger, irrespective of the lightning conductors erected around the magazines according to established usage. The answer given by the gentlemen forming this commission is:—"If the War Administrator adopts for his new powder magazines ventilation chimneys, and arranges the system of conductors so that the superior extremity of the chimnies remain always largely included in the generally admitted zone of protection, the commission is of opinion *the existence of these chimnies will not become in times of storms a special cause of danger*. However, in certain circumstances when, by reason of the impossibility of reaching an underlying inexhaustible sheet of water, or of the necessity of seeking for water at a large distance by conductors too much exposed to risk of malicious accidents, it is found advisable to give up supplying a magazine with lightning conductors, then air-shafts will be an element of considerable danger—especially when, on account of atmospheric causes, their interior sides becoming damp. Under such circumstances they should never be built."

Elec News Nov 15, 78

THE AURORA BOREALIS.—Prof. Edlund, of the Swedish Royal Academy, in a series of papers now being published in the *Phil Mag*, deduces the theorem that all other circumstances being equal, the resistance to the flow of the electric fluid from the atmosphere to the surface of the earth is greater at the equator and in the equatorial regions than at a certain distance from that circle, and that the resistance diminishes as the dip of the magnetic needle to the earth increases. And in this he discovers the cause not only of the strong disruptive discharges of violent tropic thunderstorms, but the rarer and gentler discharges of higher latitudes, culminating in the aurora borealis, in which the discharges are transformed into slow and continuous currents.

Tel Jour Jan 15 77

Proceedings of Societies.

THE SOCIETY OF TELEGRAPH ENGINEERS.

THE Annual General Meeting of this Society was held at the Institution of Civil Engineers, 25, Great George-street, on the evening of Wednesday, the 13th ult. Mr. C. V. Walker, F.R.S., President, in the chair.

The adjourned discussion on Mr. Andrew Jamieson's paper "On a New Form of Lightning-Protector for Lines and Apparatus," was re-opened by the President, who remarked upon his form of Bobbin Lightning-Protector mentioned at the last meeting, and after having explained its construction, exhibited some which had been fused and otherwise damaged by lightning. The Acting-Secretary then read a communication from Mr. John Aylmer, the Honorary Secretary of the Society for France. Accompanying Mr. Aylmer's letter were two forms of Lightning-Protector employed by the French State Telegraphs, which he now presented to the Society. The first of these protectors was enclosed in a strong and water-tight cast-iron box, two sides of which were strongly glazed, to allow the interior to be readily inspected. In the interior of this box were two brass plates, each carrying 300 fine silvered points, which were opposed to each other, and separated by a uniform distance of about one millimetre. The lower plate was in electrical connection with the cast-iron box, which is itself when in use connected with earth. The upper plate was insulated by means of ebonite washers from the box, but had two insulated terminals connected to it passing through the top. To these are brought the line and instrument wires respectively. This form is intended to be employed outside the station.

The second protector consisted of three brass plates one above the other. The top plate carrying two hundred silvered points was insulated from the one below it, upon which its points projected, by ebonite washers. This in its turn was insulated from the lowest by a thin sheet of gutta-percha tissue. The first and third plates were in communication with each other by means of two brass clamps, which served to keep the whole together, and were connected to earth. The middle plate carried two terminals for the reception of the line and instrument wires. Thus the lightning either escaped to the plate below through the tissue, or above by means of the points. The whole was enclosed in a wooden box, and was intended for use within a station.

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MR. LATIMER CLARK brought before the Society a form of Lightning-Guard of novel principle, a model of which was exhibited. It consisted of the usual two plates of iron or brass, separated by ebonite washers. The points, however, instead of being fixed, were movable in a vertical direction, through holes pierced through the upper plate for that purpose. The points were surmounted by a small knob or head, whose weight allowed the points to rest upon a thin piece of carbonised paper placed on the lower or earth plate. The advantage Mr. Latimer Clark claimed for this arrangement was that the points could be easily brought nearer to the earth plate, than they could by the use of ebonite washers alone, and that whatever number of points were used, they must all be separated from the earth-plate by a uniform distance.

MR. TREUENFELD remarked upon the principles and construction of Mr. Jamieson's form of protector, and expressed the opinion that whenever the station-clerk could not at a moment's notice examine the protector at the station if a fault occurred, or when tools were required to inspect the internal arrangements, uncertainty and dissatisfaction were sure to follow, and for that reason he preferred the old form of Siemens plate-protector.

MR. W. H. PREECE then entered upon the whole subject of Lightning-Protectors at considerable length Starting with the assertion that our lines in England suffer more from atmospheric electricity than those of any other country, Mr. Preece gave several interesting statistics as to the damage done to telegraph plant and apparatus by ligthning; and having explained the

Tel. Jour Aug 1, 76 15

Sir Robert Christison, Bart., recently read a paper before the members of the Botanical Society in Edinburgh, in which he described some observations he had made on an ash-tree near Dean Bank Toll, which was struck with lightning in 1874. This tree (one of a row) was about 30 feet from those nearest to it. It was for the most part exposed on the west side, and when, during the storm, it was struck by the lightning, this side suffered most from the electric fluid, which stripped off the bark and made two long narrow fissures in the trunk. In the spring of last year, but some fourteen days after the other ash-trees in the row had began to bud, this one put on some buds. On the west side, however, where the electric fluid had taken most effect, not a single bud was visible. At the present time the great bulk of the foliage on the tree is very thin, and during the last three weeks it has made no progress. Sir Robert had spoken to the owners with regard to the purchase of the tree for botanical purposes, and found that they were favourable. He thought, however, before it was got, some further time should be given it in order that its further progress in the way of vegetation might be watched. At the conclusion of the paper, Mr. Potts called attention to a curious incident which occured two years ago at Lasswade Loan, when a flash of lightning ran along the telegraph wire, whose connecting poles were parallel to a row of ash and elm-trees, and the lightning, strange to say, passed the elm-trees and split the ash-trees. Sir Robert Christison said, in reference to Mr. Potts' remarks, that even in the days of Shakespeare there was a belief that some trees were more likely to be struck than others, and he believed the ash was one of these.

Tel Jour Dec 15, 76

No. 22: 27TH NOVEMBER.

On Crystals of Magnetic Oxide of Iron formed during the Roasting of a Spathic Ore.—By M. BOUSSINGAULT.

On a Remarkable Fall of Hail, observed at Gutta-Ferrata. By P. SECCHI.

THE hailstones were formed of groups of crystals five or six sided, with pyramidal ends, round an irregular mass of ice. The groups weighed 40 to 60 grammes; certain blocks 300 grammes. The cloud was like a huge ball of cotton or wool moving from N.W. to S.E. It showed a whirling movement, and gave out a dull crackling noise, like that from collision of hard bodies. There were continuous and intense electric discharges in the heart of it. P. Secchi considers that in general electricity is not the cause, but the effect, of hail.

8 16

Tel Jour Dec 15. 76

On some Peculiarities of Lightning. By M. Renou.

He describes—1. A case of beaded lightning which he witnessed in 1859. 2. Purple or violet flashes of the tint of electricity traversing air rarefied to 3 or 4mm. of mercury. These discharges were probably at 25,000 to 30,000 metres altitude. 3. Lightning, without thunder being heard. This may occur directly overhead. 4. An observation regarding the distance at which thunder may be heard. He heard it one quiet evening at 40 kilometres distance.

Tel. Jour. Aug 1. 76

Automatic Discharger for Electro-Atmospheric Rods. By M. Serra Carpi.

This consists of a copper lever 30 centimetres long, with equal arms, turning about a pivot in communication with the part of the conductor which carries the discharge to the ground. At one end of it is a gilt ball, situated 5 centimetres from the end of the insulated conductor; the other end is fitted with a piece of soft iron. When the end of the lever has acquired sufficient tension to produce small sparks, attraction occurs between the gilt ball and the end of the insulated rod; so that the lever turning on its pivot, comes into contact with the rod. That this contact may be maintained, spite of wind and other disturbing causes, a small magnet is so placed, that when the first contact takes place between the lever and the rod of the conductor, a second occurs between the magnet and the other arm of the lever. The magnet should be so strong as to maintain the attraction by contact without attracting at a certain distance. This can be effected with an armature or a screw movement. The lever turns only in one direction, and it can be made immovable in case of a special observation. This apparatus has been tried at Rome during thunderstorms. Whenever the rod acquired a tension capable of producing sparks of two to three metres, it came automatically into communication with the ground, and the lever remained in contact with sufficient force for ordinary disturbing causes.

Elec. News July 8. 75

Electric Discharges on Fine Metallic Wires.—M. Melsens.—These studies are related to the question of lightning protectors by multiple conductors. In 1865 the author showed how the spark from batteries divides itself between all the metallic conductors in its path, in a similar manner to the spark from the great Ruhmkorff coil. In view of multiple conductors for lightning protectors, several experiments have been made with Holtz's splendid machine to confirm his old experiments; and he now states he has been able to lengthen the conductor of the smallest diameter, to introduce several thousands of Siemens's resistance units, and to still ascertain with the greatest facility that a portion of the current instantly passes through such a conductor. He also inserted long columns of ordinary water, distilled water, moist earth, dry sand, and various dry or wet gases, without essentially modifying the phenomena, on the express condition, however, that the two extremities of the conducting wires were put in contact with the two poles of the electric source; or were at least brought into very close proximity to them. "Ten years ago I proved," says M. Melsens, "that the spark from the great Ruhmkorff coil passes very easily through conductors of the same dimensions whether of copper or iron; but I then only experimented with conductors of very small length. Recently desiring to experiment with lengths as long as those of lightning conductors, I soldered into a brass sphere a copper wire 100 metres long, and an iron wire about 200 metres long—both being 0·1 millimetre in diameter. From this sphere the wire started, each separately, wound round long glass rods. The free ends were, in their turn, each soldered into a brass sphere. Now a spark striking the sphere into which the two wires are fixed, divides itself between them in such a fashion that if we place the two other spheres at equal distances from a conductor in contact with the opposite pole of the Holtz machine or Ruhmkorff's coil, the spark traversed the two conductors, or one of them if it offers a much smaller resistance." Measuring this resistance for a 2 Leclanché-element current it was found that the copper wire corresponded to 540 Siemens's units, and the iron wire to 3300 units.

17

The series of figures now presented illustrate amongst other matters the following actions:

(1.) The attraction (or repulsion) of magnets by magnets.
(2.) The attraction (or repulsion) of currents by currents.
(3.) The attraction (or repulsion) of magnets by currents.
(4.) The rotation of magnets by currents.
(5.) The rotation of currents by magnets.
(6.) The rotation of a magnet round its own axis under the influence of a current.
(7.) The repulsion by a current of its own parts.
(8.) The mutual inductive action of solenoids and magnets, and of magnets and magnetic matter.
(9.) The flow of currents in conductors and conducting media.
(10.) The action on magnets of magnetic media.
(11.) The action of magnetic instruments, magnetometer, galvanometer, electro-dynamometer.
(12.) The action of magneto-electric machines.
(13.) The magnetic properties of cobalt and nickel.

The figure illustrative of the lines of force surrounding a current has been previously given by Faraday, Guthrie, and Barrett. Those illustrative of the attraction and repulsion of parallel currents, by Faraday, but imperfectly. Those illustrative of flow of currents in conductors by Kirchhoff, Guthrie, and Carey Foster and Lodge.

Those illustrating the action of the galvanometer and the Gramme machine were suggested to me respectively by Mr. C. W. Cooke, and Mons. A. Niaudet.

The photographs have been executed directly from the filing figures by Mr. Robt. Gillo, of Bridgwater, of the firm of F. York & Co., of Notting Hill, the eminent manufacturer of photographic transparencies for the lantern.

ON LIGHTNING CONDUCTORS AND ACCIDENTS BY LIGHTNING.

By RICHARD ANDERSON, F.C.S., Member of the Society of Telegraph Engineers.

Abstract of Paper read before Section A of the British Association, August, 1878.

At the present time at least one-half of all the public buildings, including the churches and chapels, of Great Britain and Ireland are without protection against lightning. As to private houses, it is safe to assert that not five out of every hundred have lightning conductors.

According to the reports of the Registrar-General, the number of deaths from lightning in England and Wales during the eight years from 1869 to 1876 reached a total of 182.

According to the report of Dr. Engel, Director of the Statistical Bureau of Berlin, the number of lives lost during the same period in Prussia was 819.

The terrible losses, both of property and human lives occasioned by lightning, are mainly due to three causes, namely: first, in not providing any lightning conductors at all; secondly, in not placing them in the right position, or in sufficient number to cover a given area; and, thirdly, in not having them regularly tested, so as to ascertain their constant efficiency. Even some of the first cathedrals of England, such as Peterborough, have no lightning conductors whatever, while others, supplied with them, Windsor Castle for example, are insufficiently protected, as is apparent to any competent observer.

If the entire absence of lightning conductors is the most prevailing cause of the still exceedingly great number of casualties occasioned by lightning, that of ill-placed or insufficient conductors is another deserving much attention. The mischief done in this case is not only that the conductor gives a false security, but that, should the dwelling on which it is placed be struck by lightning, it leads to the belief that the wonderful scientific discovery of Franklin is nugatory, or at least uncertain in its action. A case of the most instructive kind, in which a house with a proper conductor fixed on it was struck and damaged by lightning, came under my own observation quite recently; a heavy thunderstorm passed over it, and the electric discharge fell on one of the towers, knocking down part of a crenellated wall, not more than three yards from a lightning conductor, and then passing off without doing further damage. The conductor being new and in good order, it seemed at first sight a very extraordinary case; but the mystery of it was soon explained by an examination of the premises, which I undertook. I found that the roof of the tower on which the lightning fell was covered by a solid mass of lead, of unusual thickness, connected at one end with a large iron water-pipe about four inches in diameter. In this case the electric force, to get to this rival conductor, heavier in metal than the one designed for the purpose, and therefore offering the best road earthward, had to smite the brick wall in its way, and having done this, it went down the iron water-pipe into the ground, doing, as already mentioned, no more damage. Had the actual conductor either been larger, that is, heavier in metal than it actually was, or had it been connected with the mass of lead in the first instance, the lightning could never have struck the house. The incident forcibly illustrates the necessity of leaving the design and erection of lightning conductors to no others but those who have made a thorough study of the subject, since the work is not by any means so free from complexity as is commonly believed.

The third cause is the utter neglect of the conductor, when once it has been put in its place; other repairs to all sorts of public buildings are regularly executed, but the lightning conductor is taken no notice of and is never tested.

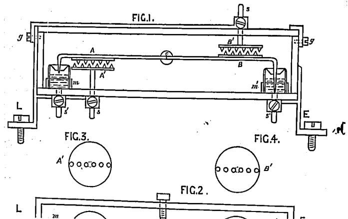
Having drawn attention to the chief causes of the numerous and fatal casualties caused every year by lightning, I have only to add a few words of advice as to how they might be prevented, or at least greatly diminished. First of all, I think it most desirable that public recommendation should be made, by local and other authorities, to place lightning conductors on all exposed or high-lying buildings, whether public or private, as well as on those standing near woods and on moist ground. It might be well worth the trifling expense to place simple conductors also against trees in parks, under which there are benches, or where persons are likely to gather during a thunderstorm, they forming a prolific source of fatal accidents. Above all, no church, chapel, school, prison, or other large public building, ought to be without one or more lightning conductors. But if it is necessary to greatly multiply lightning conductors, it is equally so that they should be planned, erected, and also periodically tested by competent persons, with scientific as well as practical knowledge of the work. The testing should take place at regular intervals, perhaps best in the spring, before the advent of the summerly thunderstorms, and it should likewise be made whenever a building has been undergoing repairs which may have damaged the conductor. To show the importance of constantly testing even the best laid conductors, I can cite another instructive case where a house was apparently well protected. On the 19th of August, 1876, shortly before midnight, a heavy stroke of lightning fell upon a mansion near Kew Bridge, Middlesex. The electric force destroyed the top of a large chimney, knocking off part of the coping, not more than two or three feet from a lightning conductor, to which it then flew, making its way down to the earth, but not without causing the greatest disturbance all along its path—lifting up, among others, some heavy marble toilet tables in bed-rooms some six feet distant on either

18

metallic discs oppositely electrified, the strength of that attraction determining the relative proximity of the discs.

Fig. 1 is a section, and fig. 2 a plan of the instrument (the cover and with it the plate B′ has been removed in order to show the balance portion), while figs. 3 and 4 show the distribution of points on the discs A′ and B′. A and B (figs. 1 and 2), are two copper discs, attached to the under and upper surfaces respectively of a stout copper rod, which being pivoted at *c*, *c*, forms a very delicate balance. The ends of the axis *c*, *c*, move freely in holes drilled in the ends of the screws, as shown in fig. 2. The discs at either end of the balance are provided while the whole of the balance, including the rod and discs A, B, are in permanent connection with the earth through the mercury in the cup *m′*, which is in metallic connection with terminal E.

The *modus operandi* is as follows:—So long as the line is free from the influence of atmospheric electricity, by virtue of B being slightly the heavier of the two arms, gravity operates, and draws it down till the prolongation at that end rests on the bottom of the mercury cup *m′*. If now the plates A′, B′, and the level of the mercury in the cup *m* have been properly adjusted, whenever the line becomes charged with atmospheric electricity, the discs A′, B′, being in metallic connection, become similarly



A NEW FORM OF LIGHTNING DISCHARGER.

By J. RYMER-JONES, late Electrician to the Imperia Government Telegraphs, Japan.

THE principle involved in this instrument is somewhat analogous to that of the *attracted disc*, or *trap-door* electrometer of Sir William Thomson, inasmuch as it depends on the mutual attraction of

(1) Comptes-Rendus, Vol. 84, p. 914.
(2) Note on Thunder and Lightning, by the Count du Moncel 1857, p. 47.
(3) Bulletin de l'Association Scientifique de France, No. 457, p. 305.
(4) *Telegraphic Journal*, Vol. 6, page 139, Comptes-Rendus, Vol. 85, p. 619 and 622.

Commence over

by drawing B down, breaks the earth connection. The cups which contain the mercury are formed by small portions of test tubes, the rounded bottom being slightly softened by heat, and pressed inwards by a suitable point, so as to form a hole of the proper dimensions. This forms the top of the cup, which resembles somewhat the top of a *safety ink-bottle*. The bottom of the tube is open and is cemented into a brass cup, as shown in fig. 1. Not only does this form of cup circumscribe any possible splutterings of the mercury, but the level of the mercury is also seen through the glass, and, since the sides of the instrument case are of glass, adjustments may be made without removing the cover. When, however, this is necessary, in order to fill the cups and fix the balance, it is readily done by removing the screws *g g*, when the cover, together with the plate B′, may be taken off.

Although such a modification will materially reduce the efficiency of the discharger, it is evident that by varying the connections, and putting A′ to line and B′ to earth, or *vice versâ*, the balance, when attracted, forms a bridge between the two. By employing the mercury cups, however, the contact with earth is not only more perfect, but there is less danger of the plates being fused together, as is not unfrequently the case with the ordinary *plate-dischargers*. Moreover, as the instrument is dust-tight and firmly screwed down, the mercury contacts, when once adjusted, need furnish no source of inconvenience.

Tel Jour. Apl 1. 78

EARTH CURRENTS.

By CHR. DRESING, of the Great Northern Telegraph Company.

HOPING to obtain some few additional facts to our present unsatisfactory knowledge of earth currents, I and Mr. Terp, the company's superintendent, a couple of years ago commenced a series of observations of earth currents on the Scotch-Norwegian Cable. The line being a busy one, was only occasionally (and especially on account of an interruption of the Norwegian and Scottish lines) at our disposal, and though the observations in consequence could not be carried out as frequently as could be desired, the following table, *which is a fair specimen of all the observations*, will be sufficient to demonstrate a certain regularity in the *diurnal variations* of the *strength* and *direction* of the natural current.

I may remark, that the deflections noted are readings from the scale of an *ordinary*, but sensitive *detector* of a resistance of about 1,200 ohms, and th- strengths of the current and the deflections are not directly proportional to one another.

From this table and from all my numerous observations, which have tended to confirm the above results, without however, throwing any new light on the subject, the following conclusions may be derived:—

1st.—That there is always a natural current flowing through the cable.

2nd.—That this current is sometimes flowing from Scotland to Norway, sometimes in the opposite direction.

3rd.—That the current after each change of direction increases gradually, from a minimum to a certain maximum strength, and then again decreases until, after passing the zero-point, which only occupies about a minute, it assumes an opposite direction.

4th.—That the change of direction takes place about every six hours, *i.e.*, 4 times in the 24 hours.

5th.—That the *normal maximum strength* of the *natural current*—as proved by proper measurement—scarcely ever exceeds 3 to 4 Léclanché's cells.

6th.—That great *meteorological* disturbances *usually* are preceded, accompanied, or followed, by similar *electric* disturbances in the cable.

19

Date.	Time.	Deflection. +	Deflection. −	Remarks.	Weather.
Jan. 1	8 0 a.m	..	38	Steady deflection	N.E. breeze fine.
—	9 40	0	0	Changing direction	
—	10 40	65	..	Steady	
—	12 40 p.m	63	..	*i.e.*, equal to 4 Leclanche's cells	
—	2 0	60	..	Steady	
—	3 10	54	..	„	
—	3 40	47	..	„	
—	4 30	15	..	„	
—	4 50	0	0	Changing direction	
—	5 0	..	10	Steady	
—	5 30	..	30	„	
—	6 0	..	45	....	
—	6 30	..	52	Steady; increasing	
—	6 45	..	53	....	
—	7 30	..	55	....	
—	8 35	..	50	Steady; decreasing	
—	9 46	..	10 to 35	Swinging	
—	10 15	..	..	Changing direction	
—	10 50	40	..	Steady; slowly increasing	
Jan. 2	12 0 a.m	48	..	....	
—	1 15	50	..	....	
—	7 50	..	86(?)	Steady	Fine; frosty.
—	8 25	..	55	....	
—	8 52	..	52	Unsteady	
—	9 45	..	42	Steady; decreasing	
—	10 0	..	..	Unsteady; swinging across zero	
—	12 0 noon	45	..	Unsteady	
—	1 0 p.m	57	..	Steady	
—	1 46	58	..	„	
—	2 23	50	..	„	
—	3 38	48	..	„	
—	4 0	12	..	„	
—	5 0	..	..	Changing direction	
—	5 35	..	25	Constantly increasing	
—	6 57	..	55	„	
—	8 57	..	58	Steady	
Jan. 3	8 40 a.m	..	55	....	Fine weather; frosty.
—	10 0	..	45	Steady; decreasing	
—	11 15	..	..	Changing direction	
—	11 30	25	..	....	
—	1 15 p.m	53	..	....	
—	2 47	58	..	....	
—	3 45	56	..	....	
—	5 50	30	..	Rapidly increasing	
—	6 0	..	..	Changing direction	
—	6 30	..	8	Steady; increasing	
—	8 30	..	60	Steady	
—	10 5	..	59	Decreasing	
Jan. 4	12 32 a.m	..	..	Swinging across zero	N.E. gale.
—	8 15	..	43	Steady	
—	11 20	..	13	Rapidly falling	
—	11 57	..	..	Changing direction, gradually assuming positive tendency	
—	12 52	30	..	....	
—	1 50	43	..	Variable	
—	2 38	45	..	„	
—	4 2 p.m	50	..	„	
—	6 20	39	..	Steady	
—	7 7	27	..	„	
—	7 15	16	..	„	
—	7 36	..	..	Changing direction	
—	7 45	..	15	....	
—	8 45	..	34	Steady	
—	10 55	..	43	„	
—	11 40	..	42	„	
Jan. 5	7 30 a.m	15	..	....	N.E. gale.
—	8 0	..	..	Changing direction	
—	9 40	..	30	Variable	
—	10 20	+20 to	−40	Very variable	
—	11 30	..	30	Steady	
—	12 45 p.m	+30 to	−30	Very variable	
—	12 58	..	5	....	
—	1 30	..	..	Changing	
—	1 50	15	..	....	
—	3 0	34	..	....	
—	3 40	40	..	Variable	
—	4 10	43	..	Steady	
—	4 45	45	..	....	
—	6 15	38	..	Decreasing	
—	8 0	..	..	Changing direction	
—	8 15	..	9	....	
—	10 17	..	48	....	
—	11 15	..	55	....	
Jan. 6	1 0 a.m	..	52	Decreasing again	

20

Tel Jour, Feb 1 .76

CONSTRUCTION OF LIGHTNING PROTECTORS.

By E. SAINT-EDME.

WHETHER the point of a lightning-conductor is made of platinum or of copper, or whether it is sharp-pointed, as suggested by Franklin, or presents an angle of 30° degrees, in accordance with the latest notions, however great may be the care taken in welding the metals, it is certain that in this respect the mode of construction is defective as regards conductivity, and it is to be feared that the conductivity is diminished by the action of the weather. But it appears further to be demonstrated that it is at the joint that a lightning protector is most often destroyed; it is there the discharge takes place.

At first, Franklin proposed that the conductor should be made of one metal only. It is owing to the rapid oxidization of iron that the successive Commissions have proposed to modify the nature of the extremity of the conductor. We think that it is possible to return to the original idea, since it is known how to cover iron with a metal (nickel) which forms on its surface a film perfectly protecting it from oxidization, and possessing the necessary conductivity.

We have experimented with the conductivity of nickel spread over a rod of iron. The nickelized surface indicated a rather higher conductivity than the mass of iron; it resisted better the electric discharges given off by a powerful battery. This same rod, after being immersed in water for 10 days, did not indicate any alteration, and the electric conductivity remained the same.

We think, then, that in the future construction of lightning protectors, it would be expedient to do away with the copper or platinum tips, the termination being made of a single piece of nickelized iron, the same as the conductor.

The lightning protector would thus become a safeguard against electric discharges, and, owing to the preservation of its point, would always possess the same protective effect.

Again, the conductivity would remain constant, and the necessity of supervision be done away with. This last condition is of great importance, as illustrated by General Morrin. According to him, it is desirable that you should be able to verify automatically the condition of the lightning protector as regards conductivity. In fact, everyone knows that if the conductivity is defective, the lightning protector becomes a source of danger.

Electrical News July 1 1875

Report of the "Commission on Lightning Conductors" Relative to a New Arrangement for Powder Magazines.—The new arrangement refers to the proposition of constructing air-shafts so as to place powder rooms in communication with the exterior air. The question asked by the War Administration of France was whether these air-shafts were sources of danger, irrespective of the lightning conductors erected around the magazines according to established usage. The answer given by the gentlemen forming this commission is:—"If the War Administrator adopts for his new powder magazines ventilation chimneys, and arranges the system of conductors so that the superior extremity of the chimnies remain always largely included in the generally admitted zone of protection, the commission is of opinion *the existence of these chimnies will not become in times of storms a special cause of danger.* However, in certain circumstances when, by reason of the impossibility of reaching an underlying inexhaustible sheet of water, or of the necessity of seeking for water at a large distance by conductors too much exposed to risk of malicious accidents, it is found advisable to give up supplying a magazine with lightning conductors, then air-shafts will be an element of considerable danger—especially when, on account of atmospheric causes, their interior sides becoming damp. Under such circumstances they should never be built."

Electrical News Sept 9 1875

No. 16, August 19, 1875.

Lightning Conductors.—The following are the results of investigations undertaken in France by a Commission to study the establishment of lightning conductors on the principal buildings of Paris. (1.) *Points.*—A stem consists of a conductor rising to a certain height above the buildings. The point should have a mass and conductivity sufficient to resist a disruptive discharge. Platinum points were found useless, and the Commission says—"Place at the top of each stem an 'arrow' of pure red copper, about 50 c.m. long, with sides sloping upwards 15° towards its central perpendicular." (2.) *Stems* should be of wrought iron, in one length, slightly conical. They should also be as much as possible galvanised, but under no pretext whatever should they be painted. The jointing between the stem and the conductor should be bolted, and well covered with a thick coating of tin solder. (3.) *Protecting zone of each stem.*—For an ordinary construction the stem efficiently protects *the volume of a cone* having the point for its summit, and the height of the stem—measured from the roof-ridge multiplied by 1·75—for radius of the base. Thus a stem of 8 metres protects a cone whose base, measured upon the ridging, = 14 metres radius, or 1·75×8. In practice the stems may be a little further apart, on condition that the "circuit of the roofs" be made use of. (4.) *Circuit of the roofs* means a metallic conductor making a circuit around the ridges of the roof It must be in metallic connection with the lightning conductors of the building. (5.) Every metallic piece of considerable mass, forming part of the structure, should also communicate with the lightning rods. (6.) The extremity of the *rod* ought to be soldered to a metallic plate or hollow cylinder, of as large a surface as possible, and immersed deeply into water. *When it is not possible to reach a sheet of water the establishment of a lightning conductor must be discarded, as it would prove a source of danger rather than a protection.* (7.) The Commission recommends that conductors be completely inspected at least once a year, towards the end of autumn; moreover, their electrical resistance should be tested periodically by ordinary processes.

No. 17, August 26, 1875.

Electrical News Aug 26 1875

Construction of Lightning-Conductors for Electric Telegraphs.—M. Schaack.—The ordinary arrangements are objectionable on account of complexity (and consequent danger), uncertainty, expense, and the fact that when *e.g.* the opposed cones get fused together by the lightning, repairs cannot be done by the person who works the apparatus, &c. M. Schaack's arrangement is briefly as follows:—On the two long sides of a tin case (about 10 c.m. square section), at the top, are fixed two insulating wooden bars which carry binding screws C and C'. C is connected with the line; and from C' a wire passes through the telegraph apparatus and to the outside of the case, which is connected with earth. The screws are connected together by a loosely wound spiral of German silver wire, the silk covering of which has been passed several times through a caoutchouc solution. The case is filled three-fourths with water. When lightning enters the line, the spiral, with its thin coating, offers it a nearly direct path through the water to earth. The windings act like the points of a cone, &c., in other arrangements. The spiral is either fused, or its envelope burst through; and in both cases, the way to the apparatus is broken and the lightning passes more directly to earth. After the storms, the attendant fits a reserve spiral in place of the one destroyed. The length of the case depends on the number of line wires.—*Dingler's Polytechnisches Journal.*

21

Study of these tabulated results of involution will lead us to the principles by which we may write down the power of any binomial.

First, we perceive that the number of terms is always one greater than the power required.

Secondly, if both terms of the binomial are positive, all the quantities remain positive; but that a residual* binomial has its odd terms (counting from the left) positive, and its even terms negative.

Third. The exponent of the first or *leading* quantity (a) is always the index of the required power; and the powers of this quantity decrease by 1 in each successive term. The index of the second term of the quantity to be involved (b) (called the *following* quantity), begins with 1 in the second term and increases by 1 in each successive term until it equals the required power.

Fourth. The coefficient of the first and last terms is always 1. The coefficient of any term multiplied by the index of the first letter (leading quantity) in that term, and divided by the index of the second letter (following quantity) increased by 1 gives the coefficient of the next succeeding term. The coefficient of the second, and next to the last terms, is the index of the required power.

The algebraic formulation of the theorem is—

$$(a+b)^n = a^n + na^{n-1}b + n\frac{n-1}{2}a^{n-2}b^2 +$$

$$n\frac{n-1}{2}\cdot\frac{n-2}{3}a^{n-3}b^3 + \text{\&c.}$$

By the substitution of the letters, A, B, C, for the coefficients

$$n,\ n\frac{n-1}{2},\ n\frac{n-1}{2}\cdot\frac{n-2}{3},\ \text{\&c.}$$

the formula is simplified, and becomes

$$(a+b)^n = a^n + Aa^{n-1}b + Ba^{n-2}b^2 + Ca^{n-3}b^3, \text{\&c.}$$

Let us now endeavour, by following the foregoing rules, to raise $a+b$ to the sixth power. By the first principle, the number of terms will be 7. The signs will be plus.

The indices of the 7 terms will be $a^6, a^5b, a^4b^2, a^3b^3, a^2b^4, ab^5, b^6$.

The coefficients will be—

$$1,\ 6,\ \frac{6\times 5}{2},\ \frac{15\times 4}{3},\ \frac{20\times 3}{4},\ 6,\ 1.$$

Collecting these steps, we have the complete expression—

$$a^6+6a^5b+15a^4b^2+20a^3b^3+15a^2b^4+6ab^5+b^6.$$

By substitution other binomials may be reduced to the form $(a+b)^n$. Thus, if the 6th power of $(3d+2e)$ were required, the result could be obtained by substituting a for $3d$ and b for $2e$. Then, raising $a+b$ to the 6th power, as given above, we afterwards obtain, by restoring the values of a and b, the expression—

$$729d^6+2916d^5e+4860d^4e^2+4320d^3e^3+2160d^2e^4+576de^5+64e^6.$$

Or it may occur that one of the terms of the binomial is a unit, as $(a+1)^n$. In this case, since every power of 1 is 1, and multiplication by 1 is unproductive of alteration in the product, the unit is usually omitted, except in its essential place, the first or last term.

For example—

$$(a+1)^3 = a^3+3a^2+3a+1;$$

and—

$$(1+x)^n = 1+nx+n\cdot\frac{n-1}{2}x^2+, \text{\&c.}$$

By similar tact in dealing with problems, the binomial theorem may be made to include the involution of quantities of more than two terms. In the event, also, of one of the terms of a binomial being a fraction, as $(a+\frac{1}{2})^2$, tact affords a far better method than rule in solving the question. Thus, $a+\frac{1}{2}$ may be written $\frac{2a+1}{2}$, and

$$\left(\frac{2a+1}{2}\right)^2 = \frac{4a^2+4a+1}{4} = a^2+a+\tfrac{1}{4}.$$

* A residual quantity expresses the difference of two quantities, as $a-b$.

LIGHTNING AND LIGHTNING-RODS.*

By JOHN M. MOTT

LIGHTNING is atmospheric electricity moving through bad conducting matter under an explosive form.

A lightning-rod is a conductor of electricity so applied to an object as to prevent the accumulation of free electricity upon it, by induction, and also to enable it to transmit, in safety, the electric force by which it may be assailed.

The construction and application of lighting rods has appeared to most persons a matter too simple to need aid from scientific minds, while not a few have looked upon the whole theory as absurd, and as a source of danger rather than of safety. There has been, consequently, but little encouragement for presenting to the public those facts which are requisite for guidance in applying the discovery of Franklin, successfully, to the protection of life and property.

The fact of electrical conduction by metallic substances having been long and well established, any further discussion of the application of this principle to the purpose of protection against injury by lightning may possibly appear, to persons conversant with such subjects, in some degree superfluous. The damage, however, which so frequently occurs in thunder-storms, attended, as it is, with loss of life and with serious inconveniences to the best interest of the country; the various theories advanced by persons who have only partially considered the facts; systems of rodding which have been adopted in different localities, and the numerous modifications of the conductors, each claiming some peculiar advantage over all its competitors, has created a curiosity, if not a necessity, which seems to call for investigation, and may be fairly offered as a sufficient reply to such an opinion.

When we consider the coincidences of lightning and ordinary electricity, together with the fact that atmospheric electricity may be conducted from the clouds, or strata of charged air, and applied to produce the same effects as those resulting from electricity generated by means of an electric machine, it becomes quite evident that the causes, whatever they may be, of ordinary electricity are identical with those of lightning; consequently we arrive at the important conclusion that lightning and common electricity are subject to the same

* Abstract of a paper read before the Meteorological Section of the Franklin Institute of Philadelphia. From the "Journal of the Franklin Institute."

Electrical news.
Oct 14 1875.

Description of a Special Lightning "Protector" for Aërial Lines.—J. F. Vaes.—A metal ring about 1½ centimetres wide, and 2½ centimetres diameter, is cut in two: on one side the two ends are joined together by a hinge; on the other they are closed by means of a screw. This metal ring surrounds a hardened wooden reel, likewise divided in half, and perforated through its axis. The metal band is retained in position by the raised edges of the reel, and to its inner side a "preservative" point of aluminium bronze or platinum is fixed, which penetrates the reel to within 1 or 2 millimetres distance from the hole through it. In order to attach this "protector" to a telegraph wire, the metal band is opened, and with it the two halves of the reel. It is then placed upon the line wire, and closed by the screw so that the wire occupies the axial perforation. To the head of the screw is then fastened a gutta-percha-covered copper wire whose other extremity is affixed to a metallic plate in the post, or some other "earth." In this little device it is impossible for the "preservative" point to touch the wire; and it is, moreover, shut out from atmospheric influences. (1). The aperture of the reel should have its diameter a little smaller than that of the wire, in order that the "protector" be properly fixed. (2). To fill up the cleft that will always exist, more or less, between the two halves of the reel, place there some gutta-percha, or tarpaulin, before the reel is fastened: these materials, by compression, will entirely fill the cranny. (3). In times of thunderstorms the "protector" will give rise to derivations by reason of the small distance of the exterior surface of the band from the telegraph wire. Many means are available whereby this inconvenience may be remedied. It will be insufficient to varnish the metallic parts; it is much better to lengthen the reel, or to give greater height to the raised edges. Another means consists in covering the wire with an insulating layer for some centimetres on each side of the "protector;" but that which appears to be the most simple and efficacious is to as it were "house" the "protector," so as to protect it from the rain. (4). The construction, though based on the principles expounded, may be varied considerably, such as by replacing the single point with several points, or with a many-toothed metal plate, &c. (5). It may also be used without altering the supporting poles. One is not limited in the choice of situations, and one may thus regulate electrical discharges at convenient distances from cables and instruments, so that in case of a storm they would be found much less exposed to derivations.

Electrician Nov 27 1875

Double Maximum in the Frequency of Thunderstorms during the Summer Months.—M. von Bezold.—The results of this investigation are thus formulated:—Phenomena of thunderstorms show in general, during the summer months in the northern hemisphere, two maxima. These maxima approximate nearer to each other the further we go north. But not only can they be decisively proved for Germany, but they are distinctly recognisable (taking the principle of five-day sums) even in Barnaul and St. Petersburg. Among the places examined there is only one which showed but one maximum, and this is Katharinenburg, the climate of which is less influenced by the meteorological phenomena of the tropics than that of any other place taken into consideration. [In the tropics it has been shown that strictly there is summer twice in the year. These two maxima of temperature, which, as you remove from the tropics, approach each other very quickly, merging into one another in the high latitudes, appear much more strikingly in the frequency of the thunderstorms. Thus the phenomenon in question may be regarded as an echo of the two tropical summers, or heat maxima.]

AUGUST 15, 1874.

You again write to us without giving your name and address.

M. P. S. says: Your repeated cautions in regard to lightning rods lead me to ask your advice through your columns upon the following points: I have erected at my country residence a water tank and fixtures of rather novel construction. At one corner of the house, I have placed an old cylinder boiler, about 30 feet long and 3 feet diameter, standing on end, resting on brick foundation. The upper head has been removed, making a huge water tank. The top projects above the eaves of the roof, but not higher than the peak. It is encased in an ornamental frame tower connecting with the main building. I propose to keep this tank filled with water by force pump from the well. It is now empty, however. From this tower, iron water pipes lead to the kitchen and bedchambers, and also to the cast iron force pump in the well, and probably 10 feet down into the water. The house has two ordinary lightning rods on chimneys, leading to the ground on the opposite side of the house. 1. Is this arrangement dangerous? A. The arrangement as described is not to be called exactly dangerous, but might be made much better by a little change. 2. Would lightning be attracted by the large mass of iron of the boiler, rather than by the lightning rods, which are higher? A. If, as would appear, the iron tank is in excellent connection with the ground, it is quite possible that lightning might strike it or some of the pipes running from it in the house in preference to the lightning rods. 3. If struck, would the lightning follow the mass of iron to the ground, or pass through the pipes into the well, or enter the chambers through the discharge pipes? A. If the tank or its connections were struck, the lightning would, without doubt, go to the earth and not into the house. 4. Would it be advisable to put a lightning rod on the outside of the tower leading to the ground? A. A lightning rod on the tower should be put into perfect metallic connection with the tank, and need not extend below its upper edge. Let the tank and water pipes, in other words, be the lower part of the rod. 5. Would not this last tend to attract the lightning, and in such case would not the electricity be likely to leave the rod and enter the boiler with same effect as if no rod were there? A. Both your suppositions in this paragraph are correct. 6. Will not this large mass of iron resting on the ground and this indirect water connection answer the purpose of a conductor? A. This question is already answered in No. 4, assuming that the pipe into the well is in perfect metallic connection throughout, with no rust or cement joints. Red lead is an admirable insulator. In the way of advice we would say: Connect all your lightning rods together, and also to your iron tank and water, gas, or other pipes, not by separate connections, but so that there is some connection between all as high as possible. If you have a metal roof connect all rods with it. If not, connect them by a good sized conductor running along the ridge of the roof. Bear in mind that, to carry off the heaviest lightning flash known, a copper rod one inch in diameter is not considered too large, and, though of course such flashes are of very rare occurrence, they may come. Hence the great value of uniting your different rods high up. Read our article in vol. 29, p. 26, and our editorial remarks upon a letter, p. 111 of the same volume.

L'Electricité Aug. 76

entraîner aucun inconvénient sur son passage. Mais l'ingénieur dirigeant cette partie du service municipal a mis son *veto*. En conséquence, on est réduit à creuser partout des puits, quelquefois très-profonds, afin d'aller chercher fort avant la nappe conductrice.

N'est-il pas déplorable de voir que le défaut de compétence d'un seul personnage suffit pour entraîner des dépenses si considérables?

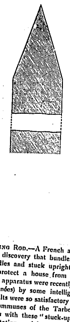
Nous ne savons comment il se fait que les membres de la commission se soient inclinés devant de pareilles prétentions.

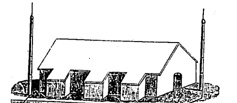
***

On a fait à l'Académie des sciences des communications destinées à appeler son attention sur la mauvaise qualité que l'on puisse imaginer de l'ignorance dans laquelle on se trouvait alors en matière de paratonnerres. On avait armé de tiges innombrables un bâtiment qui était tout en fer, mais on ne s'était pas borné à cette étrange absurdité. On avait eu soin d'isoler avec de petits bouts de bois une couronne horizontale qui les réunissait tous, ainsi que les conducteurs destinés à mettre en rapport ladite couronne avec le réservoir commun.

Les paratonnerres en cuivre sont, de l'avis de tous les spécialistes, bien préférables aux paratonnerres en fer. Mais les ennemis du cuivre ont découvert un argument singulier.

Les voleurs qui dédaignent les paratonnerres de fer déroberaient les conducteurs de cuivre! Nous allons raconter une petite anecdote qui prouvera que les tiges de fer





A Rustic Lightning Rod.—A French agricultural paper announces the discovery that bundles of straw bound on broom-handles and stuck upright over the roof will effectively protect a house from lightning. The first trials of this apparatus were recently made at Tarbes (Hautes Pyrenées) by some intelligent agriculturists, and the results were so satisfactory that soon afterwards eighteen communes of the Tarbes district decorated their houses with these "stuck-up" but at the same time unostentatious and ingenuous lightning protectors, and it is reported that there have been no accidents from lightning since. By what experimental process the intelligent agriculturists came to their conclusion is not stated; nor can we learn what the idea was which inspired the plan, although it appears to have been the old proverb about a hair of the dog which bit you, for it has long been known that witches ride the storm on broomsticks.

CHRONIQUE DES PARATONNERRES

La ville de Paris a pris toutes les précautions désirables pour que les paratonnerres de ses différents établissements publics soient construits d'une façon irréprochable. Mai les résultats sont loin d'avoir répondu au zèle des commissaires. En effet, on doit regretter que le budget municip ait été surchargé de dépenses inutiles à cause de l'entêtement d'un ingénieur.

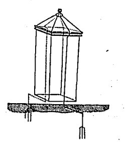


Diagramme montrant la disposition d'une cage dans laquelle un électroscope ne peut être influencé par une décharge extérieure.

La théorie des paratonnerres montre d'une façon tout à fait incontestable qu'il suffit que les tiges soient en commune action ec les tubes de la canalisation de l'eau pour que le fluide se rende dans le réservoir commun sans

No. 19. April 25, 1874.

Improved Lightning Rod.—Electricity is best dissipated by conductors which present a large number of sharp edges; and if such angles extend throughout the length of the conductor, the current is received at any point as readily as at the pointed apex. It is on this principle that Mr. Minsen, of Indianapolis, has invented his improved form of lightning-rod. In addition to these advantages, it presents a variety of others, rendering it, it is claimed, a thoroughly efficient protection to any edifice upon which it may be placed. The rod is composed of copper wires and large galvanised iron wires, manufactured into a single rope. The copper wires are square in section, and are drawn perfectly straight, so that when they are twisted up in the rod an innumerable number of sharp edges is presented. The iron wire is galvanised not only to prevent corrosion but to increase its conducting power. The presence of two dissimilar metals in the rod also results in constant magnetic action, whereby its effectiveness and durability is enhanced, while its electric condition is preserved. There are no joints in the invention to become disconnected and thus offer points of escape for the current. The rod is perfectly flexible, and can be bent to any angle or curve, while it cannot be broken from its fastening by the effect of wind or jars. Its continuity, therefore, is a point of considerable importance, which, taken in connection with the conducting capacity of the metals used, the spiral form, and the other advantages already alluded to, combines to render the device theoretically one of much value.

Lightning Conductors.—M. Colladon, the Geneva physicist, has published an essay on the subject of turning poplars into lightning conductors. He proposes to insert in the lower part of the tree a metallic rod in connection with the earth by a chain, so that the fluid cannot leave the tree to dart at any object placed within a short distance, which at present is very often the case.

[27107.]—Electricity from the Clouds.—The apparatus employed by Mr. Crosse consisted essentially of a series of poles projecting upwards into the air to a height of about 100ft. At the top of each pole was a sharp metal point, insulated from the support in an appropriate manner by means of an insulating stand or collar. These points were connected to one another, and to an insulated receiving ball in the observatory by means of about one mile of copper wire. This apparatus was erected at Bromfield, near Taunton, in Somersetshire. A somewhat similar arrangement was adopted by Mr. Ronalds, at the Kew Observatory, where observations were made for the British Association. The results of the combined observations of Messrs. Crosse and Ronalds are as follows:—1. The electricity of the air is always positive, increases after sunrise, diminishes towards noon, increases again towards night, after which it again increases. 2. The electrical state of the apparatus is disturbed by fogs, rain, hail, sleet, and snow. It is negative when these first approach, and then frequently changes to positive, with subsequent changes at every three or four minutes. 3. Clouds also, as they approach, disturb the apparatus in a similar way, and produce sparks from the insulated conductor in rapid succession, so that an explosive stream of electricity rushes to the receiving ball, which it is wise to let pass off to the earth. Similar powerful effects frequently attend a driving fog and heavy smart rain.—ELECTRICIAN.

On the "Gliding" of Electric Sparks.—M. Antolik.—This new phenomenon may be most easily obtained by coating a glass bar with soot, and making an electric spark strike it. The "spark-streaks" (which mark the path of the spark) present two light parallel lines, and one dark line between them. The former evidently arise from a thrusting aside of the soot; the outer edges appear, in the microscope, somewhat thicker (they also show a number of dark and light triangles, evidently due to induction; the dark have their base, the light their apex, turned to the edge). In the middle black streak the soot seems compressed, and when water is poured on the rod the soot here remains, while it leaves the rest of the surface. And even when the last remnant has apparently been wiped off (with a cloth), the path of the spark may still be detected by breathing on the glass. The soot seems to have been pressed into the plate. Sometimes an inner white streak appears within the inner dark one. Some other appearances of similar nature are also

ARRANGEMENT OF LIGHTNING CONDUCTORS.—According to the views of Mr. Preece, presented at great length in a paper read by him before the Society of Telegraph Engineers, London, the two main conditions that determine a perfect lightning conductor are—that it shall expose, in some prominent position on a building, a metallic point, and that it shall offer from this point to the earth a path of little or no resistance to the passage of the current. He also asserts that, instead of the costly copper rods, the ordinary galvanized iron wire, known as number four, and which is one fourth of an inch in diameter, is amply sufficient for the purpose, in the case of any ordinary dwelling house.

The reason given by Mr. Preece for recommending telegraphic wire is based on the experience of English companies in protecting the poles of their telegraph lines. These, it appears, are invariably supplied with lightning conductors of number eight wire, running from the upper end of the pole to the ground, and it is stated that no pole so protected has ever been known to be damaged by lightning.

Among the precautions mentioned by Mr. Preece as necessary to be observed in fixing conductors, the first is that it should be solid and continuous, there should be no joint unless it be a well soldered one, and chain-like rods, braided rope, tubing, etc., should be avoided. The ground connection, too, must be sound and good, and each conductor, if there be more than one, should have a separate ground connection, but they should also be all connected together, and connected with the lead roofing and all masses of metal in their neighborhood.

L'ozone a été découvert par Schönbein en 1839, mais avant lui on avait déjà quelque idée de son existence et van Marum, Cavallo et Davy avaient déjà fait des observations à ce sujet. L'ozone trahit toujours sa présence dans l'air par une odeur particulière. C'est une transformation de l'oxygène sous l'influence de l'électricité et d'autres forces de la nature. Le phosphore s'oxydant lentement à l'air transforme l'oxygène en ozone. On suppose que l'oxygène est divisé par l'électricité en deux parties, l'une négative l'ozone, l'autre positive l'antozone. L'ozone agit comme matière oxydante plus énergiquement que l'oxygène. Dans l'air que nous respirons il y a toujours une quantité minime d'ozone $\left(\frac{1}{450000}\right)$. La quantité relative d'ozone dans l'air augmente avec la hauteur comme l'électricité. Pour les hommes et les animaux une petite quantité d'ozone a des effets rafraîchissants.

11. *L'électricité atmosphérique et l'ozone*, par George M. Beard. (Telegraphic Journal, vol. III, page 169).

HEAVY LOSS FROM LIGHTNING ROD IGNORANCE.

On the 6th of September last the large woolen mill of Robert Fitton, Esq., at Cavendish, Vt., was struck by lightning and consumed, with a loss of $100,000; 130 persons were thrown out of employment. The mill was 45 feet wide, 106 feet long, 4 stories high. It had a flat, gravel-covered roof, and around the eaves ran a ½ inch iron lightning rod with vertical points every four feet. From the eaves rod six branch rods extended to the ground, five of which terminated at a depth of three feet below the surface, and the other was carried thirty feet underground to the bank of a pond. These particulars have been mostly furnished to us by the proprietor of the mill. The Boston *Commercial Bulletin* states that the insurance underwriters regarded the mill as particularly well protected against lightning, as there was upon it an unusual array of rods, which had been overhauled and put in good order during the year. Yet the mill was struck, the flames flashing instantaneously through the spinning room. The *Bulletin* thinks that the loss of this mill shows what value there is in lightning rods. The insurance companies had to pay $84,000 in settlement.

The principal comment we have to offer is that the burning of the Cavendish mill was a glaring example of the results of lightning rod ignorance. It would be difficult to find a more sagacious or enterprising body of business men than are the presidents, directors, secretaries, inspectors, and agents of our fire insurance companies. It would naturally be supposed that, in a matter which so directly affects their pecuniary interests as fire losses from lightning, they would take great pains to acquire knowledge concerning the means of safety, and promulgate the strictest requirements among insurers. But they appear to be lacking in this respect, although year after year the records of annual losses of millions in property, by fire caused by lightning, are forced upon their attention, and large sums of money in damages are drawn from their coffers. By consulting the naval records they may easily satisfy themselves that, while formerly the losses of ships and lives by lightning were enormous, the losses immediately ceased when rods were introduced upon vessels: and at the present day we seldom or never hear of a serious injury to or loss of life from lightning, upon a properly rodded ship. The same appliance that protects a wooden vessel at sea will protect a wooden building on land, and we will here briefly describe this appliance, though in doing so we only repeat what we have oftentimes published.

In general terms, a ship's lightning rod consists of a rope or rod of copper or iron wire, lashed to the rigging and extended from the sky pole down so as to connect at any suitable place with the copper bottom, which is in contact with the sea. The rod thus has for its terminal a very large surface of conducting material, larger in fact than the deck surface of the vessel, and the lightning passes off harmlessly.

The golden rule of safety for rodded buildings is analogous to the above. *The rod must have for its terminal a very large surface of conducting material*, placed underground in contact with the earth. Without such a terminal, no rod can be considered safe.

How large should be the conducting surface of the terminal, and of what materials made? The area of conducting surface necessary to ensure safety varies with the nature of the soil. If the ground is always moist, a smaller extent of conducting surface for the bottom of the rod will be safer than if the soil is generally dry.

To meet the contingency of a very dry soil at the driest season of the year, the electrician, Mr. David Brooks, of Philadelphia, recommends that the rod have for its terminal a conducting surface, placed underground, equal in area to that of the roof of the building; if this rule errs, it is probably on the side of safety.

Applying the Brooks rule to the Cavendish mill, the rods should have had for their terminals, underground, 4,770 square feet of conducting material, in contact with the earth, instead of which they only had the beggarly amount of less than thirteen square feet. No wonder that the building was struck.

Of what material should the terminals of lightning rods be composed? Iron or copper plates or pipes are the best material. In all cases where there are underground water pipes, the rods should connect with them. If these are of any considerable extent, nothing more is required. In cases where metal terminals cannot be provided, then good charcoal may be used in quantity sufficient to furnish the required extent of conducting surface. This substance ranks next to the metals in conductivity. It may be placed in a trench leading away from the building, with the rod extended along the center. Full particulars concerning lightning rods, the electrical laws concerning them, the electrician's tests for safety, and the best methods for their construction have been given, many times over, in our back numbers; but we propose to continue the subject from time to time so long as may be necessary. We are confident that, if the insurance companies were each to spend seven dollars and place the SCIENTIFIC AMERICAN and SCIENTIFIC AMERICAN SUPPLEMENT on file in their respective offices during the year 1876, they would derive many most valuable suggestions from our pages, not only concerning the means of safety from lightning, but the prevention of fires of every description: suggestions which, if required to be carried into practice by insurers, would save large sums of money to the companies.

MISCELLANEA. Sept '75

THE commission appointed by the Prefect of the Seine to report upon lightning conductors, and the method of constructing them, recommend the use of copper terminal points instead of platinum.

LIGHTNING CONDUCTORS. 1876

AT one of the recent scientific conferences at South Kensington, Dr. R. J. Mann gave an account of lightning conductors, laying particular stress upon the necessity of providing a sufficient outflow for the lightning channel. He gave the arithmetical proportions which must be observed between the height of the conductor, its circumference, and the outflow; and mentioned that coke saturated with water was the best material in which to imbed the base of the conductor for the purpose of establishing sufficient earth contact. It is not necessary, he said, in answer to a question, to insulate the conductor if the proper proportions are observed. He described Sir William Snow Harris's model which is exhibited in the collection, and showed how that distinguished man, by connecting the conductors fitted to the masts with the copper sheathing of ships, established sufficient contact with the salt sea-water. Water itself, he remarked, is not an effective receptacle for electricity, but every impurity in water greatly increases its use for the purpose.

PROTECTION FROM LIGHTNING.

During a recent thunderstorm in the village of Trumbull, Conn., a family of three persons, husband, wife and child, who had taken refuge on a feather bed, were instantly killed by lightning; the house had no rods. In the same village, during the same storm, a dwelling house, which had two lightning rods upon it, was seriously damaged. Several of our readers, who have seen the accounts of these disasters, and others who cite analagous examples, have had their faith in feather beds, as a place of safety during thunder storms, severely shaken; while some of them would fain believe that lightning rods serve to destroy rather than to preserve life and property. We are asked to print something upon the subject; and we cheerfully comply, premising, however, that there is little that is new to be said, and that the subjoined information has for the most part been heretofore reiterated in our columns.

ARE FEATHER BEDS A PROTECTION FROM LIGHTNING?

Feather beds are not a protection from lightning, and the popular belief that they are, doubtless results from a misapprehension of the laws that govern the passage of electricity. The human body is a better conductor of electricity than feather beds or other objects ordinarily contained in the apartments of dwellings, and therefore, *a priori*, when the lightning enters an apartment, the human body is likely to form one in a chain of inductions, determining the path of an electrical discharge, unless better conductors are in its vicinity to divert this action.

WHAT IS THE SAFEST PLACE DURING A THUNDERSTORM?

The only place of absolute security in a thunderstorm is an iron building; or next in safety is a building properly protected by lightning rods.

Houses constructed entirely of iron manifestly stand in no need of lightning rods at all, because the electric fluid, on striking so good a conductor, would rapidly diffuse itself in all directions and flow into the ground, provided, of course, that the construction of the building is such as to allow its free escape.

ARE LIGHTNING RODS OF ANY REAL VALUE?

Unquestionably they are. Examples are numberless where the lightning has been seen to fall upon the rods of buildings and descend harmlessly to the earth; while the fact is undisputed that the principal damages suffered from lightning are in connection with buildings that are not provided with conductors. Notwithstanding these facts, some people are apt to be indifferent whether their houses and stores are provided with lightning rods or not, and are always ready to give an example where some building so provided was struck in spite of its protection. Such cases are quoted by the old fashioned "practical men" with much satisfaction, because they hail in them what they are pleased to call the victory of their sound common sense and the discomfiture of the scientific man. This class is, however, rapidly diminishing in numbers under the influence of the extensive diffusion of scientific education among the people.

It may be well to assure unbelievers that the efficacy of the lightning rod is no longer an open question, and that any

SEPTEMBER 5, 1874.] Scien Amer

failures are attributable *to bungling or ignorant construction*. It would be an easy matter to multiply statistics in proof of the assertion; but none would carry with them more force than the following statement obtained from the records of the British navy, by Sir Snow Harris, F. R. S:

"Between 1810 and 1825, before rods were introduced, no less than thirty-five sail of the line and thirty five frigates and smaller vessels were completely disabled; and in 200 cases recorded, 300 seamen were either killed or injured. When the lightning rod was introduced, every mast was furnished with a capacious conductor permanently fixed and connected with bands of copper passing through the sides of the ship under the deck beams, and with large bolts leading through the keel and keelson, and including, by other connections, all the principal metallic masses employed in the construction of the hull" (Harris) Since the adoption of this arrangement, "it appears that damage by lightning has positively vanished from the records of the navy."

In England, the various telegraph companies suffered serious damages by every thunderstorm, by the destruction by lightning of their poles. The poles are now provided with small lightning rods, and all damage has ceased.

In this country the Western Union Telegraph Company has suffered in the same manner, especially, says a recent number of the *Journal of the Telegraph*, "upon the plains and prairies, where every lightning storm formerly shattered and destroyed more or less of our poles, but which are now fully protected by a conductor (No. 8 wire) placed on every fifth pole. Wherever telegraph poles are provided with such lightning rods, all damage is prevented. Where the poles are not provided with rods, damage ensues.

WHAT IS THE PROPER SIZE AND MATERIAL FOR HOUSE LIGHTNING RODS?

According to the best authorities, a copper rod of one inch in diameter, or an equal quantity of copper under any other form, will resist the effect of any discharge of lightning hitherto experienced. The copper rod is therefore the safest and best material that can be used, but it is expensive. Iron rods of one inch in diameter are very commonly used, and, if pointed with solid copper and properly put up, are efficacious in the great majority of cases. The particular form of the rod makes no difference. It may be round or square, twisted or hollow, composed of one solid piece or made of wires twisted together. It is the quantity of metal contained in the cross section of the rod that is of value, not the form.

WHY SHOULD THE ROD BE POINTED?

The reason for terminating lightning rods in a point is as follows: When a thunder cloud highly charged with positive electricity comes up, it repels the positive electricity of all bodies on the surface of the earth coming within its influence, and causes negative electricity to accumulate in them. This is called induction, and it always takes place before a discharge. Now it has been discovered that, when electricity is accumulated in a body in this manner, it can most readily escape by sharp points because in them it meets with the least resistance. A lighted candle held near the prime conductor of an electrical machine furnished with a point will be nearly blown out by the current of air produced by the escape of the electricity. Lightning rods are therefore provided with sharp points to allow the accumulated negative fluid to pass off readily into the air and neutralize the positive fluid of the thunder cloud.

HOW SHOULD RODS BE MADE AND APPLIED?

The object being to make so good a passage for the lightning to the ground as to remove all danger of its leaping to some conductor in the house, the greatest care must be taken not to have any break in the conductivity. As it is inconvenient to manufacture or transport the rods in one piece, the different parts must be in intimate connection when they are put up; it is best to have them soldered and the joints protected from the air and moisture.

The point of the rod should be extended a little above the chimney or highest part of the building, and should be fastened in contact with the building by staples or cleats. Glass insulators should not be employed. It makes no difference in conductivity whether the rod is painted or not painted.

No building can be said to be properly rodded or protected against lightning, unless the lower part of the rod or terminal under the ground is made quite extensive. The extremity of the rod should connect with masses of good conducting materials, such as old iron, or iron ore, or coke, or charcoal, laid in trenches, or the rod itself should be elongated, sunk deep in the ground, and carried a considerable distance from the building, and put in connection with water or moist earth if possible. The golden rule for safety is: "Provide the largest possible area of conducting surface for the terminal of the rod."

Scientific American. Vol 23, 1875

Origin of Atmospheric Electricity.

According to M. Bécquerel, solar spots, which are sometimes 16,000 leagues in extent, appear to be cavities by which hydrogen and various substances escape from the sun's photosphere. But hydrogen, which appears here to be only the result of decomposition, takes with it positive electricity, which spreads into planetary space even to the earth's atmosphere and to the earth itself, always diminishing in intensity because of the bad conducting power of the successive denser layers of air and of the crust of the earth. That would then only be negative, as being less positive than the air. The diffusion of electricity through planetary space would be limited by the diffusion of matter, since it cannot spread in a vacuum.

That gaseous matter extends further through space than the distance which is generally assigned to the earth's atmosphere will be proved by the fact that auroras, which are due to electric discharges, are produced at hights of 100,000 and 200,000 yards, where some gaseous matter must exist.

M. De la Rive agrees with M. Bécquerel as to the electrical origin of the aurora, but considers that the earth is charged with negative electricity, and is the source of the positive atmospheric electricity, the atmosphere becoming charged by the aqueous vapor rising in tropical seas. The action of the sun, he considers, is an indirect action which varies with the state of the sun's surface, as shown by the coincidence in the periods of aurora and sun spots.

In the accounts of travelers in Norway, we often read of their being enveloped in the aurora, and perceiving a strong smell of sulphur, which must be attributed to the presence of ozone. M. Paul Rollier, the aeronaut, who descended on a mountain in Norway 4,328 feet high, saw brilliant rays of aurora across a thin mist which glowed with a remarkable light. To his astonishment an incomprehensible muttering caught his ear; when this ceased he perceived a very strong smell of sulphur, almost suffocating him.—*Manual of the Natural History, Geology, and Physics of Greenland.*

LIGHTNING CONDUCTORS.—At a recent meeting of the *Académie des Sciences*, M. Saint-Edmé gave some interesting information on lightning conductors. If not thorough conductors throughout their whole length, they are far worse than useless, for, in such a case, they attract the lightning and then allow it to escape by a channel which offers less resistance, to the great danger of the edifice; it is, therefore, necessary that the condition of these appliances should be inspected at certain intervals. The author, while endeavouring to find a suitable method of ascertaining automatically any loss of conducting power, has introduced a great improvement into the manufacture of lightning conductors themselves. This consists in making the iron rod in one length, and by electro deposit, giving it a thick coating of nickel, which is an excellent conductor of electricity.

Eng. Dec 75

(25) E. G. A. says: I am continually seeing statements to the effect that, during a thunderstorm, the electricity passed down the lightning rod, escaping into the ground. Is not the reverse the case? Does not the electricity pass from the earth up the rod and neutralize the electricity of the cloud overhead? If not, why not put a ball on the upper end of the rod and point the lower, for has not experiment demonstrated that electricity will flow off a point with more rapidity than off a round surface, and the reverse in passing on? If this be not the case, what is the necessity of placing balls on the posts of an electrical machine and points on the ends of the spokes of an electrical wheel? A. It is conventionally assumed that the current always passes from positively to negatively electrified bodies, so that what we call its direction depends altogether upon which is the positive and which the negative body. As a matter of fact, the atmosphere is usually positive relatively to the earth; but it is evident that the action of the clouds upon each other, under the influence of different currents of air, may result in charging them with opposite electricities. When the conditions are favorable, they then act inductively on the earth, the positive cloud inducing a negative charge in the portion directly under its influence, and the negative cloud a positive charge. If a rod is present or the degree of electrification is sufficiently great, a discharge takes place from the earth to the cloud in one case, and *vice versa* in the other. It is not correct, therefore, to say that the discharge is always in the same direction when referring to any one rod. Points receive and give off charges more readily than surfaces do. It is in consequence of this fact that round surfaces are used with the electrical machine, and points with lightning rods, the object being an accumulation of electricity in one case and its dissipation in the other.

The Electrical Condition of Air in the Arctic Regions.

Scien. Amer 1 Mar 1875

M. Vikjander, during one of the recent Swedish expeditions to the arctic regions, made extended investigations into the electrical condition of the air there existing. All of his observations agree in showing that the atmosphere conducts electricity at temperatures relatively high, a circumstance to which may be attributed the absence of thunder and the presence of the aurora borealis. It has been suggested that this is due to the great humidity of the air in such regions; but it is evident that the phenomenon must be ascribed to other causes, since the same temperature and the same degree of humidity do not produce a like effect in lower latitudes. At less temperatures, —4° and —13° Fah., and below, the air isolates better.

Generally the arctic atmosphere appears to be positively electrified, and the earth negatively. In several instances, the air was effectively electric of itself, and this not due to terrestrial induction. During certain periods of the spring, at a time when the air isolated relatively well, both ground and air were charged with negative electricity. This change of electrical state of the atmosphere was not a constant consequence of greater cold; but when the temperature had been lowered for some time, the air had an evident tendency toward a negative condition.

There seems to be a natural connection between these facts and the aurora. During the months of January and February, the latter phenomenon appeared daily, and was especially noticeable on the 10th and 26th days of the latter month. It then disappeared, to reappear, however, on the 2d of March.

At the same time, changes in the electricity of the air were observed, suggesting the theory that the negative electricity, deprived of the possibility of discharging itself into the aurora, was obliged to accumulate in the lower atmospheric strata, which isolated relatively well. From the 2d to the 11th of March, the aurora returned; and during this period the air was in a good conducting condition, or else, when effecting isolation, was positively charged. Subsequent to the latter date, the auroras ceased entirely, and an interval supervened, of low temperature with negatively electrified air, which lasted until the increasing light of the season of the year precluded further auroral observations.

28. Scientific American

LOOK TO YOUR TERMINALS.

A lightning rod which is not properly connected with the earth is quite dangerous. The very common method of merely sticking the lower end of the rod down into the dry earth near the surface of the ground is bad, and endangers the building, because dry earth is such a poor conductor, and the amount of rod surface in contact with the earth is so small. Under such conditions, a portion of the electric current will be likely to find an easier path to the earth, through the building than through the rod; and a part of the electricity will therefore leave the rod, strike into the building, and down in various directions into the earth, making havoc as it goes. As a measure of prudence, house owners should *look to the terminals* of their lightning rods, and place there a considerable amount of the conducting materials above named.

By adopting this simple expedient, many buildings, otherwise unsafe, will be rendered comparatively secure from damage by lightning.

As an electrical conductor, well burnt charcoal ranks next to the metals. Metallic ores come next to charcoal. Water and moist earth, which are so frequently recommended as terminals for lightning rods, are among the poorest of conductors.

One of the best protected buildings that we have heard of is that of Mr. John Knox Smith, an intelligent English merchant residing at Singapore. His country house is built on a prominence, upon a bed of iron ore, with which the house lightning rods are made to communicate. The lower ends of the rods thus have a very extensive conducting surface, and the protection afforded is considered perfect. Thunder storms and lightning strokes are very frequent, but the house has never been injured;

PROTECTIVE AREA OF RODS.

It was supposed to have been established by Charles and Gay Lussac that a lightning rod protected an area whose radius was double the hight of the rod extending above the building, but this rule is no longer reliable by reason of the extensive use of metals in the shape of pipes, etc., in the construction of the buildings of our day.

WATER AND GAS PIPES SHOULD BE CONNECTED WITH THE LIGHTNING ROD.

When electricity finds several paths to the ground, it will prefer the best, it is true; but some portion will also pass along the poorer conductors. If, therefore, any metallic substances lie within the area supposed to be protected, they are in danger of being struck. This is especially true where the lightning has a chance to jump to the gas and water pipes of a building. It is a good plan to connect these pipes with the lightning rod; if the rod is struck, the electricity will then have an excellent path into the ground and will be rapidly diffused over the vast underground network of pipes. The danger to the inmates of the house of being struck from these pipes is less than that of receiving a shock from the powerful induced currents, liable to be developed in them, if unconnected, during a thunderstorm.

IS MORE THAN ONE ROD USEFUL?

The more rods on a building the better, especially if all are connected with each other near their upper ends.

Multiple lightning conductors are useful because each one helps the others, and if the discharge is too great for one, they will be able to carry it between them, but what is more important is this: The less the total resistance of the conductor to earth, the more certain is it that no other, undesirable line will offer an approximately good path to the earth, and so get a part of the flash. Thus, suppose a single rod whose resistance is 1, and that a series of bolts, hinges, gutters, stove pipes, etc., offers another line (passing perhaps through the walls of the house or the body of its occupant) whose resistance is 2. Now, under these conditions, a flash would be likely to divide itself, and while ⅔ would go safely down the rod, ⅓ passing along the other line might burn the house or kill the man. But if two rods were connected, the resistance in this line would be but half, hence ⅘ would take this road and but ⅕ tend to go by the other. Again, the less the resistance of any line, the higher the opposite charge developed in it by induction, and hence the greater its attractive influence, leading the discharge to prefer it as a path. This bears upon the importance of connecting all accidental lines of conductors, such as gas and water pipes, with the lightning rods. Insulated, these are opposition lines, soliciting the lightning to come into house and traverse them; connected, they help the rod as we have seen to get and keep the lightning outside.

METAL ROOFS, GUTTERS, LEADERS, AND WATER TANKS SHOULD BE CONNECTED WITH THE LIGHTNING RODS.

Finally, in the way of general advice, we would say: Connect all your lightning rods together, and also to your iron tank, and water, gas, or other pipes, not by separate connections, but so that there is some connection between all, which connection should be *as high up as possible*. If you have a metal roof, connect all rods with it. If the roof is not of metal, then connect your rods together by means of a good sized conductor *running along the ridge of the roof*. Bear in mind that, to carry off the heaviest lightning flash known, a copper rod one inch in diameter is not considered too large; and though of course such flashes are of very rare occurrence, they may come. Hence the great value of uniting your different rods high up.

E.M.

BEADED LIGHTNING.

Nov '76

M. G. PLANTE, whose experiments in reference to globular lightning have recently attracted attention, describes an uncommon kind of this meteor that he observed during the storm at Paris and its environs on the 18th August, 1876, about 6 a.m. It is not yet properly classed in meteorology, and is calculated to throw a new light on the globular thunderbolt. The flashes that darted from the clouds that obscured the sky were of great length and varied form, as bifurcated, in curves with multiplied points, and with closed contours. It appeared generally composed of brilliant points like ridges of fire, produced on a moist surface by an electric current of high tension.

Some of the most remarkable passed from the cloud to the ground in the form of an elongated S, lasting for an appreciable instant, like a string of brilliant grains distributed along a narrow luminous string. Observed from the heights of Meudon, this lightning appeared to strike Paris in the direction of Vaugirard, where it fell.

This formation of luminous beads alternating with streaks of fire—a consequence of the electric fluid passing through a ponderable medium—is altogether analogous to a string of incandescent globules presented by a long metallic wire melted by a voltaic current, the extremities of which remain suspended an instant in a state of fusion at the poles of a pile or to the swellings and knots resulting from the flowing of every liquid vein. Such agglomerations of electrised and luminous matter should naturally dissipate themselves more slowly than the bolt that develops them, which explains their persistence in this case.

This kind of lightning shows the transition from the ordinary sinuous or rectilinear lines to the globular form. It may be conceived, in fact, that if the electric condensation upon some points of the lightning is more considerable, the beads may acquire a certain volume, and give birth to globules remaining some time visible.

M. de Moncel records a similar phenomenon during a storm in London on the night of the 19-20th June, 1857, when several flashes persisted for some instants, and only disappeared after being, as it were, melted into granular light. M. Planté considers we may unite these examples of lightning under a particular character, and classify them as "beaded lightning" ("éclairs en chapelet.")

M. Trecul also observed some curious effects during the same storm, whilst occupied writing between 7 and 8 o'clock before an open window. At the time of the nearest flashes small luminous columns descended obliquely on his paper. The length of one of them was about ⅕ metres, and the breadth of the largest ½ decimetre (0·15m.) One more particularly under notice, the one obtuse at the farthest extremity, became attenuated gradually, and was only from 3 to 4 centimetres wide at the surface of the table. Their appearance was that of inflamed gas with badly defined contours; their colour, of little intensity, was yellow, slightly reddish, like that of many flames; but at the surface of the paper where they were agitated for 4 or 5 seconds the tints were more lively. M. Trecul does not well remember the lower part of the first, but the second presented the lively colours (yellow, green, and blue) of the rainbow: the third was of a very beautiful blue of weak tone, almost white at the contact with the paper. No detonation took place, but there was a feeble rustling when the fluid was just about leaving the paper, a noise something like that when a little water is spilt on a metal plate sufficiently heated. No odour was exhaled: the paper was neither altered nor spotted, the steel pen was not struck (*atteinte*), and M. Trecul felt nothing.

J. J. Lake.

Lightning Rods.

The committee appointed by the Prefect of the Seine to superintend the construction of lightning conductors in Paris has been changed into a permanent one. A sum of $40,000 has been appropriated by the municipal council for reconstructing all the lightning conductors in Paris, or at least all those which may be found defective or inefficient. This sum is a first instalment, as the whole of the work, it is supposed, will cost $250,000, although the committee do not recommend the use of copper conductors.

Until the appointment of the committee, lightning conductors were constructed by ordinary blacksmiths, under the superintendence of architects who knew nothing of physics. A competitive adjudication took place recently, between a number of competent electricians, for the construction of all the lightning conductors on the Paris municipal monuments. The successful competitor is M. Grenet, the well known electrician. A list of instructions with seventy carefully drawn provisions has been published. The continuity must be tested yearly, and the contractor will be paid by instalments; so that his claim will be cleared up only when the efficiency of his work shall have been tested during a certain number of years. The platinum cone has been abolished and replaced by a copper cone. The quality of the iron, as well as of the copper and solder, is to be tested by chemical analysis. The insulation of rods has been abolished as being useless. The committee has diminished the diameter of protection area, which was supposed to be twice the hight, and has reduced it to 1·45. The consequence is that rods are to be multiplied.—*Nature.*

TELEGRAPH LIGHTNING PROTECTOR.

By J. E. VAES.

A RING of metal (Fig. 1) about 1¼ centimetres wide, and 2½ centimetres in diameter, is cut in two. On one side the two halves are held together by means of a hinge, and on the other side they shut by means of a screw. This ring encircles a bobbin of hard wood, also cut in halves, and bored through its axis. The raised edges of this bobbin prevent the metal ring slipping off. In the interior of the ring is fixed a protecting point of aluminium, bronze, or platinum, which extends within a distance of one or two millimetres of the groove in the bobbin (Figs. 2 and 3).

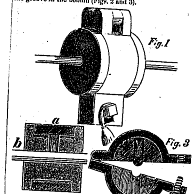


Fig. 2

To apply the protector to a telegraph wire, the ring, and with it the two halves of the bobbin (Fig. 3), are opened and placed on a wire of the same gauge as the groove in the wood. The ring and the bobbin are then closed with the screw, care being taken to pass under the head of the screw a copper wire covered with gutta percha, the other extremity of which is connected with a plate of metal attached to the bottom of the post, and making a good earth connection.

The lightning protector following all the vibrations of the wire, it is impossible that there can be a contact between the wire and the protecting point, and the point itself is excluded from atmospheric influences.

REMARKS.

1. The diameter of the groove in the bobbin should be slightly smaller than that of the wire to which it is intended to be fixed.

2. To fill up the chinks that will always exist to a greater or less extent between the two halves of the bobbin, it is sufficient to introduce, before fixing to the wire, a thin layer of gutta percha or tarred cloth. These substances, giving way to the pressure, fill up the chink entirely.

3. In case of rain, the lightning protector might give rise to derived circuits, owing to the short distance between the exterior of the metallic ring *a*, and the wire *b* (Fig. 2). Several methods suggest themselves to remedy this defect. It would be insufficient to apply a coat of varnish to the metallic parts; it would therefore be better to lengthen the bobbin so as to increase its length on either side of the ring, or even to heighten the edges of the bobbin.

Another method consists in covering the wire with an insulating material for a distance of some centimetres on each side of the protector. That which appears the simplest, and at the same time the most effective plan, is to surround the lightning protector with a covering, thus removing it from the influences of rain. Owing to its small dimensions (the protector can easily be covered with the hand), the application of this last suggestion would not be difficult.

4. It is unnecessary to say that whilst retaining all the principles on which the construction of the protector is based, it can be varied in different ways—as for instance, by replacing the protecting point by several points, or by a small plate of metal provided with teeth, etc.

5. This protector can be applied without making any special alterations to the posts. One is not limited in choice of position, and the lightning can thus be given the possibility of expending itself at a convenient distance from instruments and cables, which will find themselves in case of storms much less exposed to derived circuits.—*The Telegraphic Journal.*

July 1876

(80) M. A. G. says: We desire to put a lightning rod upon a church spire, 120 feet high. About 12 feet of the top is a galvanized iron finial, which terminates in a point covered with gold leaf. Would you advise us to carry the rod above the finial, or would it be better attached to it, so that the finial will constitute a part of the rod? If the latter is the best plan, how would you attach the rod to the galvanized iron? Would it be well to simply put the rod around one of the waists of the finial? A. The rod should be attached to the base of the finial by a firmly soldered and riveted joint, so as practically to make an unbroken connection. All joints in the rod should be firmly soldered and secured against separation. If the soil is dry, you will need a large amount of conducting material placed underground in connection with the rod. See p. 400, vol. 33.

Peculiar Effects of Lightning on Vines

At a recent meeting of the *Société Helvétique des Sciences Naturelles*, Professor Dufour mentioned a lightning stroke which in the month of June last struck simultaneously two vineyards, distant over 360 feet apart. In one, the surface affected measured 57 feet square, and included some 330 vines. In the other the surface was about 32 feet square and about 100 vines appeared to be destroyed, while others were partially so. In August, however, those vines which appeared to be the most severely injured threw out vigorous branches, and early in September were covered with new bunches of young grapes. But on the other hand, those grapes already started, and which, had the lightning not intervened, would have formed the year's crop, ceased all development.

In his treatise on lightning, Arago cites, as remarkable facts of rare occurrence, lightning strokes apparently divided into two or three branches. Here, however, the lightning divided into two branches to strike vineyards considerably distant from each other, and then the branches must have produced 330 and 100 jets respectively in order to strike the separate vines.

LIGHTNING CONDUCTORS.— Messrs. R. S. Newall and Co., of the Strand, London, the well-known lightning-conductor manufacturers, have, we understand, entered into a contract to supply their copper-rope lightning conductors to the South African International Exhibition buildings which are to be opened at Cape Town on the 15th of March next.

Construction of Lightning Protectors.

"Whether the point of a lightning conductor is made of platinum or of copper, or whether it is sharp-pointed, as suggested by Franklin, or presents an angle of 30° in accordance with the latest notions, however great may be the care taken in welding the metals, it is certain that in this respect the mode of construction is defective as regards conductivity, and it is to be feared that the conductivity is diminished by the action of the weather. But it appears further to be demonstrated that it is at the joint that a lightning protector is most often destroyed; it is there the discharge takes place.

"At first, Franklin proposed that the conductor should be made of one metal only. It is owing to the rapid oxidization of iron that the successive commissions have proposed to modify the nature of the extremity of the conductor. We think that it is possible to return to the original idea, since it is known how to cover iron with a metal (nickel) which forms on its surface a film perfectly protecting it from oxidization, and possessing the necessary conductivity.

"We have experimented with the conductivity of nickel spread over a rod of iron. The nickelized surface indicated a rather higher conductivity than the mass of iron; it resisted better the electric discharges given off by a powerful battery. This same rod, after being immersed in water for 10 days, did not indicate any alteration, and the electric conductivity remained the same.

"We think, then, that, in the future construction of lightning protectors, it would be expedient to do away with the copper or platinum tips, the termination being made of a single piece of nickelized iron, in the same way as the conducting rod is made.

"The lightning protector would thus become a safeguard against electric discharges, and, owing to the preservation of its point, would always possess the same protective effect.

"Again, the conductivity would remain constant, and the necessity of supervision be done away with. This last condition is of great importance, as illustrated by General Morin. According to him, it is desirable that you should be able to verify automatically the condition of the lightning protector as regards conductivity. In fact, every one knows that, if the conductivity is defective, the lightning protector becomes a source of danger."—*E. Saint-Edmé.*

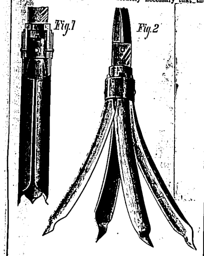
Lightning.

The celebrated experiment of Benjamin Franklin, by which he demonstrated the identity of lightning and the common electric spark, was performed by him in June, 1752, at Philadelphia, Pa. Having made a small cross-stick kite, he covered it with a silk handkerchief instead of paper, so that it would stand rain, attached a tail, etc. The upper end of the cross had an iron point, connected by a string to the usual kite cord, which was of hemp. To the lower end of the cord an iron key was attached, and to that a short length of silk ribbon, as a non-conductor, by which the kite string could be safely held in the hand. On the approach of a thunderstorm he proceeded to a common near the city, and, with the assistance of his son, sent up the kite. Ere long the thunder cloud approached, the electricity came down the kite string, and Franklin, standing under a shed, received the electric sparks through his knuckles which he applied to the key, and charged his Leyden jar by putting its conductor in contact with the key. The rain then fell, which improved the conductivity of the kite cord, and the electricity appeared in increased quantity.

The news of this wonderful experiment rapidly spread over the world, and was extensively repeated. In France, Professor Romas made a kite seven feet high, with a fine wire interwoven in the string. The kite was raised five hundred and fifty feet, and is alleged to have yielded flashes of electric fire ten feet in length. In St. Petersburgh, Professor Richman, while attempting to repeat Franklin's experiment, received so heavy a charge of electricity that he fell dead. This was in 1793.

WESTON'S LIGHTNING ROD DISCHARGING POINT.

In order to render lightning rods of any efficacy as a protection to a building, it is absolutely necessary that the



ground terminals shall be large, and sufficiently so to discharge all the electricity from the rod. The object of the device illustrated herewith is to secure an extensive metallic surface in contact with the earth, with comparatively little cost and trouble.

The device consists of four metallic arms, formed as shown and riveted about a central socket. When closed, the point appears as in Fig. 1. To attach it to the lower end of the ground rod, the pivot of the latter is inserted in the socket and the nut screwed on from the inside, as represented in the broken away portion in Fig. 1. A hole is then made in the earth with a crowbar, and the point, with the section of rod attached, inserted. When at the bottom, by forcing the rod down, the sheets or arms of the point will spread out as in Fig. 2, thus giving a large discharge area. The nut which connects the lower section of the rod with the point is left loose, so that the former is allowed to turn when screwing it into the section above. To attach the point to cables, a zinc ring is first put on, then the discharger, and then another ring near the end of the rod. The discharger and upper ring are slipped back to their proper position and fastened with set screws.

Patented through the Scientific American Patent Agency, March 7, 1876. For further information address the inventor, Mr. J. H. Weston, 20 West Sixth street, Cincinnati, Ohio.

Scientific American.

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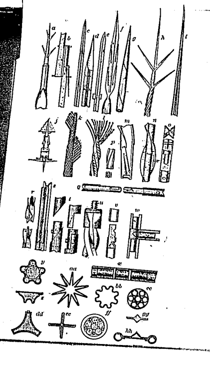
LIGHTNING RODS,

which may be described as follows:

a has a series of points formed of spiral coils, combined with a tubular portion, forming the tip. The conductor is a flat strip. *b* is a jointed tubular conductor for vessels. It is divided at the head of the lower mast, a branch leading down the shrouds on either side to the water. *c* is an iron rod tipped with copper, the point of which is gilded. *d* has a central copper slip inclosed between iron side pieces; the points of connection have interposed zinc plates. At *e* the iron rod is grooved to receive a copper slip. The joints are secured by screw-threaded washers. At *f* the point is formed with two opposite wings. The rod, *g*, is composed of a single strip of copper wound spirally so as to form a tube. *h* is composed of several strands of wire laid together so as to form a rope, and having several tips. The point, *i*, is formed of three or more metals inclosed one within the other, the most fusible outside. *j* is an insulating attachment with additional conductor points at the coupling of rod sections. *k* is a copper cable, composed of a central wire rope and two exterior strands laid up in opposite directions. *l* comprises two or more copper wire ropes intertwined with an equal number of iron rods. *m* is a series of metallic strips, forming a tube, are joined together. *n* is a metallic strip, doubled up or corrugated so as to form a tube with spiral flanges. At *o* the joints of the rod are coupled by pieces cross shaped in section and secured by rivets and bolts. *p* has four twisted rods with wire warming. At *q* the tubular sections are united by short pieces, slotted inside so as to form a species of bayonet joint, and held by pins. *r* is composed of two strips of sheet metal, riveted together at their angles and twisted spirally. The strips in *s* have slots through which staples fasten them. *t* is connected by short pieces fastened by pins, *u* is an exterior cable stiffened by a spirally flanged core, and the sections of *v* are secured by plugs fastened by indenting the tubes into suitable depressions. At *w* the sections are coupled by an interior cylinder and a tapering plug projecting from each of its ends. At *x* an interior tube with

Fig. 6.



An inquest has been held on the body of William Stevens, killed by a telegraph wire at Islington. It appears that the wire broke before the accident, and that a gentleman, with the best intentions, made fast the end to some railings, but left it hanging across the omnibus yard, and that the poor deceased drove at a trot against the wire. The evidence given on behalf of the post office is stated to be to the effect that "the wire in question would have been taken down next year because of its being worn out. It would have lasted till then but for the violence of the storm." This does not seem very satisfactory. If all the other wires over head are run to within a year's estimate of their life, every heavy gale must bring some down, even if their life can be estimated to a year by the most competent judges. Apr 76

EFFECT OF LIGHTNING ON TREES.

A Swiss savant named Colladon has made some interesting observations in regard to the effect produced on different kinds of trees by lightning. In the neighborhood of Geneva Lake, where these observations were made, the poplar tree suffers least from lightning, seeming to conduct it away rapidly. Oaks, when struck, lose the tops. Elms are as little injured as poplars. Colladon has found that *young* pear trees recover from the effects of lightning, but old ones die, which seems to be a proof that young trees are better conductors. The practical conclusion that he draws from this is that poplar trees may serve for lightning rods when planted near houses, provided care be taken to connect the lower part of the trunk with a well or moist ground by means of a strong metal plate buried in the earth. Without this precaution the electric current may leave the tree and take another direction. This happened in one case, where it took an oblique course through a house in order to reach a neighboring puddle. If the ground water is not very deep, this is not necessary, as on river banks and in valleys.

FREAKS OF LIGHTNING IN ITALY.

Correspondence of the London Echo. 77

ROME, July 12.—Padre Secchi publishes an account of the singular phenomenon which occurred at Velletri during the violent thunder-storm of June 28, and which is to be ranked among the hitherto unexplained caprices of nature. Just as the tempest was at its hight, and the rain torrential, six persons taking shelter in a stable, which was also occupied by three horses harnessed to as many wine-carts, witnessed the extraordinary appearence. A luminous mass rose from the threshold of the door, entered the stable, glided from one cart to another, attracted, probably, by those fringes of bells characteristic of the Roman wine-carts, and then passed through an iron grating into the street. The bells rang, the horses plunged, a woman and a man felt a certain giddiness of head; but no accident happened. Outside the stable, a carpenter at his shop-door saw the luminous mass (which some of the witnesses compared to a fiery club as thick as a man's arm) issue from the grating, the pavement, and disappear in a dazzling flash. However, the meteor visited several portions of the large house with which the stable was connected, flew through large chambers, blackening slightly a gilt cornice in one, and scattering fragments of plaster in another. Strangest of all, this extraordinary visitor, after completely destroying the new ceiling of a room leading into a vast kitchen, danced round a woman who was standing at a table. She described the meteor as a fiery serpent, which she first saw standing upright on the floor, within two metres' distance of her. Then it flew toward her whirling several times around her knees with great velocity. She felt a sudden blow on the head and fell to the ground; but her husband, who saw the whole apparition, on rushing to what he supposed was the corpse of his lightning-destroyed wife, found that she was only stunned a little. On recovering, she complained of pain in the scalp, and her hair had become and remains, dry and rigid. After this last caprice the meteor disappeared, and from the quantity of soot which fell from the chimney, it is supposed to have found vent in that direction. It was accompanied by a loud detonation, but whether on its first appearance, or when it vanished, none can say. These details are gathered from a letter written to Padre Secchi from the Meteorological Observatory at Velletri, and published in the *Voce della Verita* of July 9. After this one may believe that Tanaquil really did see a "lambent flame" play around the head of Servius Tullus in his cradle; nor can the tale of the stars playing on the River Moldau at Prague over the body of St. Jean Nepomuc be so certainly set down as a pious fancy of the Middle Ages, unsupported by natural phenomena.

[28010.]—**Lightning Conductor.**—I would not use gas-piping unless fully 1in. Better by far to use copper rod or rope made of a thickish wire. The ends are better tipped with some non-oxidisable metal; this will make the conductor last longer. The great point in lightning conductors is not so much the top as the bottom. I would run the rod down into the earth, and connect it with a large plate of iron or copper placed in some damp spot, into which occasionally the rain might run, so as to keep a good connection between earth and rod.—W. J. LANCASTER.

STRUCK DEAD BY LIGHTNING.

From the Sioux City (Iowa) Journal. 77

While the thunder storm of yesterday afternoon was raging at a distance of apparently a couple of miles from this place, a singular freak of nature took place in the striking by lightning of the depot, and the striking and killing subsequently of J. H. Boyer, the postmaster and blacksmith of this place. At about 5 o'clock in the afternoon, at which time not a cloud obscured the sky overhead or stood between the sun and the town, a terrible flash of lightning, followed by a deafening peal of thunder, struck the wires of the telegraph office and set it on fire. The damage done to the telegraphic apparatus was most complete, the wires being torn to pieces and the different instruments being almost without exception distorted and broken and completely wrecked. Immediately after the stroke John H. Boyer, who was in his shop at the time, ran out in the street toward the depot, where some boys had been playing. He approached them rapidly and said, "Why, boys, I thought some of you had been struck. I was frightened on account of you." He evidently had it in his mind that the terrible shock might have frightened his family, as he started toward his home immediately. When within about fifty yards of the house, from the front window of which his wife was anxiously watching his approach, another vivid flash of lightning dazzled the eyes of all, and ere the thunder had ceased rolling the naked body of the unfortunate man was seen to be lying prone upon the ground. A number of people, among them his wife, rushed to the spot, and so horrible was the situation that it was not until he had been carried to the house that a full appreciation was had of the terrible death which nature had inflicted upon him. An examination of the body, from which every vestige of clothing, not excluding even a pair of cowhide boots, had been instantly torn, showed that the subtle and terribly fatal fluid had first struck him on the top of his head, whence, though the skull was left apparently intact, the hair had been burned off for the space of the size of a silver dollar. Thence the fluid had run down the side of his face, as was shown by a clearly cut track, to the shoulder, and thence to the heart, where it apparently had spread all over the body.

The terrible power of the fluid was shown by the presence in the ground, on the spot where the unfortunate man's body had been picked up, of a hole eight feet deep by actual measurement. The clothing of the deceased was found to have been shredded and when first discovered was on fire, while the silver watch he carried had been driven into the ground, and when lifted up, it was found that the works had been fused into a lump of shapeless metal.

BALL LIGHTNING.—A very fine display of this interesting meteor was witnessed at Vence, in the south-east of France, on the night of March 21-22, by M. Ed. Blanc, of which an interesting detailed account has just appeared in the *Comptes Rendus* of the French Academy, p. 666. Toward midnight there was observed, about eleven miles north-east of Vence, a large black thundery cloud, in a state of extreme agitation, and continually raising and lowering its position. At the upper part of this cloud three or four balls of fire issued every two minutes, as if from the invisible centre of the cloud, diverging in all directions, and after running a course of from six to eight degrees, broke silently with effulgent brightness. Their apparent diameter, as seen at a distance of eleven miles, was about a degree. They were mostly of a reddish colour, a few, however, being of a yellowish tinge, but all of them assumed a white colour in the act of bursting. Their course, which was horizontal and parallel to the plane of the cloud, was relatively slow, not exceeding two degrees per second, and they bore a strong resemblance to immense soap-bubbles, both as regards apparent lightness and general appearance. From time to time a discharge of lightning passed through the cloud from above downwards, followed some seconds after by a dull rumbling sound. The cloud, with its fine display of fire-balls, took a course from east to west, passing about a league to the north of Vence. The glimmering of the lightning with its low dull thunderous sound continued for more than an hour, after which the sky became darker and darker; rain mixed with hailstones fell, and lightning, accompanied with thunder, furrowed the sky in all directions. 77

A new electromagnetic lighting instrument has recently been described in *Dingler's Polytechnisches Journal*, by M. Hess. It consists of a chromic-acid element, a small induction coil, and a vessel containing a mixture of alcohol and sulphuric ether. The pressure of a knob puts the zinc of the element in contact with the liquid, and the small induction sparks inflame instantaneously the vapours of ether liberated from a sponge, which has been dipped in the mixture of alcohol and ether. According to the inventor this instrument has the advantage of lasting a long time without requiring any attention. 77

ASCENDING LIGHTNING.

[11887.]—MAY not "J. T. M.'s" experiment (letter 14738, p. 601) be an illusion itself? If the electric spark be limited to the apparent time a flash of lightning is seen by the eye, he might see (perhaps impossible) the spark begin and end its career.

Now, suppose lightning to be visible for the space of, say, one minute, an observer would see it travel downwards or upwards, as the case may be, at the beginning of the flash; but soon after would be unable to say which way the fluid was travelling. It would seem to proceed from that part of the flash his eyes were directed to; but as the beginning of a flash is followed almost instantly by its disappearance, an observer would be able to say whether it rose upward or downward. I therefore think "F.R.A.S." really saw an upward flash.

G. W. B.

32 34

SCIENTIFIC

THE CAUSES OF ATMOSPHERIC ELECTRICITY.—In continuation of an article under this head, on page 38 of our volume for 1876, we will now give some additional detailed explations of the Northern lights by M. Luthstrom, as published in the *Archives de Genera.*

The phenomena of very extensive northern lights extending over a large space, are usually produced as before explained; but the same phenomena can be produced in another way. Let us imagine that a cloud, charged by induction from the earth with +E below, and −E above, be driven by the wind from the southern countries toward the Polar regions; it may happen that the +E of the lower part of the cloud is discharged slowly into the earth without luminous effects, while the +E of the space of rarefied air combines with the −E in the upper part of the cloud with the production of light. This was repeatedly observed during the Swedish Polar expedition of 1868; it happened that the upper borders of the clouds were luminous, and this form of the phenomenon developed itself especially in a brilliant manner during a tempest on the ocean near Van Buren Island.

It is evident that the nature of the surface of the earth in those countries where the aurora borealis takes place has a great influence on the phenomenon. If the surface is equal and level, the passage of the current will be made more easy. A surface covered with snow and ice must be very unfavorable to the electric currents, but it contributes to augment the tension before the neutralization commences, and it is for this reason therefore that the northern lights mostly appear in winter. They are nevertheless often seen at the end of the summer or at the beginning of the autumn.

A singular case was observed during the expedition in Lapland, in 1871–72; the aurora showed one single ray, which raised itself above Mount Suosmavaara, where, for the abduction of electricity, an apparatus had been erected, composed of fine points of copper, put in communication with the earth. Though it is not certain, it seems very probable that the ray was caused by the presence of the apparatus in that locality.

The measures which have been taken to determine the hight of the Polar auroras above the earth, have only given approximate results, which are still sufficient to determine that it is truly above the layer of air in which the conducting power is at its maximum. Usually the lower border of the bow of the aurora borealis has been fixed at about 50 miles above the surface of the earth, that is to say, more than double the hight of the best conducting layer of atmospheric air which we have considered. It has been found that this hight varies greatly. The Polar aurora in the northern countries can even become as low as the region of the clouds. The experiments made with the Geissler tubes prove that a luminous effect can be made at a pressure of 1¼ inches mercurial column, and if the air contains enough moisture, at 5 to 6 inches, if the electric charge is only strong enough. This is not the case with the earth, for its electric tension is very small, but its great surface fully compensates for this. Experiments with different spheres have shown that a greater sphere with the same charge illuminated a Geissler tube at a distance at which, with a smaller sphere, there was no more effect. The hight of the aurora borealis is, in any case, small compared with the radius of the earth; but even if the distance of the aurora borealis from the earth was to be brought to 60 to 80 miles, that would not affect our theory, for though the conducting power be at its maximum at a pressure of three 16ths of an inch, it does not prove that a luminous phenomenon must show itself more readily at that pressure. This depends upon the heat developed by the current which illuminates the molecules of the gas; and this can be done by a much weaker current when the gas is rarefied, for then the quantity of heat needed is much smaller.

The great distance of the arc of the rays of the aurora from the earth shows thus that atmospheric conductibility extends to a considerable distance towards the higher regions. The phenomenon begins usually in the lower conducting layers of the rarefied atmosphere, (the regular way is to begin with an arc which extends itself upward by rays of undulating light.) It is therefore the lower parts of the conducting air layer which play the principal rôle. The currents which pass the upper layers are undoubtedly caused by the equilibrium being destroyed by the currents which go to the earth from the lower layers. These layers seem to neutralize themselves soon enough, to judge by the short duration of the rays of the aurora compared with those of the arc itself, which proves besides that they have only a secondary importance, the principal phenomenon remaining—the electric current of the atmospheric conductor through the intermediate layer toward the earth.

We will also say a few words concerning the double periodicity of the aurora borealis—the one of 10 years, the other of 60 years, which seems well established through the labors of Weld, Loomis, and others. The theory which we have advanced is the result of the hypothesis that the aurora is a phenomenon belonging entirely to our globe, and is produced by forces which have their seat in the earth itself. The system of the two conductors, the earth and the rarefied air, does not exclude the possibility of a direct electric influence from the sun and the planets, which has been looked upon as the cause of the periodical variation; but the supposition of such a direct influence becomes only necessary when meteorology proves that such a periodicity does not exist in the phenomena which have their cause in the heat of the sun, as, for instance, the cyclones and the tempests; when, on the contrary, that periodicity is proved, it would in that case prove a relation with other phenomena, as the quantity of evaporation on the surface of the earth and the periods of the aurora should be considered as a consequence of the periodicity of said meteorological phenomena, a periodicity the cause of which should be looked for only in the changes of the sun, indicated by the corresponding periods of the spots on that body.

The solution of this latter question seems important in regard to the study of the electric phenomena on the earth and in the atmosphere, because the possibility of discovering the correct laws governing these phenomena vill then be greater.

33 37

Lightning Rods—How the Centennial Buildings were Protected.

.. the Editor of the Scientific American:

Your recent articles upon lightning rods supply much-..eded information relative to the most important requisites .. protection. The following system, as applied to the Cen-..nial Machinery Hall, combines great economy with the ..st perfect protection and security, and may frequently be ..opted with advantage for large buildings.

The tin roof of Machinery Hall has an area of 14½ acres, .. this is utilized as a lightning conductor in this manner: ..ing above the roof are 100 wood terminals (used as flag ..es), to each of which is attached a copper wire rope ⅜ inch ..iameter, its upper end rising a few inches above the top .. pole; at its lower end the wires are spread out, and 3 .. of its length is firmly soldered to the tin roof. Earth ..ons from this massive roof conductor are made at ten ..erent places by soldering one end of copper ropes to the tin .., the other end being firmly attached to 8 inch city water ..s in the ground. Thus it will be seen that every square .. of this huge building is covered and thoroughly pro-..by an ample conductor; and it is believed there is no ..g in this country so perfectly protected as this. The ..st was only one tenth the amount requisite to protect ..e usual way with rods, or less than $50 per acre.

..connections being all-important in all cases, I would ..mend the following for country buildings: Extend the ..g rod underground, say 20 or more feet from the ..; fasten and solder to its end a sheet of copper 2 by .. dig a pit 3 by 6 feet, and 4 to 6 feet deep; put 2 .. in depth of finely broken charcoal over the bottom, .. in the plate and rod, with another layer of charcoal ..w inches of earth; then fill up to surface with loose stones, leaving it so that the rainfall can freely find ..ay down to the copper plate; water from the roof may .. into the pit. One such earth termination is of more ..an half a dozen of the usual kind.

..delphia, Pa. J. D. RICE.

Nature March 15 1881

31

Lecture Representation of the Aurora Borealis

I HAVE recently employed a simple device for giving to an audience a vivid idea of an aurora, and that has been to paint a representation of it with Balmain's luminous paint. When dry the drawing may be hung up in the lecture-hall and covered with black tissue-paper until required. At the appointed time the lights are lowered, the tissue-paper withdrawn, and magnesium wire burnt in front of the painting. I had last week the pleasure of showing this to an audience of 500 persons, and from the expressions of curiosity and approval found it to be a very taking experiment.

WM. ACKROYD

Sowerby Bridge, March 10

SOME EARLY EXPERIMENTS WITH LIGHTNING.

SIGAUD DE LA FOND compared him who should attempt to capture the lightning and to use it for electrical experiments to the ancient hero who, cuirassed in triple brass, was the first to trust his life to the hazard of the waves. Benjamin Franklin proposed the risk. In a letter written in 1750 he says, "In order to decide whether thunder clouds are or are not electrified, I propose to construct on the summit of some lofty tower or steeple a kind of sentry box (see Fig. 1, for which with the other engravings here given we are indebted to *La Nature*) large enough to contain one

FIG. 1.

man and an insulating stool, and to keep both well sheltered and dry. If from the middle of the stove there starts a bar of iron, curved toward the door, then carried vertically upward for twenty or thirty feet and terminating in a sharp point; by means of this conducting rod the man standing on the stove may be electrified by the low flying storm clouds. If there be any danger to fear for the man, although I am persuaded that there is none, he must step off the stool, stand on the floor of the sentry box, and every now and then bring near the bar a hook of brass wire which leads up to the metal covering of the roof. With this apparatus, if the rod becomes electrified, the sparks will pass from rod to wire without touching the man."

D'Alibard, an amateur in physics, had the boldness to carry Franklin's suggestion into execution. At Marly-la-Ville, he says, in a memoir read before the French Academy of Sciences in 1752, in a meadow on elevated ground he erected an iron rod about an inch in diameter and forty feet in length, having a steel point. A triangle of three posts, thirty feet or so in height, was erected, two posts being attached to a garden wall and the third standing alone. All three were strongly braced by beams and cordage. Against the wall the sentry box was arranged, the insulating stool being merely a piece of plank supported by four wine bottles. The arrangement is exhibited in Fig. 2, which is a fac-simile of a wood-cut of the period. The iron rod was attached to the posts by silk cords, and its lower end bent twice so that the water should not flow down to its base, was connected with the insulating stool. Horizontal pieces, *h* and *i*, were used to shelter the silk cords. The protecting device for the observer was simply a piece of brass.

On May 10, 1752, an old soldier named Coiffier, probably as ignorant as was Alibard himself of the dangers of receiving a lightning stroke *via* the rod, noting the advance of a thunderstorm determined in the absence of Alibard to experiment on his own account. Accordingly he mounted the stool, presented the wire to the rod, and obtained a fine spark; then another even more brilliant. He at once called all his neighbors, and some one ran in search of the parish priest. The latter was seen making his way to the apparatus in such undignified haste, that it was immediately surmised that the daring Coiffier had fallen a victim to his bold experiment, and accordingly the good father found himself the leader of a miscellaneous mob of villagers. Regardless of the pouring rain and hail, the crowd surrounded the machine and there in open-mouthed wonder watched the priest himself draw sparks from the rod. But both the clergyman and the soldier managed to get lightly struck—so slightly that in their absorbed attention to the sparks they scarcely noticed the occurrence until afterwards, when each, feeling stinging

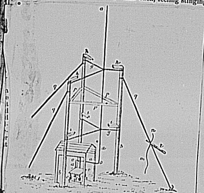


FIG. 2.—FIRST LIGHTNING ROD PROPOSED BY FRANKLIN.

pains in their fore-arms, searched for the cause and found bright red stripes on the flesh, just as if a few sound lashes had been administered. There is no doubt but that the villagers saw no good in these supernatural manifestations, and when they all perceived about the persons of the priest and his companion a marked sulphurous odor, due of course to the ozone generated, they were confirmed in their ideas that the powers of the nether world had been evoked.

The remarkable experiment above detailed (we add a sketch of the scene from an old print) resulted in others being undertaken. Delor of the University erected a pole 99 feet high and obtained fine sparks; others followed, and investigations into the phenomenon began in the laboratories of all the scientists. But these wise gentlemen did not play with the lightning unscathed. Scarcely was there one that could not show its marks on his person. A soldier, employed by Abbé Chappe to turn his electrical machine, underwent the same experience which Professor Tyndall has so graphically described: the reception of a heavy charge of static electricity, which knocked him heels over head among the apparatus, smashing the same, and leaving the victim insensible for an hour. Finally, the terrible death of Richmann, of St. Petersburg, occurred, and for a time the physicists suspended

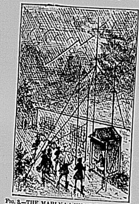


FIG. 3.—THE MARLY-LA-VILLE EXPERIMENT.

their dangerous experiments. Richmann was struck by ball lightning, a variety which M. Gaston Planté has only very recently explained (see SUPPLEMENT, No. 61), and which possesses an explosive power comparable to that of the most potent torpedoes, yet greater. The unfortunate man was standing near a rod which he had carried up through the roof of his house, and was in the act of presenting to it an electric gnomon in order to measure the degree of electrification of the passing clouds. The gnomon was simply a metal rod entering a glass vase at the bottom of which copper filings had been placed, though for what purpose it is hardly possible to divine. At the end of the rod there was a thread which, when not electrified, hung vertically, but which otherwise stood out at various angles. Richmann was bending over his instrument, and Solokow, an artist, was standing by, ready to sketch the phenomena which might occur. Suddenly the latter perceived a globe of blue fire, about as large as a man's fist, leap from the rod of the gnomon toward Richmann's head, scarcely a foot distant. At the same instant Solokow was violently thrown down. On his recovering consciousness, he found the apparatus shattered into minute fragments, the door of the room crushed and thrown over, and even the woodwork of the apartment was everywhere split. Richmann was dead. The lightning had passed through his body, and made its exit by the left foot. On the forehead were a few drops of blood, although the skin was not broken. There was a blue mark on the foot and a hole pierced clear through the sole of the shoe. On the side of the body were red and blue spots, as if burned. Thus perished the first martyr to electrical science.

Among the new inventions for determining the degree to which air is electrified was that of Abbé Nollet, who made shortly the experiments at Marly-la-Ville. He devised the apparatus, as represented in Fig. 5, for leading the electricity into a room so that it may be examined. At E F

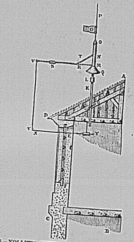


FIG. 5.—NOLLET'S DEVICE FOR STUDYING ATMOSPHERIC ELECTRICITY.

is a garret window, K is a wooden rod extending about 4 feet above the roof, and surmounted by a tin socket which receives a tube of thick glass, L M, which in turn supports a tin tube, N O. The latter, about 5 inches in length, is surmounted by an iron rod, O P. The cone Q serves to protect the glass from becoming wet by the rain, and attached just above this cone is the upper horizontal rod of the frame R V X E. The end, Y, enters the garret through one of the window panes, and is supported by the rod, Z. The collected electricity is thus led into an apartment, where it may be examined.

FIG. 4.—RICHMANN STRUCK BY GLOBE LIGHTNING.

About this period also Abbé Poncelet conceived the idea of lightning shelters, or structures in which people might take refuge during thunderstorms. He had no notion of lightning rods, nor did he believe that such could serve any protective purpose, but he proposed to make his structure of a frame of resinous wood covered with three thicknesses of waxed cloth. Inside the tent was to be lined with silk. "Suppose now" the inventor quaintly says, "that the thunder happens to fall on this little edifice, what will happen?

SOME EARLY

Less than nothing. As it presents on all sides resinous sur-
faces, which never receive phlogiston by communication, the
latter, after having leaped lightly around the pavilion and
finding itself unable fo attack it, will propably depart in or-
der to pursue its ravages elsewhere." As a frontispiece to
his book, Abbé Poncelet has a picture which we reproduce in
Fig. 6, representing the interior of his pavilion. He himself
is standing in the center withdrawing sparks from a rod
which descends from the roof, while the lightning and storm
clouds harmlessly surround the structure.

While Franklin was pursuing his electrical experiments in
the United States, an unknown provincial magistrate named

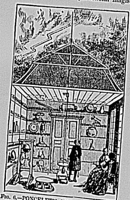


Fig. 6.—Poncelet's insulated house.

De Romas was likewise making researches with the greatest
zeal. He, like Franklin, suspected the analogy between
lightning and electricity, and was led to the idea by phenom-
enon of attraction, of which he was witness, caused by a
lightning stroke, which occurred in 1750. In order to pro-
duce more powerful sparks, he thought of raising an isolated
conductor to a great elevation, and in this way he reached the
notion of using a kite as the conductor. Here we meet one of
those disputes as to priority which strew the borders of the
entire road along which the onward march of invention has
progressed. It is unnecessary here to recall the circumstances
of Franklin's kite experiment, which De Romas claimed to
have anticipated, and it will suffice to state that even, if the
French investigator was the first to conceive the idea, he
placed his early results on record in such mysterious and
confused language that the same furnishes but little evi-
dence in support of his assertion. Some of De Romas' re-
sults of later dates are, however, quite interesting. In 1753
he sent up a kite of about eighteen square feet in area, but
his cord remained dry and he obtained no sparks; the failure
caused both merriment and mockery among those assembled
to witness the experiment. Next time he oiled his kite,
wound the cord with very fine copper wire, and sent the kite
aloft in a thunderstorm. His arrangements worked so well
that he obtained shocks which, as he expressed it, made him
"feel every point in his body;" and those who doubted the
matter and tried for themselves found out to their confusion
that he was exceedingly right. With great intrepidity he
then assumes the unknown risk of severe shocks. From a
glass tube about a foot in length, the end covered with tin
and connected by wire to the ground, he made an excita-
tor, Fig. 7, by which he was enabled to obtain sparks seven
or eight inches instead of scarcely an inch in length as hith-
erto. The noise of the discharge was audible at a distance
of more than 200 feet, and even as far away as 6 feet the
spider web sensation on the face could be felt. Three straws
were attracted by the tin tube, danced between earth and
tube for some time. Then one touched the tube, a dis-
charge passed through it and made a hole in the ground.
The straw then ran up the cord until the kite was attained,
which it touched, then retreated, and so kept moving to and
fro, at each contact drawing a spark. At this time neither
lightning nor thunder was present. A strong ozone odor
was noticeable, and the cord was surrounded with a cylinder
of light 3 or 4 inches in diameter. Subsequently De Romas
found that the danger in the kite experiment was greatest
during the raising of the kite, as he himself repeatedly sus-
tained severe shocks during that proceeding. Accordingly
he invented a carriage on a reel on which he placed his cord
and then dragged his vehicle behind him while running by
silk lines, Fig. 8.

The old experiments which we have here detailed, as well
as others made at the same period, have proved, as now well
known, of great scientific value. They demonstrated the
certainty of the fact that lightning only differs in abundance
from the electricity which we can easily accumulate in con-
ductors cr in batteries.

Fig. 8.—Romas' electrical kite experiment.—The cord carriage.

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Fig. 7.—Romas' electrical kite experiment, 1753.

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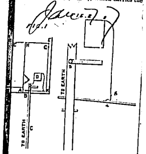
APPARATUS FOR LIGHTING AND RE-LIGHTING LAMPS.

[213.]—IN the accompanying diagrams is shown
paratus for lighting and re-lighting gas lamps
distance. Fig. 1 shows a sketch of whole, and
the top part. The wire on the left-hand side
to the line wire; the wire on the left passes
and is fastened to pipe (gas), which carries the



city to the earth. On the rod, A H, are fixed
carbon points; it will be seen that the elec-
coming from the line wire comes on to the
H, thence through the carbon points, there
a non-conductor placed between them from A H
the expansion wire, E F, through F K to the
(Fig. 2) along through 3, 2, 5, through the
t to the earth. When the electricity passes
h the carbon points it intensely illuminates
and when it passes through the magnet
es the bar which is connected to the gas tap
position shown in the figure, thus opening the
It lights the gas, and the expanding bar
s by the heat and moves the lever, F K,
g the circuit at 4, also turning the lever,
by the crank, H B, and moving the carbon
out of the way of the gas. If the gas goes
expanding bar contracts and makes the con-
bringing the carbon points in the position
in the Fig. 1. The same process takes place
ting the lamps again, if required. To turn
gas a contrary current is sent, and the arm
n towards the magnet, and the gas shut off.
it a spring on the axle 5, to keep it from
, except when acted upon. T. BOVAN.

Nov. 15-78

41 43

Ama Casualty by Lightning. 77

The Salem (N.J.) *Standard* states that recently Mr. Henry White, a well-known resident of Lower Penn's Neck, was killed by lightning as he stood in his own doorway. He went to the door to look at the clouds, and as he looked out he placed his hand upon the water conductor, and was instantaneously struck by the electric fluid, which, it is supposed, was at that moment passing down the spout.

Nov 15-78

ATMOSPHERIC ELECTRICITY.—In a recent article in *Appleton's American Popular Science Monthly*, Mr. Elisha Foote argues that when escaping steam infringes upon a conductor, the electricity generated in the latter is not due to friction, as Faraday believed, but to condensation of the steam. Blasts have been accidentally exploded by the steam from locomotives enveloping the naked wires of the electric fuse, and sparks have been observed on the switch board of railway telegraph offices when locomotives vented steam against the telegraph lines near by. These cases, however, speak at least as much for Faraday's explanation as Mr. Foote's.

JOURNAL OF THE TELEGRAPH.

VOL. X., NO. 3. NEW YORK, FEBRUARY 1, 1877. WHOLE NO. 222.

INFLUENCE OF ATMOSPHERIC ELECTRICITY AND INDUCED EARTH CURRENTS IN TELEGRAPHY.

As long ago as 1752, Franklin demonstrated conclusively, by the well-known kite experiment, that when a thunder storm is in progress, the upper portion of the atmosphere is in an electrified condition. He has also shown that the storm breaks forth as soon as a discharge of the electricity contained in the clouds takes place, either directly with the earth or with other clouds charged oppositely. Various experiments since Franklin's time have shown that traces of electricity are to be found in the atmosphere at almost all times. One of the simplest ways of showing this is to erect a conducting rod in the air and connect its lower end to an electroscope, Peltiers' electrometer, fig. 1, answers the purpose very well.

When the sky is clear, the air is always positively electrified to a height of perhaps five feet above the earth's surface, but the electric potential at that distance is not very perceptible except with the most delicate apparatus, it increases however, with the elevation, but is not the same for any one point at different times of the day, there being maximum and minimum conditions. The former occur about two hours after, and the latter about the same length of time before sunrise and sunset.

When the atmosphere is positively electrified it acts inductively on the earth so that the latter is almost always found to be negative with respect to the former, but owing to the very great insulating properties of air the two electricities do not unite as a general thing except during thunderstorms, at such times the electric accumulation becomes so great that it is enabled to break through the insulation of the atmosphere and a discharge takes place almost instantaneously.

As regards the real cause of atmospheric electricity physicists still differ but it is generally conceded that the rapidity of evaporation, especially at sea, and the subsequent condensation of aqueous vapor in the upper air currents which flow from the poles, has something to do with the phenomenon.

Clouds are charged sometimes with positive and sometimes with negative electricity. The positive charge is supposed to be derived directly from the atmosphere by the vapory particles floating therein, and which, before condensation occupy comparatively vast fields of space. In the process of condensation or cloud formation, the electricity distributed over these extended tracts becomes concentrated within narrow limits and the clouds thus acquire large quantities of electricity of high potential. The negative charge, it is assumed, is derived from contact of the cloud with the earth. In what follows we will suppose the charge to be positive. When a cloud W fig. 2 so charged passes over a place it disturbs the electric equilibrium of all bodies beneath it, attracting the negative electricity to the parts A and B in its immediate vicinity and repelling the positive to the more remote parts D and C. As the elevation of the objects above the earth's surface and their conductivity increase the accumulation or charge which they receive becomes greater. It is therefore obvious that a metallic conductor such as a telegraph line whose termini are in communication with the earth will attain its maximum charge sooner than other and less elevated objects. Men and beast do not, as a general thing, perceive any change of the neutral state from this inductive action because it is produced in a gradual manner by the nearer approach of the cloud. When the latter disappears without the establishment of equilibrium between W and A B by direct discharge, the negative electricity at A

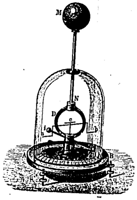


Figure 1.

B gradually reunites with the positive at D and C. and a telegraph line LL_1 between these points is traversed by a current.

If the electricity of the cloud W is suddenly removed as for instance by a discharge into a neighboring cloud these currents become strong enough to make themselves manifest by their action on the apparatus and it sometimes happens that they are so frequent as to greatly interfere with, or even altogether prevent the working of the line.

From numerous careful experiments it appears that telegraph lines are almost always traversed by currents due to actions of this kind, even in clear weather, but at such times they are too feeble to be observed unless special means are taken for that purpose. They are more marked, after some days of hot weather, a sudden change of temperature, or at the beginning of a rain or hail storm.

The disappearance of a heavily charged cloud from any given place is not, in general, so rapid as its appearance because of the attractive influence exerted between the positive electricity of its own charge and the induced negative charge on the earth's surface below it; this influence moreover, tends to draw the cloud nearer and nearer to the earth and at the same time causes the opposite charges to concentrate within more narrow limits until finally the potential becomes great enough to break through the intervening air stratum, as before remarked, and a flash of lightning occurs.

In such cases the greater part of the electricity of the cloud is discharged and the electric equilibrium of the earth below renewed, as shown by the momentary current in the line L L', fig. 2, even though the latter is not in the direct line of the discharge. Any remaining portion of charge in W, if sufficiently large, again acts inductively on the earth, and thus forms the necessary conditions for another flash, sometimes, indeed, for many more of them, until the cloud becomes completely discharged and the storm is passed. It is evident, from the above, that an electric disturbance always precedes the appearance of lightning. This is especially marked in elevated objects, which, as such, soonest reach a limiting charge, and also, by reason of their comparatively low resistance, offer a ready path for the combination of the opposite electricities of the earth and clouds. Telegraph lines fulfil the last condition very perfectly, and being also very extensively developed, thus become particularly liable to being struck by lightning.

The disturbing influence of lightning on a telegraph line is well known. If the wire itself or any object in its vicinity is struck interruptions or damage to the wires and instruments of a more or less serious nature will follow unless special precautions have been taken to guard against such results. It is also a fact that slight interruptions are apparent at a distance of even three or four hundred miles from the place where the storm is in progress. We thus see that it is possible by merely observing whether the disturbance gradually increases or decreases, to determine when a storm is approaching us or passing in the opposite direction. When, however, the storm is near and heavy, large quantities of electricity of high tension instead of following the route of the wires alone, frequently enter the station and pass in the form of sparks from the line and neighboring metallic parts to earth by way of the ground wires or such other means as may be available. Sparks have been seen to pass in this manner from one object to another although the latter were some yards apart. In all such cases fusion of the wires and other damage is sure to follow.

From the preceding remarks is is evident that all of the general phenomena of interruptions from atmospheric electricity may be classed under the four following heads:—

1st Interruptions produced when the line is in the

44

A curious variety of the globular form of lightning has been described in a letter from M. Blanc, of Venice, read to the French Academy. About midnight, on the 21st of March, he noticed the east was lit up with flashes, unaccompanied by thunder. Taking a good position, he saw a bank of dark clouds, with several small fleecy clouds moving above it in various directions. The appearance was like that of a dense mass in ebullition, with light scoriæ carried hither and thither on the surface. Over one such dark mass, which was greatly agitated, balls of fire appeared to rise from an invisible centre, moving in all directions, and after a course of 6 to 10 degrees, bursting silently with a dazzling brightness. Their apparent diameter, at a distance of 18 kilometres, was about 1 degree; their colour reddish, sometimes yellow, but always white at bursting. Their horizontal course was parallel to the plane of the clouds. They had the aspect of immense soap-bubbles, and seemed of similar lightness. The phenomenon was reproduced about three or four times in a minute. The motion of the balls seemed comparatively slow.

Mar 77

The Destructive Effects of Lightning.

The amount of destruction of life and property by lightning, or rather electrical discharges, has been very great throughout the world.

It is estimated that at least 45 persons are killed annually by lightning in this country. The average number of deaths by lightning has been 22 in England, 9 in Switzerland, 8 in Belgium, and 75 in France. In France alone, during a period of thirty years, over 10,000 persons were smitten, of which 2,252 were instantly killed. Eighty were wounded and 9 killed during one thunderstorm at Châteauneuf les Montiers in 1861, and within one week, when the air was highly charged with electricity, thirty-three fearful flashes of lightning were observed, each bringing death to some victims.

During the sixteen years between 1799 and 1816, 150 vessels of the British navy were struck by lightning; 73 men were killed and 138 injured, and the loss of materials amounted to over a million dollars; but since the system of metallic conductors, adapted for vessels, devised by Sir W. Snow Harris, has been applied to the vessels in that navy, the losses and damages by lightning have almost entirely ceased, although the number of vessels has been greatly increased.

In Fuller's Church History it is stated that "scarcely a great abbey in England exists which once, at least, was not burned down by lightning from heaven."

On the night of April, 1718, twenty-four steeples were struck along the coast of Brittany; and on the 11th of January, 1815, twelve steeples suffered a similar fate in the Rhenish provinces.

On the 27th of July, 1759, lightning burnt all the woodwork of the great cathedral at Strasbourg; and on the 14th of August, 1833, it was struck three times within a quarter of an hour, and so much damaged that the repairs cost about $6,000,000. In 1835 lightning conductors were placed upon the building and steeple, and since then it has not been damaged whatever by lightning, although discharges have on several occasions occurred in line with the top of the steeple, which is 437 feet above the ground.

On the 18th of August, 1769, the Tower of St. Nazaire, at Brescia, was struck, and the subterranean powder magazine, containing 2,070,000 lbs. of powder, belonging to the Republic of Venice, was exploded. One sixth of the whole town was laid in ruins and the rest very much injured, and about 3,000 persons killed.

On the 26th of June, 1807, the powder magazine of Luxembourg, containing 28,000 lbs., was struck, and besides about 30 persons killed and 200 injured, the town was ruined.

Explosions and large fires, involving a great loss, have become rather frequent in this country, owing to the iron tanks used for the storage of petroleum being struck by lightning. From March to August, in 1876, over 10,000,000 gallons, and on April 19, 1877, over 2,000,000 gallons of oil, and the village of Troutman, were destroyed in the oil regions of Pennsylvania.

Some of the thunderstorms which have prevailed in this country have been very terrific and destructive. During August 14th, 15th, and 16th, 1872, portions of New York State and the New England States were visited by some of the most terrific thunderstorms ever experienced, during which over 200 dwellings were struck and damaged, about 10 persons were instantly killed, and 160 stunned. Quite a number of barns, with their contents, hay and cattle, were also struck, fired, and consumed. Cars, while running on some of the railroads, were surrounded by a vivid electric light, but no passengers were injured, although they were greatly alarmed. Telegraph wires were melted by the half mile, telegraph instruments broken, and poles shattered in all directions. One of these storms occurred at midnight, at Arlington, Mass., August 14th, in which brilliant streams of electricity darted across the sky in every direction, and the thunder which followed was constant for a period of thirteen minutes, without the intermission of an instant of silence. Three hundred and thirty-one discharges were counted in seven minutes by an observer, and each discharge was followed by loud and sometimes rattling reports, whose reverberations rolled through the heavens in an endless procession of majestic and terrific sounds. During this scene, the moon, which was about half an hour above the western horizon, was visible, but so magnified, through the haze and vapor, as to appear like a brilliant flame suspended in the sky. For a period of twenty minutes the scene was one of grandeur and sublimity rarely witnessed.

In the States of Illinois and Iowa, and the prairie country west of the Mississippi river, thunderstorms are generally more terrific, and more lives have been lost there from the effects of lightning than in any other section of this country. Owing to the said country being level and devoid of trees, the equilibrium between the electricity of the atmosphere and that of the earth is principally restored by disruptive discharges.—*Spang's "Treatise on Lightning Protection."*

It is now exactly a hundred years since the first lightning conductor was placed in Berlin. Franklin's discovery was made in 1751, and in 1777, on recommendation of Professor Sulzer and M. Gerhard, it was applied to the (then) magazine of military equipments in Köpnicker Strausse, No. 11, built under Frederick the Great, in 1773. At present there is a Ministerial order which regards the application of lightning conductors to (German) Government buildings as unnecessary. In France a different view is taken; every public building—even the school—is provided with a lightning-rod.

Sept 77

LIGHTING STREET LAMPS BY ELECTRICITY.

July 77

MAYOR PRINCE, Alderman Slade, and other gentlemen of the Boston city government, have been here inspecting the system of lighting the street lamps by electricity, which has been successfully introduced by the Electric Lighting and Telegraph Company. It should be stated at the outset that the system here in use is entirely different from those which have been tested in Boston and other cities without success. Hitherto attempts have been made to operate the stop-cock connected with the lamps and light and extinguish the gas by means of electricity. This method proved a failure chiefly because the faulty working of the stop-cock, which fact of course vitiated the whole system. The objections to this plan have all been obviated by the Electric Lighting Company. Instead of attempting to operate the stop-cock by the agency of electricity, compressed air is used, thus making the turning on of the gas and lighting it by electricity two entirely separate and distinct operations. By this process all the operations are conducted in clock-work order, and the failures in lighting the lamps in this city for six months have been less than one-fifth of one per centum, and the failures in extinguishing them have been less than one-fiftieth of one per centum, reckoning in both these estimates all defects arising from the clogging of the gas burners, leakage of pipes, breakage of lanterns, and other mishaps which are inevitable even under the system of lighting by hand.

The process by which the lamps are lighted and extinguished is exceedingly simple. All the lamps are connected with a battery by an underground wire running through an airtight tube, which is attached to an air-pump. This tube is half an inch in diameter, and is laid fifteen inches below the surface of the streets or sidewalks. By a simple operation of the air-pump the stop-cocks connected with all the lamps are opened or closed, and by a single touch of the key connected with the electric battery the lamps for a circuit of any length, be it one mile or one hundred, are lighted in an incredibly short space of time. If, for any cause, a lamp in the circuit fails of lighting or extinguishing, an indicator connected with the battery points out the number of the lamp so failing and another touch of the key remedies the defect at once. These failures are of such exceedingly rare occurrence, however, as has already been shown, that but little or no importance is attached to this feature of the system. The cost of keeping the apparatus in running order and in good repair is scarcely appreciable, a matter of thirty or forty dollars being sufficient to keep up the works for a year. The services of one person amply suffice for conducting the entire work, and the only extra labor required is for keeping the lamps properly cleaned.

The company agree to furnish the battery, the air pump, laying the underground wires and the entire apparatus necessary for conducting the work at an expense of $50 per lamp. The company guaranteed to effect an annual saving to the city of $15,000 for the two thousand lamps in the city, or a *pro rata* saving on any smaller number of lamps that were given them. This necessitated an actual saving in the amount of gas used and in the labor of lighting of $7.50 per lamp, but as the contract covered six months only, and called for the lighting of only two hundred and twenty of the two thousand lamps, the company was thus bound to show a saving of $825 for the period covered by their contract or forfeit all claim to reimbursement. This saving appears preposterously large at first thought, but when it is remembered that the services of lamp-lighters are dispensed with, and what is still more important, that the lamps are all lighted in an instant when it is dark instead of half an hour or more before gaslight is required, as is invariably the case under the method of lighting by hand, the guaranty appears a reasonable one. That the experiment has been a successful one in every respect, and that the company has made good its boast, is shown by the fact that upon the expiration of the six months the city paid the company for its work, and an offer, based on precisely similar conditions, to light five hundred more lamps, is now before the city government, and will doubtless be favorably acted upon. A saving of over $3.25 per lamp was realized by the city during the six months.—*Providence Letter to Boston Post.*

45

LIGHTNING CONDUCTORS. 77

[13136.]—AFTER all that has been written about lightning conductors and lightning, the general information on the subject is very meagre and very unsatisfactory, from an almost total absence of any certainty. Are the thin wires used on chimney stalks and church steeples in this country any protection at all? Can they be said to conduct the electricity when struck, or do they act by preventing the building to which they are attached from being struck? I have just seen the following description of the way the Americans "protected" a portion of their Centennial Exhibition, and it will be seen how very closely they approached to Prof. Clerk Maxwell's dictum of sheathing a building in copper (at least I think that was what he proposed). The tin roof of Machinery Hall has an area of 14½ acres, and is utilised as a lightning conductor in this manner. Rising above the roof are 100 wood terminals (used as flag poles), to each of which is attached a copper wire rope ⅜in. in diameter, its upper end rising a few inches above the top of the pole; at its lower end the wires are spread out, and 3in. of its length is firmly soldered to the tin roof. Earth connections from this massive roof conductor are made at ten different places by soldering one end of copper ropes to the tin roof, the other end being firmly attached to 8in. city water pipes in the ground. Thus it will be seen that every square foot of this huge building is covered and thoroughly protected by an ample conductor; and it is believed there is no building in this country so perfectly protected. The total cost was only one-tenth the amount requisite to protect it in the usual way with rods. The tin plates are, I imagine, "terne"—that is, thin sheet-iron coated with a mixture of lead and tin—and, I presume, would thus be practically as useful in conducting electricity as copper. The latter metal, if it were not so dear, would make a handsome, not to say splendid, roof-covering for churches; but why are not "terne" plates used in this country? Is it from the acid in the air and rain, or what, that they are said to be unsuitable? It is always either zinc or lead, and the latter, owing to the "purification" it undergoes nowadays, is falling into disuse. I have seen the following recommended for "earth connections," but then I am told that a piece of iron pipe will do just as well:—Extend the lightning rod underground, say 20 or more feet from the building; fasten and solder to its end a sheet of copper 2 by 4 feet; dig a pit 3 by 6 feet, and 4 to 6 feet deep; put 2in. in depth of finely broken charcoal over the bottom, then put in the plate and rod, with another layer of charcoal and a few inches of earth; then fill up to surface with loose cobble stones, leaving it so that the rainfall can freely find its way down to the copper plate; water from the roof may be led into the pit.

This is plain and definite, if one could rely upon it; but it wants completing by information about the "rod." Of what should that consist? Will iron gas-pipe do, or must it be copper, and what should the diameter be? I suppose it is nonsense to say that a private house requires only a thin wire while a church tower would necessitate a thick rod, for it seems to me the lightning flash is not proportioned to the size of the building struck.

B. S. F.

'Duplicate -'

[3017.] — Thunderstorms. 77 Will "Thetis," page 611, col. 1, kindly inform me how long "evaporation" has been "a source of statical electricity," and give the authority? If he applies the principles to the wet and dry bulb hygrometer, and read 13133, page 590, he will see that there is something wrong in his reply. Without doubt the oppressive heat which usually precedes these storms is an effect caused by the withdrawal of the electricity from these regions to the formation of snow (a highly crystalline body) in the upper regions, electricity being the cause of crystallisation.—SCHOLASTICUS.

46

[30239.] — Thunderstorm. — Lunar Phenomenon.—To HUMPHERY BECKHAM.—I have only just now seen your question about a lunar phenomenon, under head of "Thunderstorm," in MECHANIC of August 24th, and write to say that I have several times, but at long intervals, seen the "chromatic annulus," or as I have generally called it, in speaking of it, "prismatic ring," exactly as described by you, round the moon here (county Limerick, Ireland), and I once saw it double, like a double rainbow. This was very beautiful, the inner ring being very vivid and distinct, but as remarked by you, the blue and violet tints predominating more than in the rainbow. Like you I have never read or heard anything of this very beautiful phenomenon, which is quite different from the slight tinge of prismatic colouring sometimes seen in the ordinary halo round the moon previous to wet weather. I once saw a lunar rainbow. It was a distinct and perfectly-formed arch, but showed no prismatic colours. It is a long time now since I last saw the prismatic ring round the moon, and I am sure it is of very rare occurrence. I have, perhaps, seen it three or four times in, say, 40 years. P.S.—My son has just told me that he saw a beautiful lunar rainbow last July at Kilkee, on the county Clare coast, and that it was perfectly white. He has never seen the prismatic ring.—G. J. H.

77

[31026.]—Gas Lighting by Electricity.—The apparatus to which "Agricola" refers was an American patent, and the cause of the electricity was friction. It was, in fact, an electrophorus. I don't know that they are anywhere offered for sale in England; but, if "Agricola" particularly wants one, by writing to me I can tell him where he may get one. It acts first class except in damp or wet weather.—W. J. CHADWICK.

78

THE TELEPHONE IN GERMANY.—According to a letter, which appears in *The Times* from its Prussian correspondent, it appears that several hundred specimens of improved telephonic apparatus have been ordered by the German Central Telegraph Office, to be employed for local purposes and experiments. The new apparatus, as manufactured by Messrs. Siemens and Halske, presses magnetism into the service of sound. A suspended magnet being by the human voice caused to vibrate, the several oscillations are, by means of rope wire, transferred to another magnet suspended at a distance. The tremulous motion of the air at one point being thus exactly repeated at the other, the words spoken at the receiving station are audibly transmitted to the place of delivery. The instrument is only a few inches in size, is very cheap, and may possibly be destined to work a revolution in telegraphy. Prince Bismarck's study at Varzin has been connected with the Foreign Office at Berlin by a telephone apparatus. The demand for these instruments is said to be very large.

LIGHTNING-CONDUCTORS.

ELECTRICITY—that subtle force of which we know so little, and yet the effects of which are frequently so manifest—of two or more channels, selects the best; and when it finds a sufficiently conductive passage, lightning is disarmed of all destructive energy. This is the principle of the lightning-rod, introduced by Franklin in 1752, and not materially altered in its main features from that day to this. A good deal has, however, been discovered as to the proper arrangement of lightning-conductors, and the best method of applying them to buildings, and of connecting them with the earth.

Various Governments have, from time to time, appointed committees on this subject. The Paris commission, which sat in 1823, determined the minimum sectional area of an iron conductor as a square of 15 millimetres (about 3-5ths inch) inside, and this they considered sufficient under all circumstances. The instructions issued by the Inspector-General of Fortifications for Great Britain, and which have been adopted by the American and other Governments, may be summarised as follows:—The lightning-conductor should be continuous in all its parts, should be placed in close contact with the building to be protected, not being insulated by glass or earthenware, and should be led several feet above the highest point of the building. All piping and metal on roofs should be connected with it, and when more than one conductor is required, they should all be connected together, either above or below the surface, the piping and other masses of metal in the line of probable discharge being also placed in communication. The conductor should be properly connected with the earth, terminating in a large metal surface, and lie sufficiently deep in it, according to the degree of moisture in the soil, as to secure the complete dispersion of the electricity.

With regard to powder magazines, the War Office instructions enjoin that when large quantities of explosive substances are stored in underground magazines, such as the main magazine of a

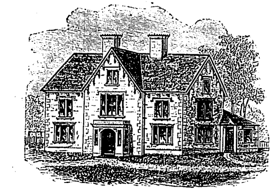


FIG. 1.

fort, they shall, as well as ordinary magazines above ground, be provided with lightning-conductors. After providing that the flagstaff should have a conductor, they add: "An iron building is of itself a good conductor, but where it is covered with non-conducting substances, such as asphalte and concrete, it is necessary to provide rods or points projecting above the asphalte, and to have a proper connection with each."

Messrs. R. S. Newall and Co., whose wire-ropes and telegraph cables we noticed lately, have also devoted a considerable amount of time and attention to lightning-conductors and the method of fixing them. They are of opinion that, for small buildings, a simple conductor will generally be found sufficient, but it should not have a less conducting power than a ½-inch copper-wire rope. This should be fitted to the end of the building, the point rising about 2 feet above the chimney. A horizontal conductor should also be added along the ridge, fixed close to the building, and having no joints, if they can be dispensed with, throughout the whole of its course. Special attention must be given to the chimneys of all buildings, because they are virtually tubes lined with a carburised conducting material, the more so if there are fires below, sending up a current of warm air, which is an excellent conductor of electricity. For larger buildings, however, a rod should be placed at each end and at intervals of from 12 to 15 yards along its length, the roof and chimneys being protected as before described. It is important to place any metal that may be on the roof in direct communication with the conductor; instances are on record where a building has been struck at some distance from the lightning-conductor. A building 40 feet long should, as a rule, have two conductors; and if 100 feet or more, three conductors. Larger and more complicated buildings should be protected on similar principles, having rods at each corner and rope along the ridge, all being properly connected with the earth. Fig. 1 of the accompanying engravings shows a house thoroughly protected against the lightning discharge on the above system; the black lines on chimneys, ridge, eaves, &c., show the conductor.

Water mains provide the best earth-connection, if conductors are properly secured to them. In the absence of these, and where there is no drain or well of water near, or where the soil is clayey or rocky, the conductors should be surrounded by a quantity of coke to increase the contact

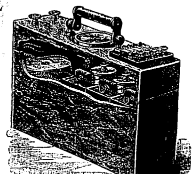


FIG. 8.

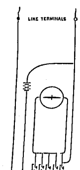


FIG. 9.

and prevent the conductor, if of iron, from rusting. Carbonate of soda may also be applied with advantage. It is a very important matter, if the conductor is in more than one length, that the joints should be carefully made; if it consists of a rod, the joint should be soldered, and if of cable the ends should be carefully spliced.

In applying lightning-conductors to chimney-shafts and public buildings, the same rules are to be observed, though the varying circumstances of each, the extent and prominent parts above the roof, must be studied, while, at the same time, the outward appearance of the structure should be preserved. In these cases a conductor of greater capacity is generally used, and the joints should be very carefully made. In ornamental constructions the lightning-conductors should invariably form part of the original design, and not be added subsequently, as if in consequence of an afterthought. In the Albert Memorial, Hyde Park, the conductor, supplied by Messrs. Newall, is carried down through the centre of the column, so as not to destroy the symmetry of the structure.

The lightning-conductor consists of three parts: the rod, which is carried up above the highest part of the building; the connection with the earth; and the intermediate portion uniting the other two.

We engrave (figs. 2 and 3) alternative forms of rod, manufactured by Messrs. Newall, who give a preference to the simple rod terminating in a sharp point; though the cluster of points is also supplied in deference to an opinion shared by some that this form affords a greater chance of dissipating the lightning-cloud. These are made of copper, sometimes with a tip of solid platinum. The rod itself is from 4 to 10 feet in height, according to circumstances. Fig. 4 shows an enlargement of the clip where the joint between the rod and intermediate conductor occurs; and fig. 5 an additional support to the rod higher up, if required.

This intermediate portion should consist of copper, and may be in the form of a ribbon or a rope; but a copper-wire rope is much to be preferred, on account of its easier adaptability to the irregularities of a building. Fig. 6 shows a holdfast to be driven into the wall for securing the rope, and fig. 7 a guide intended to be built into the corner of a square chimney for the same purpose. These are made of copper if a conductor of that metal is employed.

Great difference of opinion has existed as to whether the conductor should be insulated from the building or not; but there is strong reason for believing that insulators, instead of being a protection, are positively a source of danger. They become covered with moisture during a storm, and are, therefore, of no effect, moisture being a good conductor of electricity.

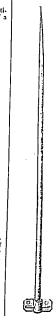


FIG. 2.

FIG. 3.

FIG. 4.

FIG. 5.

FIG. 6.

FIG. 7.

With regard to the best metal to be employed, the relative conductivity of the metals to electricity is given as follows:—Lead, 1; tin, 2; iron, 2½; zinc, 4; and copper, 12. The last-named is the best conducting substance of all the ordinary metals, as, besides its high conductivity, it is very durable, and not liable to oxidation. When, however, conductors are exposed to abrasion or torsion, or are liable to be stolen, and where attendant circumstances are unfavourable to corrosion or oxidation, iron may be substituted; but proportionately larger dimensions must be given to the conductor, to compensate for its smaller conductivity. Iron has this advantage, that its fusing temperature, 2786° Fah., is so much greater than that of copper, 1994°; but in all other respects copper is preferable. An equal amount of conducting power may be obtained in iron and copper for about the same price; as the smaller cost of the iron makes up for its lower power of conduction.

The proper arrangement of the third portion, viz., connection with earth, is certainly not less important than the other two. *If it should terminate in a dry sandy soil, the lightning-conductor would be worse than useless. The best arrangement is that the conductor should terminate in a* well or large body of water, as the water, having various ramifications in the soil, presents the best means of dispersing the electricity. Where this is impracticable, the conductor should be continued into deep ground; and, as sand, shingle, or other light dry soil, does not form a good earth-connection, the rod should be led through these strata until water or a permanently deep soil be reached. The conductor should be led into moist ground, by means of a trough extending to at least 18 inches below the surface, and in which there is a considerable length of metal—the War Office authorities recommend as much as 30 feet of metal—or a plate 4 feet square should be placed in actual contact with the moist earth. In the case of very dry sandy soil, the trench should extend from the foot of the conductor to distances of from 10 to 40 yards, according to the amount of moisture; and it is useful to lead the water from the roof of the buildings, through the down pipes, over the ground in the vicinity of the earth-connection, or into the trough just referred to.

In applying lightning-conductors to vessels, it must be borne in mind that a ship at sea is more liable to receive great discharges of electricity than buildings on land, for the reason that, while on land the intensity is generally spent on more than one of the objects within its range, the vessel is often the only object intervening between the clouds and the earth, and it receives the full force of the lightning discharge. For this reason a conductor of greater capacity is required. All masts are equally liable to be struck, whether one of them be protected or not, many cases being on record of damage occurring to the foremast of the ship while the mainmast was protected. It follows that each mast should be provided with a lightning-conductor, which should have a sectional area equal to at least ⅝-inch diameter. The copper rope is also found the most useful form of conductor in this case, as it may be obtained in any length, is simply applied, and yields to every movement of the vessel. The method of fixing recommended is to carry the ropes down the backstays, and nail them to the ship's sides. Formerly the link or chain form of cording was employed, but the discontinuity of the parts formed a material objection to its use. When struck by lightning, the expansive and heating effect at the joints was so great that the metal became fused, and in many cases the links were broken.

In a previous paragraph we have spoken of the importance of terminating the rod in "good earth." Upon this depends the value of the lightning-rod. Most of the accidents which have taken place where conductors have been on the building, can be accounted for by insufficient earth-connection. A lightning-rod when fixed should be tested by a galvanometer, and the earths should be tested at least once a year. A very portable galvanometer for testing lightning-conductors has recently been introduced by Mr. Richard Anderson, M.S.T.E., F.C.S., London, manager to Messrs. R. S. Newall and Co. The wood-cut (fig. 8) shows the arrangement of the battery, galvanometer, and resistance coils. The battery consists of three cells, and is a modification of the old manganese cell, in which the carbon and oxide of manganese occupy the outer, and the zinc plate the inner or porous cell. By this arrangement the surface of the negative element is greatly increased, and hence a more constant current is obtained on account of the battery not polarising so rapidly as in the old form. Another advantage of this arrangement is that the cells can be almost entirely sealed up, the air-openings being made within the porous cell. In the centre of the lid of the box is placed the galvanometer with a "tangent" scale. On the left are two terminals, by which to connect the conductor to be examined. On the right hand end of the lid, are placed five keys, marked, respectively, L, B, 1, 2, 3. Under B is one pole

of the battery, so that by depressing this key, as will be seen by the following connections in the diagram (fig. 9), the battery current is sent through the galvanometer direct. If, however, we depress key No. 1, we connect the battery with the galvanometer through a known resistance—key No. 2 has a larger resistance, and No. 3 still larger. The fifth key, L, closes the circuit within the limit of the instrument, but on being depressed opens it, and includes the line or conductor placed between the two terminals at the other end. Battery key also must be pressed down. By this arrangement it will be seen that the resistance of the line or conductor may be compared with the known resistance connected with any of the keys Nos. 1, 2, 3, or any of these resistances may be included with that of the line, so as to get a convenient deflection of the galvanometer needle. In the case with the battery is a bobbin of insulated wire for connecting the instrument with the conductor and earth to be tested.

Among the works and buildings provided with lightning-conductors by Messrs. Newall are those of Messrs. Maudslay, Sons and Field; Messrs. Ransomes and Sims, of Ipswich; the Great Northern Terminus, King's Cross; the Pumping Station, Commercial Docks; most of the ship-building works on the Clyde; and those of the London gasworks, breweries and hospitals; several London Fire Brigade Stations; the Alexandra Palace; the Royal Aquarium, Westminster; the Monument, Fish Street Hill; and Her Majesty's Laundry, at Richmond. We notice that the firm have been awarded a gold medal at the Cape Exhibition this year.

Remarkable Form of Lightning

I AM able to confirm the fact that lightning occasionally takes the "punctuated" form described by Mr. Joule in NATURE, vol. xviii. p. 260. Some forty years ago, in a thunderstorm which I had the good fortune to witness at Ampton, in Suffolk, the lightning (with heavy rain) was almost incessant for half an hour or more, and about a quarter of the flashes (speaking from memory only) presented this unusual appearance. I have often looked out for it since, but only once with success, and then it only showed itself in a single flash out of many. On both occasions the "punctuated" flashes presented in general a curved or sinuous line without sharp angles; and two or three of them in the first-mentioned storm *appeared* to my eye as closed curves, one an almost perfect figure of 8; but their dazzling brightness made it impossible to speak to this with certainty.

London, July 8 78 — E. J. LAWRENCE

[33346.]—**Equatorial and Lightning.**—It would
be desirable to connect the top of the pillar to the
exterior of the observatory, and to provide there an
ordinary conductor point. The pillar, of course,
to a certain extent, invites a discharge, if it is a tall
one, and will do so still more if properly connected
to earth; as a consequence, some injury might occur
to the observatory roof. The danger which I referred
to in previous reply would be at the foundation. The
pillar, providing a shorter path than the air, tends to
collect the electricity into that path, and then
at the foot of the pillar there would be a violent dis-
charge, and possible destruction of the foundation,
and overthrow of the pillar, which a good earth con-
nection would entirely prevent. If a good connection
is made, it is of no consequence whether the wire is
attached to the stone pillar or not, but it is always
best to connect the conductor as much as possible to
every part of an edifice it is meant to protect. There
need be no difficulty about the revolving top, as a
sliding contact piece, such as two tubes one within
the other, could be used.—SIGMA.

ON LIGHTNING CONDUCTORS AND ACCIDENTS BY LIGHTNING.

By RICHARD ANDERSON, F.C.S., Member of the Society of Telegraph Engineers.

Abstract of Paper read before Section A of the British Association, August, 1878.

AT the present time at least one-half of all the public buildings, including the churches and chapels, of Great Britain and Ireland are without protection against lightning. As to private houses, it is safe to assert that not five out of every hundred have lightning conductors.

According to the reports of the Registrar-General, the number of deaths from lightning in England and Wales during the eight years from 1869 to 1876 reached a total of 182.

According to the report of Dr. Engel, Director of the Statistical Bureau of Berlin, the number of lives lost during the same period in Prussia was 819.

The terrible losses, both of property and human lives occasioned by lightning, are mainly due to three causes, namely: first, in not providing any lightning conductors at all; secondly, in not placing them in the right position, or in sufficient number to cover a given area; and, thirdly, in not having them regularly tested, so as to ascertain their constant efficiency. Even some of the first cathedrals of England, such as Peterborough, have no lightning conductors whatever, while others, supplied with them, Windsor Castle for example, are insufficiently protected, as is apparent to any competent observer.

If the entire absence of lightning conductors is the most prevailing cause of the still exceedingly great number of casualties occasioned by lightning, that of ill-placed or insufficient conductors is another deserving much attention. The mischief done in this case is not only that the conductor gives a false security, but that, should the dwelling on which it is placed be struck by lightning, it leads to the belief that the wonderful scientific discovery of Franklin is nugatory, or at least uncertain in its action. A case of the most instructive kind, in which a house with a proper conductor fixed on it was struck and damaged by lightning, came under my own observation quite recently; a heavy thunderstorm passed over it, and the electric discharge fell on one of the towers, knocking down part of a crenellated wall, not more than three yards from a lightning conductor, and then passing off without doing further damage. The conductor being new and in good order, it seemed at first sight a very extraordinary case; but the mystery of it was soon explained by an examination of the premises, which I undertook. I found that the roof of the tower on which the lightning fell was covered by a solid mass of lead, of unusual thickness, connected at one end with a large iron water-pipe about four inches in diameter. In this case the electric force, to get to this rival conductor, heavier in metal than the one designed for the purpose, and therefore offering the best road earthward, had to smite the brick wall in its way, and having done this, it went down the iron water-pipe into the ground, doing, as already mentioned, no more damage. Had the actual conductor either been larger, that is, heavier in metal than it actually was, or had it been connected with the mass of lead in the first instance, the lightning could never have struck the house. The incident forcibly illustrates the necessity of leaving the design and erection of lightning conductors to no others but those who have made a thorough study of the subject, since the work is not by any means so free from complexity as is commonly believed.

The third cause is the utter neglect of the conductor, when once it has been put in its place; other repairs to all sorts of public buildings are regularly executed, but the lightning conductor is taken no notice of and is never tested.

Having drawn attention to the chief causes of the numerous and fatal casualties caused every year by lightning, I have only to add a few words of advice as to how they might be prevented, or at least greatly diminished. First of all, I think it most desirable that public recommendation should be made, by local and other authorities, to place lightning conductors on all exposed or high-lying buildings, whether public or private, as well as on those standing near woods and on moist ground. It might be well worth the trifling expense to place simple conductors also against trees in parks, under which there are benches, or where persons are likely to gather during a thunderstorm, they forming a prolific source of fatal accidents. Above all, no church, chapel, school, prison, or other large public building, ought to be without one or more lightning conductors. But if it is necessary to greatly multiply lightning conductors, it is equally so that they should be planned, erected, and also periodically tested by competent persons, with scientific as well as practical knowledge of the work. The testing should take place at regular intervals, perhaps best in the spring, before the advent of the summerly thunderstorms, and it should likewise be made whenever a building has been undergoing repairs which may have damaged the conductor. To show the importance of constantly testing even the best laid conductors, I can cite another instructive case where a house was apparently well protected. On the 19th of August, 1876, shortly before midnight, a heavy stroke of lightning fell upon a mansion near Kew Bridge, Middlesex. The electric force destroyed the top of a large chimney, knocking off part of the coping, not more than two or three feet from a lightning conductor, to which it then flew, making its way down to the earth, but not without causing the greatest disturbance all along its path—lifting up, among others, some heavy marble toilet tables in bed-rooms some six feet distant on either

Comptes Rendus Hebdomadaires des Séances, de l'Académie des Sciences. No. 3, July 15, 1878.

Remarks Concerning the Influence of Atmospheric Electricity of Low Tension upon Vegetation.—M. Berthelot.—Referring to M. Grandeau's paper "On the Influence of Atmospheric Electricity upon the Nutrition of Plants" (*Comptes Rendus*, lxxxvii., No. 2), the author recalls the analogy of the result with his own experiments on the formation of nitrogenous matters under the influence of atmospheric electricity. Hitherto in agricultural chemistry there has been understood under the name of atmospheric electricity merely the formation of nitric and nitrous acids and their ammoniacal salts, produced by the passage of lightning, without having any idea of the direct reactions which may come into play between plants and the atmosphere. Yet these latter seem to me the more important, the smallness of the effects being compensated by their duration and by the extent of the surfaces influenced.

THE ELECTRICIAN, JULY 13, 1878.

THUNDERSTORMS.—We have experienced this year a succession of extraordinary thunderstorms, accompanied by an excessive downpour of rain. Had our telegraphic society been duly organised, the opportunity of a fairly thorough investigation of these phenomena would not have been lost. We would humbly suggest to the Society of Telegraph Engineers that sub-committees of investigation should be formed to carry out experiments and record observations upon various phenomena connected with electrical subjects. The late Professor Henry suggested to the American Electrical Society that it should collect and preserve information relating to thunder storms, and also prepared a series of questions as a contribution towards a more complete series to direct attention to special points of inquiry. These questions may prove useful in scientific investigations, and we therefore append them to this note. *Particulars of the Storm:*—(*i.*) Give the number and time of occurrence of thunder storms, so as to show their distribution through the months, days, and hours of the year. (*ii.*) Note the point of the horizon in which the storm generally arises in any given locality, and the point to which it tends. (*iii.*) Observe whether it usually divides into two storms at any point; if so, what is the topography of the surface below? (*iv.*) Determine the width of the storm from the extent of the surface covered by rain, and also, if possible, by means of the telegraph, the length of its path. (*v.*) Note the condition of the air before and after the storm, as to temperature, moisture, and pressure; also the temperature of the water which falls. (*vi.*) Give the direction of the wind previous to the beginning of the storm, during its continuance, and after its ending. (*vii.*) Observe whether a calm precedes the violent part of the storm, and whether in front of it a curtain of dust is raised to a considerable height in the air. (*viii.*) Note the number of seconds the sound of a discharge continues, which will give approximately the minimum length of its path. (*ix.*) Note the time between the appearance of the flash and the hearing of the thunder, and also the angle of elevation; these will give approximately the height of the cloud. (*x.*) Ascertain whether any hail accompanies the storm; if it does not, whether it falls along in two tracks, or in one. In the former case, give the distance between the tracks. Give the size and character of the hail, whether it consists of an agglomeration of crystal, or of rounded masses stratified with clear ice and snowy concretions, and whether it contains in some cases small particles of dust or sand. (*xi.*) Note the number of discharges between the different parts of the same or different clouds, and also between the cloud and the earth. The former will probably be more frequent than the latter. (*xii.*) Note the colour of the lightning, particularly if it be violet, which will probably indicate a cloud of great elevation. *B. Effects of the Electric Discharge:*—(*i.*) State what kind of trees are struck, and on what parts of the tree the effects are most apparent—on the branches, or the trunk. (*ii.*) What are the mechanical effects observed in the tree; is it torn asunder laterally, or is it broken transversely to the axis, or both. (*iii.*) Was the tree green or dry? (*iv.*) When a house is struck, state if it had a lightning-rod, and, if so, give its character and especially its connection with the ground. (*v.*) Mention the part of the house struck; if the chimney, was there fire in it at the time? Give the path of the discharge through the house, and its relation to conducting metals? (*vi.*) Note the inductive effects of the discharge in producing sparks and flashes between different objects within the premises. (*vii.*) If the discharge passes through metallic conductors and disintegrate them, note any appearance which might tend to indicate whether the effect is produced by heat or by repulsive energy imparted to the atoms at the moment of the discharge. (*viii.*) If the discharge takes place between two surfaces, note if there is any apparent transfer of material from one to the other. (*ix.*) Note any peculiarity of odour that may be observed. All mechanical effects produced by the discharge should be mentioned, and notes should be made as to whether they are not in most cases produced by a violent repulsive energy given to the air in the path of the discharge, and whether the effects are greater in the direction of the axis of the discharge than in that at right angles to the same. (*x.*) Note the effect upon man and animals; whether a part of the discharge passed through the body, or whether inductive shocks were felt.

EXPERIMENT FOR ILLUSTRATING THE TERRESTRIAL ELECTRICAL CURRENTS.—The following experiment enables a lecturer to exhibit to a large audience in a very simple way the action of the currents of electricity that pass around the earth. A rectangular frame, made of light poplar wood, of section three by two centimetres, with sides in length a fraction over a metre, and in breadth three-fourths of a metre. About the perimeter of this rectangular frame twenty coils of insulated copper wire, each extremity of the wire terminating near the centre of one of the shorter sides, and passing through the wooden frame, is fastened and cut off about three centimetres from the frame. This rectangular frame is then so suspended in a horizontal position, by wires attached to the frame of an ordinary hydrostatic balance, that the longer sides are at right angles with the beam. By adjusting weights in the pans the index of the balance can be brought to the zero point. Two small orifices bored in a block of wood a centimetre apart serve as mercury cups, in which the extremities of the short terminal wires are immersed. Near the bottom and through the walls of these wooden cups are screwed small brass hooks, which serve as connections, to which the wires of the battery are attached. The balance is now so placed that the longer sides of the suspended rectangle are at *right angles with the magnetic meridian*, or in the *magnetic* east and west line. When the current from the battery is made to pass around the rectangle from east to west on the northern side, and from west to east on the southern side, by the theory of terrestrial magnetism, the northern side of the rectangle would be attracted and the southern side repelled; and that this is so the corresponding deflection of the balance renders plainly visible. When the current is reversed the deflection is in the opposite direction. By breaking and closing the circuit at proper intervals to augment the oscillations the large frame is readily made to oscillate through an arc of five degrees. When the sides of the rectangle are placed north-east and south-west the current produces no sensible effect. A bichromate-of-potash battery of sixteen cells, with plates of zinc and carbon twenty-five by six centimetres, is used. With a rectangle containing a large number of coils of wire attached to a very delicate balance, by using a *constantly-acting* battery the variation in the magnetism of the earth might be advantageously observed.

[33728.]—**Thunder and Lightning.**—Remember that for every five seconds between flash and thunder the flash is one mile distant. This you will find quite as accurate as any measurement you can get. You may either read the seconds off a watch dial, or count them, the latter preferred when you have learned how to count accurately. The velocity of sound roundly is 1,120ft. per second; hence, in five seconds the sound should travel 5,600ft., or 1,866yds. This is 140yds. beyond a mile, but the difference is inappreciable, for the distance over which every flash travels is so great that it is impossible to get an accurate distance.—W. J. LANCASTER. 78

THE RECENT THUNDERSTORMS.—An unusual number of accidents by lighting, both serious and curious, have been reported. At Witham the lightning ran along the telegraph wires into the instruments at the Post Office, fusing the coil of the galvanometer, shooting from thence to the testing box, with a vivid blue flame, succeeded by a loud report, and passing out and along the wires to the Braintree Post Office, seven miles distant, where some slight damage was also done.

LIGHTNING AND LIGHTNING CONDUCTORS.

[14813.]—I CANNOT agree with "J. T. M." (14814) either that the motion of a flash of lightning is not perceptible to the eye, or that every flash will have a visible ascending and descending portion. I think he can hardly argue from what is observed at the terminals of a wire circuit during the quiet passage of the galvanic current to the state of things at the moment of the eruptive discharge of lightning. In a perfect conductor the passage would no doubt be practically instantaneous; but as air is by no means a good conductor, it is not surprising that an ordinary lightning flash should be progressive, as the experience of ninety-nine persons in every hundred tells them that it is.

A downward and an upward lightning flash take place under different circumstances. The up-stroke, or back-stroke, as it is sometimes called, is simply the restoration of equilibrium at one end of a body of charged cloud travelling near the earth at the same instant that a down-stroke has occurred at the opposite end.

The result of my own experience on this point is that, when an electric discharge from the clouds strikes an oak tree, for instance, a considerable portion of the charge is dissipated in air, and it barks and splinters one, or, at most, two branches, then proceeds downwards under the bark of the stem, dividing sometimes into two or more streams, cutting grooves an inch or two deep in the timber, and then going to earth, and that is the extent of the injury. But the discharge of the up-stroke is very different, of much rarer occurrence, and far more destructive. The whole charge passes at once from the earth into the tree, and the stem or bole is completely shattered, every particle of sap being converted into steam. On reaching the junction of the branches more resistance still is encountered, and every branch is flung down or left hanging by the bark, most of them being shattered into mere splinters as the charge is dissipated into the atmosphere. Such instances are rather rare. I had the good fortune to witness one about seventeen years ago, and photographed the remains of the tree, and one has just occurred, similar in all respects, in this neighbourhood (Hereford) on the night of the 7th instant.

As some questions have been asked lately about lightning conductors, I may say that my own plan has invariably been to use 4in. strips of galvanised iron plate, riveted together, as being the safest and the cheapest. Much of the copper-wire rope I have seen used for conductors is too small to carry a heavy discharge of lightning. I have heard on several occasions of such conductors being fused, as, for instance, one at Stonyhurst College a few years ago. The iron band is easily fixed, can be diverted from the straight line at any angle, and if properly terminated above and below, such a conductor will carry off the heaviest discharge in perfect safety. Moreover, it improves as a conductor with every discharge that passes through it, whereas I believe that copper wire becomes more and more brittle.

H. O. Key.

ASCENDING LIGHTNING.

[14814.]—THERE seems to be a good deal of interest taken in this rather insignificant matter, and a good deal of confusion of thought into the bargain. It is quite certain that if lightning has any motion of translation at all, and is not, in fact, omnipresent in its track, it must often ascend. If the electric action is single, and passes as a current or "bolt" from the positive charged surface to the negative, it must travel both ways, because it is well known that the clouds have negative as well as positive charges. Indeed, it is probable that both always co-exist, and form a complete circuit; the visible discharge may, therefore, happen in either path, and be accompanied with what is called the "return stroke" by some, at perhaps a great dis-

ASCENDING LIGHTNING.

[14738.]—In the first paragraph of his letter (14451) your able correspondent, "A Fellow of the Astronomical Society," states that during a thun[der]storm in the neighbourhood of Tunbridge We[lls] "very distinctly saw one flash of lightning [shoot] upwards from the earth into a dark lowering [cloud] poised at some distance above it," and he re[marks] that "theoretically, of course, this is a phenom[enon] which not unfrequently occurs."

I once saw a similar phenomenon when st[anding] with a friend during a thunderstorm at an [open] window of his house in the country. A vivi[d flash] appeared to shoot upwards a few hundred y[ards in] front, from the very part of a meadow at w[hich I] was looking, and was instantly followed b[y a tre]mendous clap of thunder. My companion [said he] had distinctly seen the flash, but did not not[ice any]thing unusual about it, except that it was [bright] and nearly vertical. He was, however, not [looking] at the meadow, but at a wood on the hill [beyond]. The difference of our impressions seemed t[o me un]accountable.

Since that time the subject has occasio[nally oc]cupied my thoughts, and I am now of opi[nion that] ascending lightning is a mere illusion, [which] happe[ns] entirely to the eyes of the observer happe[ning to be] directed to that part of the landscape at [which the] discharge occurs, and that it is no proof o[f the earth] having been charged positively.

Wheatstone proved that the duration of [the electric] spark is about 1-24000 of a second; a[nd he] showed by means of a revolving whee[l that the] duration of the lightning flash is littl[e greater, and] cannot exceed a minute fraction of the [thousandth] part of a second. The moment of time [which is] visible to us—about the tenth of [a second—is] therefore hundreds of times greater th[an the flash's] duration. Now, is it credible that we [can judge by] the eye of the direction of motion in a [spark]—that we can see the progress of the [flash] of lightning?

The idea seems absurd, yet this fo[rm of judgment must be] formed before we can know with certa[inty that a] flash has travelled in this or that dire[ction].

The following simple experiment [will] illustrate the argument:—Place befo[re the] prime conductor of a good electrical [machine a] ball of equal size connected with a d[ischarger], and so adjust their distance apart [that on] working the machine distinct zig[zag sparks] pass across the interval. Now, le[t several persons] attentively watch the balls, and se[e from which of] them each spark proceeds. Opinio[ns will be found] to differ, but the following rule wi[ll admit of] no exceptions:—*The spark app[ears to] issue from that ball to which th[e eye of the] observer is directed.* It is worth [noting that the] end of the spark next the negative [ball is brighter] and thicker.

Let me, in conclusion, ackno[wledge the pleasure] and instruction I have derived [from the] letters of "F. R. A. S."

Lightning Conductors.

This paper, Mr. R. Anderson's, F.C.S., was as follows:—One hundred and twenty-six years have elapsed since Benjamin Franklin discovered, by means of his famous kite, that lightning could be drawn from the clouds, and its destructive qualities extinguished by very simple means; and one hundred and ten years are gone by since the first of Franklin's "lightning rods" was set up for protection over the dome of England's metropolitan cathedral, St. Paul's. Yet, so slow has been the "march of progress" in the application of one of the greatest scientific discoveries of modern times to the uses of daily life, that even now, after the lapse of more than a century, the employment of lightning conductors, simple as they are, and as inexpensive as simple, is far from being general, still less universal. At least one-half, and perhaps two-thirds, of all the public buildings, including the churches and chapels, of Great Britain and Ireland are without protection against lightning. As to private houses, it is safe to assert that not five out of every hundred have lightning conductors. It is well-known that the amount of property destroyed annually by lightning is very great, though it is naturally impossible to form any estimate of it. However, there are some facts as to the annual destruction of human life. According to the Thirty-ninth Report of the Registrar-General, issued in July, 1878, and former reports, the number of deaths from lightning in England and Wales was 182 from 1869 to 1876. In Prussia, where the registration of the causes of death is under the enforcement of strict legal enactments, and, in consequence, far more accurate than in England, there were 819 persons reported as killed by lightning in the eight years from 1869 to 1876. The population of Prussia is larger than that of England and Wales—25¾ millions against 24½ millions—but, on the other hand, thunderstorms are less frequent there than with us. Altogether it will be rather under than over the mark to say that as many persons are killed by lightning in England as in Prussia, the loss of life amounting to over a hundred every year on the average. The terrible losses, both of property and human lives, still occasioned by lightning are the more lamentable as they are in nearly all cases the result of the grossest negligence. The negligence is threefold, namely—first, in not providing any lightning conductors at all; secondly, in not placing them in the right position, or in sufficient number to cover a given area; and, thirdly, in not having them regularly tested so as to ascertain their constant efficiency. Of course, the first-mentioned cause of neglect is by far the most important. It is one alike astounding and baffling all search for a reasonable explanation. Every year brings its regular thunderstorms, more or less in number, and most of them accompanied by fatalities. All see the terrible lightning flashing over their heads, all tremble before the approach of the awe-inspiring electric force, the mere touch of which brings instantaneous death, and yet but an excessively small number of persons make any efforts to protect themselves, their families, and houses against the electric fire from the clouds. Public buildings fare very little better than private houses. Even some of the first cathedrals in England, such as Peterborough, have no lightning-conductors whatever, while others, supplied with them, are insufficiently protected, as apparent to any competent observer. A glaring case of absence of protection against lightning is to be found at Windsor Castle, grandest of all the historic buildings of England, and the residence of our sovereign. It may seem incredible but I can vouch for it as an actual fact, ascertained by myself on a quite recent visit, that several portions of the noble pile, among them St. George's Chapel, home of the illustrious Order of the Garter, and the adjoining belfry tower, overhanging the main street of Windsor town, are entirely unprovided with lightning conductors. On other parts of the castle a few conductors are placed, but clearly not enough. It is needless to say that, speaking only of St. George's Chapel and the belfry tower, these splendid ancient structures, in their exposed situation, constantly touched by the storm-clouds that sweep up the valley of the Thames, are liable any moment to destruction, with irreparable loss to the nation. I now come to the third cause of neglect, which, though ranged as the last, is by no means the least. My argument is that lightning conductors ought to be at regular intervals, at least once a year, carefully inspected, and their efficiency tested by a galvanometer. The absolute neglect of this precaution, which is now prevailing, is, I believe, the cause of a vast number of casualties by lightning, inflicted upon buildings nominally protected by conductors. Exposed as they are to all the destructive influences of wind and weather, and the often still more pernicious assaults of ignorant workmen, masons, bricklayers, and others, who, while undertaking repairs, tear down ruthlessly, as a nuisance, the wonderful yet fragile string of metal which leads the electric flame on its path, it but too frequently happens that persons who have had the wisdom to erect lightning conductors over their houses, and believe themselves fully protected, are in reality far worse off than being without a conductor. But utter neglect of the conductor, when once it has been put in its place, is the commonest thing, and indeed the rule, as regards private dwellings; and, I fear, there is little difference in this respect as to most public buildings, churches, and chapels. In fact, it is the old case of a matter, however consequential, yet being utterly disregarded as "nobody's business." Other repairs to all sorts of public buildings are regularly executed; the walls are kept safe; painting and whitewash are renovated from time to time; the roof is preserved watertight; and the turret clock, if there is any, is thoughtfully looked after, oiled, cleaned and repaired. But who is there that ever inspects the half-hidden little thing on which the safety of the whole fabric against the destructive effects of lightning depends? I made a great many inquiries on this highly important subject, and the more I did, the more I was surprised at the profound negligence generally prevailing about it. Between three and four thousand pounds were spent in protecting the Houses of Parliament by lightning conductors at the time of their erection some twenty years ago. Since that time, as far as I can learn, after minute investigation, they have never been tested, and there is no guarantee whatever that a discharge of lightning may not at any time fall upon the Queen's throne, the Lord Chancellor's woolsack, or the Speaker's chair. As regards Windsor Castle, already referred to, the case is even worse. While parts of it are entirely unprotected, it is exces-

sively doubtful whether the few conductors placed upon some of the eminences of the vast range of buildings are at all efficient, and not merely a "delusion and a snare." It is well known that the all-important matter in respect to a lightning conductor and the principal element of its efficiency is the earth connection, that is, the immediate and complete dispersion of the electric force after it has made its way from the clouds through its metal path in the ground below. Moist earth is indispensable for the purpose, and I am very sceptical as to whether the few rods that stand over the Queen's private apartments at Windsor Castle and the culminating mass of brickwork, the Round Tower, actually have their root in moist earth. If not, it would be better certainly the things were taken away altogether, and the whole magnificent structure treated like St. George's Chapel and the Belfry Tower. A French writer pithily expresses the results that follow from a lightning conductor over a house not having a proper "earth connection," by saying it is lightning guided to the owner's iron bedstead. Having drawn attention to the chief causes of the numerous and fatal casualties caused every year by lightning, I have only to add a few words of advice as to how they might be prevented, or at least greatly diminished. First of all, I think it most desirable that public recommendation should be made, by local and other authorities, to place lightning conductors on all exposed or high-lying buildings, whether public or private, as well as on those standing near woods and on moist ground. It might be well worth the trifling expense to place simple conductors also against trees and parks, under which there are benches, or where persons are likely to gather during a thunderstorm, they forming a prolific source of fatal accidents. Above all, no church, chapel, school, prison, or other large public building ought to be without one or more lightning conductors. There can be no excuse whatever for omitting this simple protective means against death and destruction, which may come at any moment, in the cases of edifices devoted to public or national uses. But if it is necessary to greatly multiply lightning conductors, it is equally so that they should be planned and erected by competent persons, with scientific as well as practical knowledge of the work. There are a hundred circumstances which ought to be taken into account in selecting the best positions for conductors, especially on large buildings and those of irregular construction; and only great experience, as well as cognition of all that we know about the movements of the electric force, can accomplish it. Of first importance are the considerations of the general design of the building that is to be protected; the soil on which it stands, whether dry or moist; the presence of masses of metal in or near the roof or the walls, as in the case before mentioned; the position of the chimneys; and similar matters affecting the course of the electric discharge of the clouds. It would be quite impossible to lay down absolute rules on the subject; still protection against lightning may be effected with the greatest certainty, under the guidance of well-known facts and observations which throw light upon the undeviating path of the mysterious electric force. But if everything possible has been accomplished towards the erection of the most perfect lightning conductor, there still remains something to be done. It is not only to construct a faultless conductor, but to maintain it always in good condition. This is a matter which, sadly neglected, and overlooked to a quite astounding degree, cannot be too much insisted upon. It ought to be universally known that a lightning conductor is worth nothing unless it is periodically tested. The testing should take place at regular intervals, perhaps best in the spring, before the advent of the summer thunderstorms, and it should likewise be made whenever a building has been undergoing repairs which may have damaged the conductor. To show the importance of constantly testing even the best laid conductors, I can cite another instructive case where a house was apparently well protected. On the 19th of August, 1876, shortly before midnight, a heavy stroke of lightning fell upon the mansion of Mr. Evans, civil engineer, Claypond, near Kew Bridge, Middlesex. The electric force destroyed the top of a large chimney, knocking off part of the coping, nor more than 2 or 3 feet from a lightning conductor, to which it then flew, making its way down to the earth, but not without causing the greatest disturbance all along its path, lifting up, among others, some heavy marble toilet tables in bedrooms some 6 feet distant on either side from the copper rope, which, under ordinary circumstances, would have carried the electric force noiselessly, as well as harmlessly, to the ground. The fact of this disturbance indicated at once the source of mischief. The lightning conductor, good as it otherwise was, had no sufficient earth-connection. It went into the earth, it is true, but into soil altogether dry, and therefore the conductor did not, and could not, act properly. It thus came to pass that, first of all, the lightning did not touch, as it would otherwise have done, the conductor directly, but sprang upon the coping of the neighbouring wall; and that, although it made its way down into the earth afterwards, it did so, as it were, with the greatest effort, which caused the lifting up of the marble tables and other disturbances. Nothing was wanting in this case for protection against

PROTECTION AGAINST LIGHTNING.

This year has been remarkable, on both sides of the Atlantic, for the number and severity of its thunder storms. The neighbourhood of London has especially suffered. Looking back on the summer, it seems to us as if every Sunday had brought an impressive sermon of this kind, which, if it taught no other lesson, was at least a warning to those Sabbath breakers who, in their best clothes, had exposed themselves on Hampstead Heath or Clapham Common. Now, that, after such an oppressive August, we breathe freely, attention may be appropriately called to a paper read by Mr. Anderson to the British Association, on accidents by lightning and the means of guarding against them.

Mr. Anderson's statements are by no means assuring. Many of us, when caught in a thunderstorm, have been accustomed to take refuge, first, it may be hoped, in a good conscience, and then in statistics, which, without ever having looked very closely into them, we felt sure would be in our favour. When the bolts were flashing around, we have kept telling ourselves that, if the truth were known, we were, after all, safer than in crossing Regent Circus on a busy afternoon, or in travelling by express train from Holborn to Ramsgate. But Mr. Anderson informs us that, from 1869 to 1876, the deaths from lightning in England and Wales are recorded as 182; and this estimate he takes to be very much under the mark, since during the same period, 819 deaths from lightning are reported in Prussia, where, with a population very slightly larger, there are fewer thunderstorms and a more complete system of registration. Surely, he must be mistaken in his supposition that over a hundred people are killed every year by lightning in this country. In America the ordinary number is from fifteen to twenty, if we may rely upon an electrical contemporary. We should be glad to receive further information on this point. Such information ought to be attainable, and would certainly be useful in teaching sensible people what they really had to fear from thunderstorms, though no amount of statistics would lessen the dread with which ignorant and nervous people behold these manifestations of the powers of nature. In the meanwhile, we are inclined to think that, in our climate, fewer lives are lost by the stroke of lightning than by being wet through in a storm; and that the danger to property, year by year, is not so great as that arising from the more frequent and less terrific phenomenon of a child playing with matches. So, if any of our readers should be unavoidably exposed to the rage of the elements, we advise them to keep a good heart, to think of the drains, the Corporation dinners, the metropolitan water companies, and all the more fatal weapons of death through which we are daily and hourly running the gauntlet, and, above all, not to place their bodies in any position likely to become the line of least resistance for the electric discharge.

Though we cannot accept Mr. Anderson's estimate of accidents from lightning, we are at one with him when he dwells on the want of reasonable precaution which is just in proportion to our unreasonable dread. Forty years after Franklin's celebrated discovery, his biographer observed with surprise how backward we in England were to avail ourselves of it; and now Mr. Anderson brings forward facts to show what astonishing carelessness, to give it no worse name, still prevails among us about the proper use of lightning conductors. Not only are a very small proportion of private houses provided with them, but he tells us this simple precaution is not applied to at least one-half, and probably two-thirds of our public buildings, including some of those magnificent cathedrals whose loss would be irreparable. Windsor Castle itself, he declares, from his own observation, to be insufficiently protected. It cannot be too widely known that a lightning rod is not to be relied upon as protecting more than an area extending twice its own height. At Windsor Mr. Anderson, on a recent visit, found no conductor on St. George's Chapel, or on the adjoining belfry tower; while, as for the rods that stand over the Queen's private apartments, he is very sceptical as to whether they "actually have their root in moist earth." Here is another danger of which the general public is almost entirely unaware. A man puts up a lightning rod, and for the rest of his lifetime fancies himself safe beneath its slender shadow, though, for many years, it may not have been tested, and may have originally been erected without any scientific knowledge being called into counsel. But, unless his conductor is complete, with a good connection with perfect earth, it may be actually worse than useless, since it only acts by becoming part of the cloud, so to speak, and gives off lateral charges during the impeded passage of the electricity, with results that may be imagined, and are described by Mr. Anderson in one instance as "lifting up heavy marble toilet tables in bed rooms some six feet distant on either side of the copper rope, which, under other circumstances, would have carried the electric force noiselessly as well as harmlessly to the ground."

Such a danger could have been foreseen by a scientific electrician; but it is to be feared that many lightning-conductors are no more efficient. Suppose that a conductor ends in dry shallow earth, embedded in chalk, it is only inviting the lightning to pass with difficulty and disturbance along the premises thus insecurely guarded. Good earth, in the electrician's sense, is not to be had so easily as that which a gardener would approve of. It is always safe if your conductor leads into a stream or well, where the electricity will be at once conducted away. If this be out of the question, it is well to bury a few sacks of coke in moist earth, and let the end of the rod terminate among the coke, rivetted to a large fragment of gas carbon or graphite, carefully providing against oxidisation by insulating the rivetted joint, preferably with paraffin wax; this contact will last a century. To make sure, the conductor may be tested with a galvanometer connected with "dead" earth elsewhere; if, then, the resistance be found to be merely the resistance of the wire, you may consider you have a real protector so long as the apparatus remains intact.

All owners of property should follow Mr. Anderson's strong recommendation, that competent persons be employed not only to erect but periodically to test lightning conductors at every point where they may be required. In Paris, he says, and other French towns, there exists a regular system of inspection and testing. Those who have the charge of our public buildings should lose no time in looking to this matter. The season of thunderstorms is not yet over, and as things stand now, the Bishop of Peterborough, sitting on his episcopal throne, may any Sunday become the vehicle of an electrical discharge, struggling like a giant to reach its native earth by way of the verger's mace. We wish his lordship no harm; yet we cannot but recall Sydney Smith's celebrated dictum on the most effectual way of calling attention to a neglected danger.

THE ELECTRICIAN, SEPTEMBER 7, 1878.

ASCENDING LIGHTNING.

[14738.]—In the first paragraph of his letter (14051) your able correspondent, "A Fellow of the Astronomical Society," states that during a thunderstorm in the neighbourhood of Tunbridge Wells he "very distinctly saw one flash of lightning strike upwards from the earth into a dark lowering cloud poised at some distance above it," and he remarks that "theoretically, of course, this is a phenomenon which not unfrequently occurs."

I once saw a similar phenomenon when standing with a friend during a thunderstorm at an upper window of his house in the country. A vivid flash appeared to shoot upwards a few hundred yards in front, from the very part of a meadow at which I was looking, and was instantly followed by a tremendous clap of thunder. My companion said he had distinctly seen the flash, but did not notice anything unusual about it, except that it was straight and nearly vertical. He was, however, not looking at the meadow, but at a wood on the hill beyond. The difference of our impressions seemed to us unaccountable.

Aug 78

Since that time the subject has occasionally occupied my thoughts, and I am now of opinion that ascending lightning is a mere illusion, and due entirely to the eyes of the observer happening to be directed to that part of the landscape at which the discharge occurs, and that it is no proof of the earth having been charged positively.

Wheatstone proved that the duration of the electric spark is about 1-24000 of a second, and he also showed by means of a revolving wheel, that the duration of the lightning flash is little more, and cannot exceed, a minute fraction of the thousandth part of a second. The moment of time it continues visible to us—about the tenth of a second—is therefore hundreds of times greater than its actual duration. Now, is it credible that we can judge by the eye of the direction of motion in a case like this—that we can see the progress of the end of a flash of lightning?

The idea seems absurd, yet this feat must be performed before we can know with certainty whether a flash has travelled in this or that direction.

The following simple experiment will serve to illustrate the argument:—Place before the ball of the prime conductor of a good electrical machine another ball of equal size connected with a discharging train, and so adjust their distance apart that on steadily working the machine distinct zigzag sparks shall pass across the interval. Now, let several persons attentively watch the balls, and say from which of them each spark proceeds. Opinions are pretty sure to differ, but the following rule will be found to have no exceptions:—*The spark appears distinctly to issue from that ball to which the attention of the observer is directed.* It is worthy of note that the end of the spark next the negative ball is the brighter and thicker.

Let me, in conclusion, acknowledge the pleasure and instruction I have derived from the excellent letters of "F. R. A. S." J. T. M.

Powder Magazines without Proper Lightning Conductors.

Oct /78

We have to record the explosion of 1,200 kegs of giant powder at Pottsville, Pa., ignited by a stroke of lightning, and which spread death, ruin and devastation all around.

Public safety demands that the authorities appoint competent inspectors to determine whether a locality where such dangerous material is stored can be considered safe, or can be made safe by the proper and well-known precautions. It is dangerous to trust to the owners of the material or their employés, of whom often the one is as ignorant as the other, and do not know what reliable guarantees science has provided against such calamities.

In mentioning the reliable guarantees, we do not mean the flimsy lightning-rods stuck up all over the country and improperly connected with the ground. Many of them are not worth anything, offer no protection whatsoever, and are the cause of the loss of confidence of many in protection by lightning-rods.

A powder magazine should have no lightning-rods at all, as they are apt to attract lightning; it should for the same reason not be situated on an eminence, but in a valley, and all the metallic parts of the roof be connected by means of a number of iron rods placed in different parts around the building and passing into moist ground below, the rods being carried in the earth for a distance of several rods from the building and there connected with vertical rods driven in the ground deep enough to reach moisture; if the ground is rocky, they should be carried into neighboring streams, wells or creeks where the most moist portions of the neighborhood are reached.

Then for additional security, four or five poles of the size of ordinary liberty poles should be erected around the building at a distance of say 50 feet, each carrying a pointed lightning-rod on top, with a metallic connection united with the moist ground underneath. Such elevated rods would silently discharge most of the electricity accumulated in the clouds, and in case of a violent discharge in mass would receive all the damage and make a discharge through the powder magazine itself impossible.

The reports do not state that the magazine referred to above was provided with any safety contrivance against lightning. If so, it is evident that it was of the kind we have so often seen—a vertical rod on the highest part, and a bar of iron running down from it along the wall and stuck the distance of a few inches into the dry ground below. Such a lightning-rod is worse than useless, as the principal thing is lacking, which is a perfect ground connection. We have always insisted on the right understanding of the fact that the truly protective part of a lightning-rod is not that on the top of the building, but below in the ground. When the ground connection is imperfect the lightning will not go there, but may pass through the house, always following the path of least resistance, and it appears that in the case described the path led straight through the middle of the giant powder.

56

LIGHTNING CONDUCTORS.

[14054.]—I ask permission to describe a very simple and inexpensive mode of protecting buildings against the heavy discharges of atmospheric electricity with which we have all become recently so painfully familiar. It consists in utilising the iron or other metallic rain-water pipes of our houses by bringing them into free electric communication with the roofs by means of gas-coke, which is known to be an excellent conductor of electricity. For this purpose, let a line or row of blocks, or pieces of coke, of moderate size—though the larger the surface presented by them the better—be placed in close apposition across the roof of the house or building, and just beneath the chimney or chimneys (a row of similar blocks might also with advantage be raised upon these against the side of the chimney-stack as high as, or even higher than the latter); and after fixing the blocks, by cementing the under surface of each, let them be carried along the roof to the gutter, so as to bring them into as direct connection as possible with the upper end of the rain-water pipe, and thus to form a continuous electric conductor; and for greater safety a line of smaller blocks, in contact at one end with those under the chimney, might be carried also along the ridge of the roof. The other end of the water-pipe, if not passing directly into the sewer of the house, must be brought into free and uninterrupted communication with the earth, by connecting it with small blocks or pieces of coke buried at some depth beneath the surface. And to realise this all-important object—namely, the rapid and complete transmission of the electricity to the earth—it may be proper to mention that in the case of the ordinary iron and copper lightning conductors, "three bushels of coke, broken up into small pieces, and packed round the bottom of the rod, are found, according to the French engineers, to secure a quarter of an acre of moist contact with the earth, in consequence of the number of pores contained in this substance." A hole then filled with a like quantity of broken coke, or about three bushels, would, I conceive, form an ample channel of escape for any lightning discharge that might fall upon a house, upon the plan that I have ventured to suggest. It is almost unnecessary to add that the rougher the blocks or pieces of coke selected for the above purpose the better, on account of the greater number of collecting points for the electricity which they present.

W. H. O.

Atmospheric Electricity.—In a recent memoir read before the Academy of Naples, Prof. Palmieri gives the results of his 27 years experience of this subject. He is of opinion that the formation of aqueous meteors and clouds is always attended by the liberation of positive electricity; but these clouds can afterwards change themselves negatively by induction. When negative electrification is observed, it is due to perturbations resulting from discharges at distances more or less great. In dry clear air where the distribution of positive electricity is normal, the potential diminishes with increasing height, a result different to that obtained by other observers. Nov 78

Nov 78

Compound Lightning.—Mr. E. H. Pringle, in a letter to *Nature*, October 3rd, states that "compound lightning flashes," or discharges, where several flashes follow each other rapidly in the same track, are to be seen in almost every tropical thunderstorm. When the flashes succeed each other quick enough, the effect is "beaded lightning." It is singular that the electricity should collect so rapidly; for the after-flashes do not seem to be merely residual.

as often as required. The induced currents are obtained from the screws numbered 5 and 6; the extra current passes between 6 and 7; whilst both combined are obtained from 5 and 7.

The second form of regulator, for ordinary medical use, was recently presented to the Académie de Médecine by M Gararet. Its indicating needle and graduated limb are drawn in K and L (fig. 4). It may be briefly described as a vibrating armature of special construction, involving the principle of the pendulum, so that, by the movement of K, the number of its oscillations per second may be varied between tolerably wide limits. The figures marked upon the limb *l* are determined in each case by a simple experimental method involving a small chronograph and registering apparatus specially constructed for the purpose.

The reversible battery cell, represented in Fig. 5, has been

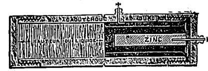


Fig. 5.

described in these columns on a previous occasion. When the fluid, a solution of bisulphate of mercury, occupies the position shown in the cut, the couple formed by the elements in the upper portion of the cell is not brought into action, and there is no consumption of material; but, when the cell is placed on its side or reversed, the couple is immediately rendered active.

ATMOSPHERIC ELECTRICITY.*

By Professor Palmieri.

Putting aside certain temporary apparatus designed to prove the existence of atmospheric electricity, such as the kite, captive balloons, the bow and arrow, and other similar contrivances, it may be said that for the daily observations of meteorology there have been used, in the first place, fixed conductors terminating in a point or "flame," next the moveable electrometer (Peltier), and, lastly, the fixed electrometer with moveable conductor (Palmieri and Thomson). The method of fixed conductors was triumphantly combated by Peltier, and I myself, without repeating what was demonstrated by the French physicist, showed further how, with that method, the observer might be deceived not merely as to the quantity, but also as to the quality of the induced electricity.†

Peltier's method, by use of the moveable electrometer, was undoubtedly a step in advance, but few were able to appreciate it; and, although Wheatstone recommended it to the British Association as the only one capable of giving results of any value, it attracted but little attention.

In 1850 I applied myself to the study of atmospheric electricity. I observed that, although Peltier's method was an important gain to electrical meteorology, nevertheless, it was not exempt from certain defects, owing to which it was impossible to get observations exact enough for comparison, and I endeavoured to find, therefore, some better method, as well as a thoroughly exact electrometer.

As regards the method, I studied the electrical manifestations occurring in the open air when two conductors are brought near to, or separated from, each other horizontally. I found that the tensions, which are manifested through contiguity, are of an opposite, whilst those which are obtained by separation are of the same nature as the electricity prevalent in the atmosphere. So that, in normal times, two conductors that are brought near to each other show negative electricity, but positive if they are separated. This law is, of course, inverted when negative electricity prevails in the atmosphere. The electrical tensions which we get in this way follow, as to their intensity, that of the air. These are the only facts which prove the electricity of bodies placed on the earth, or, if you will, the electricity of the earth; but, at the same time, they show that that electricity is induced from that of the air, and is not proper to them. If, then, this electricity of the earth is always opposed to that of the air, and follows exactly the phases of increase and diminution of the latter, it is clear that the former is induced electricity, and not *sui generis*, and thus one can understand the fact—often noticed by me—that, whilst at the University Observatory, the earth shows negative electricity to a very strong degree when two conductors are brought near to each other in the open air, at the Observatory of Vesuvius at the same time we get positive electricity—I say at the same time, for the observations were compared by telegraph. The electricity that is manifested at the approach or separation of two horizontal bodies being, then, exactly proportionate to that of the atmosphere, I concluded that from the former one might get the measure of the latter, since, to whatever method we have recourse, that which is measured is the force of the influence exerted on thoroughly exposed conductors by the electricity of the atmosphere. For reasons which it is not necessary here to repeat, I did not confine myself to the method of horizontal approach and withdrawal.

By the aid of water, I set about the study of the electrical phenomena of ascending and descending streams, and determined the origin of those electrical manifestations noticed by Tralles and Volta as occurring with the spray of the cascade.

With the descending jet I found, amongst other things, that when the vessel is insulated electricity homologous to that of the atmosphere manifests itself during the flow of the water. The same phenomenon occurs with other liquids, and also with pellets of lead, metal filings, and even with the ashes of Vesuvius.

(TO BE CONTINUED.)

* Translated from the *Elettricista*.

† I need scarcely repeat what has already been remarked by Peltier and so often verified by myself, namely, that the fixed conductors often remain for whole weeks perfectly mute, on account of electric dispersion. Volta observed that a fixed conductor required 5' to attain the maximum of its charge; and this is in conformity with the known laws, since to become charged through the point takes time, and in this period, relatively a long one, losses will have occurred which, owing to their extent and variability, it would be impossible to calculate. Thus, frequently the whole is dissipated, as happens not seldom even to the conductor of an electric machine. What means then can be employed with fixed conductors? First, in regard to the deceptions which they occasion, I do not think that they can be avoided by use of the method proposed by Volpicelli, because even on calm days, whether owing to currents in the upper regions of the atmosphere, or to other causes not yet determined, there occur sudden and rapid changes through which the curve made with observations, taken at short intervals, nearly always turns out angular (see my "Lectures on Terrestrial Physics"). The fixed conductor, then, in a time of positive electricity will give negative electricity simply by a diminution of the inductive energy in the atmosphere, and this not only in stormy weather, but even when it is fine. This is why many times it has happened to me to get negative electricity with a fixed conductor, and positive with a moveable conductor. During the eruption of Mount Vesuvius in 1872, whilst the needle inclined itself towards the Observatory, the fixed conductor frequently signalled negative phases, the moveable conductor showing instantly a positive current.

THE SOCIETY OF TELEGRAPH ENGINEERS.—CABLE GRAPPLING.

The opening meeting of the present session of the above Society was held on Wednesday evening, the 13th of November, in the hall of the Institute of Civil Engineers, Great George-street, Westminster. The chair was occupied by Mr. W. H. Preece, vice-president.

Mr. Andrew Jamieson, C.E., was called on to read his paper on "Cable Grappling and Cable Lifting." The author remarked that, before entering on the main subject of the paper, it would be as well to briefly analyse the chief causes of the interruption and breakages to submarine cables. The chief causes might be enumerated as follow:—First, total breakage, due to abrasion, suspension between submarine eminences, insufficiency of slack, volcanic eruptions, or terrestrial disturbances, or possibly large masses of rock becoming detached and falling across the cable in their descent; second, in shallow water the cable was often broken from ships' anchors; third, faults were caused by teredos or other marine animals boring; fourth, break of the conductor, with perfect or good insulation; fifth, latent faults in the cable when laid, developing afterwards, or deterioration of the core, joints, or sheathing, and, sixth, and last, lightning. Reviewing the six causes, they came first to breakages due to abrasion. This cause was mainly attributable to the cable being swayed to and fro under the influence of tides, currents, &c., and the only means of guarding against them was to submerge the cable very carefully, and use as heavy a type of cable as possible. The floating in suspension was clearly due to insufficiency of slack, and hence the great importance of a thorough knowledge of the ground over which the cable was to be laid. Volcanic eruptions or terrestrial disturbances were actions over which we have no control, and for which at present no visible means of provision could be made, except that of using as heavy a type of cable as possible where they were to be apprehended. As to breaks by ships' anchors, this danger could only be lessened by using as heavy a type of sheathing as possible, and carefully marking off the ground by buoys or otherwise, and as far as possible avoiding anchorages. The frequent injury to the core by teredos or other marine animals might be guarded against by coating the core and servings with some anti-teredo substance, which would be either distasteful or fatal to the animal, and have no effect on the cable. Various means had been proposed with this object in view. The causes of interruption from a broken conductor, with perfect or good insulation of the core, were due to an over straining of the copper wire in the manufacture, or in paying out, or, perhaps, to the brittleness of the copper. The simple remedy for this kind of fault was taking great caution to have the core of the conductor thoroughly annealed, and capable of bearing a certain strain with elongation before breaking, and being careful not to put more strain on the same when twisting it into a conductor than was absolutely necessary to form a good lay. As regarded provision against latent faults in the cable when laid, or deterioration of the core, or joints, or sheathing, they must look for a remedy in a thorough system of electrical testing. With regard to interruptions caused

58

Éclairs observés au Brésil

Nous trouvons sous ce titre, dans la *Nature* de Paris, un très-curieux article de M. Léon Dumas sur la forme des *éclairs observés au Brésil.*

Il nous a été donné d'observer, en août 1877, lors d'un orage assez violent qui avait pour théâtre la petite ville de Vanouras, dans la province de Rio-de-Janeiro, deux formes singulières d'éclairs. Les décharges électriques se suivaient sans interruption et affectaient pour la plupart le trait sillonné, d'observation commune.

Mais dans les zones intertropicales, la tension électrique des nuées est plus forte que chez nous, par suite de l'[illegible] des phénomènes d'évaporation ; de là, des dessins parfois bizarres occasionnés par certaines ramifications des éclairs.

Une forme d'éclair fort curieuse est figurée dans le premier de nos croquis (fig. 1). C'est une sorte d'explosion offrant, dans ses contours, quelque analogie avec la flamme d'une bougie. La décharge affectait, au lieu du zigzag habituel, un ensemble pyriforme allongé, rectiligne, encadré d'une auréole également fort allongée.

Une seconde forme d'éclair (fig. 2), plus commune sous la zone torride, présente un tronc principal, jaillissant d'un épais nimbus, se subdivisant en deux branches, dont l'inférieure ne tarde pas également à se subdiviser. Cette forme se rapproche assez bien des éclairs arborisés déjà signalés par M. Em. Liais.

Les phénomènes électriques, bien que communs au Brésil, n'ont pas généralement l'intensité qui rend les orages des Antilles et des Indes si redoutables. Nous attribuons ces faits à l'orographie du pays et à sa végétation. Les chaînes de montagnes sont nombreuses et n'ont pas de ces pics saillants qui semblent tout attirer. Ce sont, pour ainsi dire, autant de sommets situés à peu près à la même altitude et dont chacun exerce un rôle dans les échanges aériens.

D'autre part, la végétation couvre le pays d'un superbe manteau protecteur. Le pouvoir des pointes est exercé par des milliers d'organes qui permettent un écoulement constant de l'électricité négative du sol. Est-ce à un état réfractaire que certains végétaux doivent leur réputation d'attirer plus spécialement la foudre, en occasionnant des vides dans les zones protégées ? Nous n'en savons rien. Mais c'est là la réputation faite notamment au *Peroba* (aspidosperma Gomesianum), aussi se garde-t-on bien de l'employer comme bois de charpente.

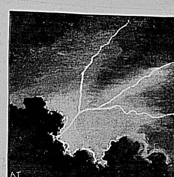
Les nuages élevés échappant en partie à ces recombinaisons constantes, les deux manières d'être de l'électricité donnent lieu à des décharges accidentées dans leur parcours par suite du voisinage de nuées différemment électrisées. Le ton rose-violet des éclairs indique déjà une élévation fort grande.

D'observations quotidiennes, trop courtes malheureusement, nous avons pu constater que les éclairs muets ou éclairs de chaleur se manifestaient de préférence dans les régions où l'altitude était la moindre.

L'auteur paraît avoir été induit en erreur dans cette dernière assertion, car les éclairs dits de chaleur sont produits par des décharges entre les nuages, ou par les reflets d'éclairs éloignés, et par conséquent ne peuvent se produire dans le voisinage immédiat de la terre.

Quand l'étincelle électrique y pénètre, c'est toujours en se faisant accompagner de tous les effets qui rendent la foudre si terrible et si bruyante.

Éclair lenticulaire



Éclair filiforme

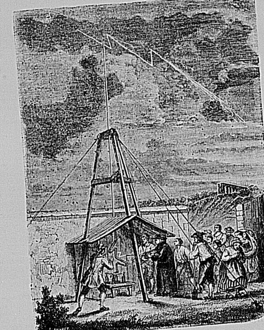
59

fuyant sous les bois, ou serpente au milieu des riches terroirs. C'est là que Diwisch passa la plus grande partie de sa vie et cette agréable situation a dû avoir certainement une grande influence sur les tendances et sur les études de ce jeune homme. Les violents orages qui éclatent fréquemment dans cette contrée, et principalement au prieuré de l'ordre des Chevaliers de la Croix, en face de la ville, ont pu lui procurer de fortes émotions : il a pu aussi trouver l'occasion d'étudier la foudre.

A quelques minutes de Znaim, dans la direction du sud-est la grande route de Prague à Vienne traverse la Taïa : on voit en cet endroit les grands bâtiments d'un cloître de religieux. C'est là que le jeune Diwisch fut reçu au sortir du collége. On l'encouragea à entrer dans les ordres ; en 1720 il prononça ses premiers vœux et, six ans après, il était fait prêtre.

Il devint bientôt un professeur excellent : il fut d'abord chargé d'enseigner les sciences naturelles et philosophiques ; Au bout d'un an, on lui confia l'enseignement de la théologie ; il contenta tellement ses supérieurs dans l'exercice de cette fonction qu'ils lui conseillèrent de passer le doctorat. Sa thèse « *Tractatus de Dei unitate sub inscriptione A et O* », soutenue à Salzbourg le 5 août 1733, lui valut le titre de docteur.

Le sort le désigna bientôt après pour la cure de Brenditz. Pendant la première guerre de Silésie, il vint administrer le



Expérience de d'Alibard à Marly, le 10 mai 1752.
Première démonstration de la présence de l'électricité dans les nuages orageux.

cloître du Pont, dont le prieur avait été mis en prison ; il s'acquitta fort bien de cette mission, et, la guerre terminée, il retourna dans sa paroisse. C'est là qu'il demeura jusqu'à sa mort.

Comme les devoirs d'un pasteur ne sont pas bien lourds dans un petit village, Diwisch put s'occuper pendant de longues années et avec un zèle admirable de nombreuses études. On sait qu'il commença ses expériences en 1727 ou 1728, et que depuis son retour à Brenditz, qui date de 1740, il s'occupa spécialement de recherches sur l'électricité.

Ayant lu dans la *Gazette de Prague* le récit de la mort du physicien russe Richmann, Diwisch publia un traité où il exposait les raisons pour lesquelles les tiges de fer employées par le professeur Richmann étaient tout à la fois sans utilité et pleines de dangers. Il terminait en décrivant un appareil capable d'attirer l'électricité atmosphérique et de la conduire sans danger dans le sol. Il fit exposer ses idées à l'Académie des sciences de Berlin par Euler, physicien distingué et mathématicien. Mais on ne prêta aucune attention à sa découverte. Un opuscule d'Euler, qui parut un peu plus tard, en 1761, et qui traite de Diwisch et de son invention, passa inaperçu.

Sûr de son fait, le prêtre de Moravie entreprit de construire lui-même son grand appareil, et, dès le 15 juin 1754, il le dressa près de son presbytère. Voici la description de ce paratonnerre dont nous reproduisons le dessin (fig. 1).

Au-dessus d'une large porte, placée verticalement, haute d'abord de 48 pieds, puis ensuite de 130, lorsque la première hauteur eut été reconnue insuffisante, s'élève une tige de fer, épaisse d'un pouce et demi, et se terminant par une pointe. Au-dessous de la pointe sont trois ailerons en tôle, mobiles sous l'action du vent et dont le seul usage est d'effaroucher les oiseaux. Du milieu de la tige principale, dont il vient d'être question, partent quatre tiges secondaires, dont chacune supporte près de son extrémité une barre horizontale. Les quatre tiges secondaires et les barres qu'elles supportent offrent en tout douze extrémités. Chacune de ces extrémités est recourbée afin de supporter une petite caisse en métal. Ces caisses (fig. 2) ont un pied de long : elles sont remplies de limaille de fer et fermées par un couvercle en bois,

60

garni de trous; dans chacun des 27 trous d'un couvercle s'enfonce une petite broche, et cette broche qui a la grosseur d'une épingle à cheveux (fig. 3) est fixée dans le couvercle à l'aide d'une rondelle en bois qui fait pour ainsi dire office de bouchon. Toutes ces broches s'enfoncent par leur partie inférieure dans de la limaille de fer. La grosse poutre sur laquelle repose la tige principale est garnie d'armatures métalliques destinées à lui donner plus de solidité : quant à cette tige de fer, elle est reliée à la terre par des chaînes dont le double rôle est de conduire l'électricité et de servir à faire tourner la machine mobile sur son pivot. Ce fut cet appareil qui fut dressé le 15 juin 1754. Voici comme Diwisch raconte ses premières expériences :

« A deux heures de l'après-midi, un orage s'éleva du Nord
et se dirigea dans la direction de l'appareil : on vit des
trainées blanches et déliées venir vers le paratonnerre.
Quelques minutes après, on aperçut au-dessus de lui un
nuage blanc; puis l'orage se dissipa, il disparut vers l'Est.
Le 17 du même mois, il s'éleva de tous les points de l'horizon
un nouvel orage; mais au-dessus de l'appareil les nuages
restèrent blancs. (A midi, Diwisch fit descendre le paraton-
nerre afin de voir si le fluide avait produit quelque effet.)
Aussitôt qu'il toucha le sol, les nuages blancs changèrent de
couleur; ils s'obscurcirent : l'orage monta; tout le ciel
devint noir; les éclairs brillèrent; le tonnerre éclata et d'ins-
tant en instant devint plus terrible. (Trois quarts d'heure

Le physicien Richmann foudroyé dans son cabinet de physique à Saint-Pétersbourg par l'électricité d'un nuage orageux, le 6 août 1753.

après, Diwisch fit replacer l'appareil sur le poteau et plaça
lui-même les chaînes de fer reliant le paratonnerre au sol.)
A peine était-il dressé que la foudre éclata sur lui avec un
fracas terrible; les nuages se déchirèrent, et, juste au-dessus
de la tige métallique, on vit une zone brillante, mesurant
environ huit pouces de diamètre (?). Le ciel redevint calme à
Brenditz, bien qu'on aperçût encore dans le voisinage quel-
ques faibles éclairs et qu'on entendit encore le bruit du ton-
nerre. Trois minutes après, un gros nuage gris s'avança du
Nord, et descendit fort bas; il vint tout près de l'appareil et
se divisa : une partie alla rejoindre un nuage orageux; tous
deux cessèrent de tonner au-dessus de Brenditz et ils se
fondirent en une douce pluie. »

M. Mayer entre dans d'autres détails que le défaut d'espace nous empêche, à notre grand regret, de reproduire aujourd'hui.

Ainsi que le dit notre jeune et érudit correspon-

dant, il est véritablement étonnant que l'on ait at-
tribué à Franklin le mérite de l'expérience exécutée
par d'Alibard à Marly-la-Ville.

Il y a longtemps que cette injustice nous a frappé
pour la première fois, mais nous ne nous étions
point arrêté à en pénéter les causes. Nous ne l'au-
rions peut-être jamais fait si la nécessité de répon-
dre à M. Mayer ne nous avait conduit à pratiquer
dans les archives de l'Académie des Sciences des
fouilles qui nous ont permis d'examiner des faits
du plus haut intérêt.

C'est le 10 mai 1750 que fut exécutée à Marly-la-
Ville, la merveilleuse observation qui eût immorta-
lisé d'Alibard s'il eût vécu dans un pays où la rou-
tine d'intrigue et la camaraderie avaient une in-
fluence dont nous pouvons facilement nous faire

ailleurs, j'avais publié dans différents ouvrages la même analogie qu'il avait cru apercevoir entre le tonnerre et l'électricité.

« Je demande, de plus, que cet écrit soit transcrit dans les registres de l'Académie, afin que j'en puisse avoir acte au cas que j'en aie besoin. »

Ainsi, cet habile homme, par un tour de force dont les académiciens de nos jours ne sont point susceptibles, niait la réalité des expériences de d'Alibard, en même temps il prenait ses précautions dans le cas où les faits annoncés seraient réels. Alors il entendait s'en attribuer le mérite, et il déclarait par avance qu'il les avait parfaitement prévus.

Ce qui est véritablement honteux c'est que les expériences se succédèrent avec rapidité. Delor les répéta à la place de l'Estrapade, Lemonnier en donna la représentation à la campagne du duc d'Anjou, à Saint-Germain.

Mais l'Académie des Sciences tint bon et le *Mémoire de d'Alibard* NE FUT POINT INSÉRÉ.

Nous ne saurions exprimer assez énergiquement notre mépris pour les savants plats et vils qui ont donné leur assentiment à une si scandaleuse suppression.

Ils étaient les dignes prédécesseurs des plus ridicules tartufes scientifiques qui aient endossé l'habit vert, depuis que l'Académie a reçu cet uniforme.

Heureusement, M. de Buffon, qui s'intéressait à d'Alibard, lui conseilla de publier une traduction du livre dans lequel Franklin exposait ses découvertes et d'y consacrer un chapitre à la reproduction de son mémoire à l'Académie.

C'est grâce à ce subterfuge, qui n'eût pas réussi, sans la protection du comte de la Marche, qui fournit l'argent, que la gloire de d'Alibard a surnagé.

Il était étouffé par le coupable Nollet, si Franklin n'était venu à la rescousse et n'avait pris, par conséquent, dans cette affaire la part du lion.

On croyait, à cette époque, que les tiges isolées absorbaient l'électricité des nuages, et, en contact avec elles, on suspendait des masses métalliques qu'on nommait des *réservoirs d'électricité*.

Ajoutons que tous les opérateurs affichaient une sécurité aussi grande que celle du brave curé de Marly-la-Ville. Nul ne croyait qu'il fût nécessaire de prendre la moindre précaution pour se garantir contre l'écoulement du fluide accumulé dans les réservoirs d'électricité.

On ne commença à comprendre le danger que lorsque Richman eut été foudroyé à Saint-Pétersbourg.

Sauf les dimensions, son appareil était identique à celui dont d'Alibard, Delor, Lemonnier s'étaient servis.

Jusqu'à cette époque, personne n'avait songé à mettre les réservoirs d'électricité en contact avec le réservoir commun.

Cette nouvelle phase de l'invention des paratonnerres doit maintenant être examinée.

W. DE FONVIELLE.

61

Annalen der Physik und Chemie, No. 12, 1878.—In an inaugural dissertation here given, Herr Nahrwold studies atmospheric electricity; his method of experiment having been to electrify air in a cylindrical vessel fitted with a (mercury) dropping collector. His first attempts, with points, convinced him that only the dust, not the air, could be thus electrified; he then successfully used a fine platinum wire kept glowing with a battery (the air having been first freed from dust), and a condenser or galvanic element connected with the circuit. Interesting data are furnished with regard to the charge of the air, the ratio of this to the source of electricity used, and the decrease of the charge. Some of the observations seem to throw doubt on Thomson's conclusions as to the distribution of electricity in the upper regions of the atmosphere.—Herr Wiedemann offers a theory on the nature of spectra, deduced from the kinetic theory of gases. Line-spectra are attributed to oscillatory motions of atoms, isolated at high temperatures; band spectra of elements and spectra of compounds to vibrations of atoms in the molecule, or of the ether-envelopes.—A quantitative verification of the electrodynamic law, regarding the reciprocal action of closed circuits, for the case in which the circuit suffers deformation, is furnished by Herr Niemöller.—Herr Korteweg discusses the velocity of propagation of sound in elastic tubes, and Herr Rühlmann gives formulæ for measurement of ocean depths with the manometer.—There are several notes on crystallography.

A New Telegraphic Conductor.

An electrical conductor of decidedly novel character has just been patented by Mr. Alberger, of Philadelphia. It consists of a conducting wire—preferably of decarbonized steel—surrounded by a vitreous substance and incased in a metallic tube. The manner of making the conductor is as novel as the article itself. The inventor produces a glass bulb at the end of a glass blower's tube, and passes a wire from a neighboring reel through the tube until its end reaches the outer end of the bulb, when the end of the bulb and the wire together are seized and drawn outward, while the tube remains stationary. The wire having the vitreous casing is now introduced into a wrought iron tube, and the whole is heated to a welding heat and reduced in size by rolling. Sections of the conductor are united at the ends by an ordinary screw coupling, the ends being first rounded off by an emery wheel to render a contact of the conducting wires certain. The conductor made in this way is protected from oxidation, and is completely insulated. March 79

62

Atmospheric Electricity

traces afforded by the self-registering electrometer at this obs... atory show that the conditions of the atmospheric electricity at Kew were very similar during the recent frosts to those observed at Montsouris by M. Descroix. We have, however, in the automatic instrument the great advantage of continuous registration, and therefore our information is not limited to the results afforded by seven observations daily.

The whole period of the frost was characterised by extremely high tension which with us averaged and frequently exceeded the amount which sufficed to derange the French instrument.

The absolute maximum tension recorded equalled 600 volts, and occurred about 4 P.M. on December 16.

The most noticeable feature in the curves of electrical disturbance during the period is that of the daily range of the instrument having attained a maximum usually between 8 to 10 P.M., the tension reaching over 400 volts at the time on the 17th, 18th, and 21st, and over 500 on the 22nd ult.

The fall in tension on the 25th was irregular and the value became almost zero at 6 A.M. on the 26th, for the whole of which day it continued low. Negative electricity was recorded for the first time from 1 to 3 A.M. on the 29th.

Undoubtedly the value of the tension of the atmospheric electricity, as measured by the Thomson electrometer is, as M. Descroix states, only a relative one. We have determined experimentally that with the same instrument the indicated tension is largely influenced by the distance of the nozzle of the water-dropping collector from the wall of the building in which the instrument is placed, and in accordance with a suggestion of Sir W. Thomson, we replace during the passage of thunderstorms our ordinary discharge-tube by a very short one, so as to get the scale of tensions within the range of the electrometer.

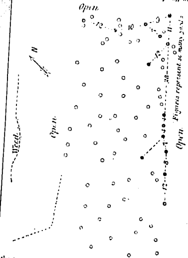
Kew Observatory, January 6 77 G. M. WHIPPLE

A thunderstorm of extreme violence is reported to have burst over Bayonne on the 15th Dec. at 6.30 a.m. The lightning struck the mast of a ship anchored in the roadstead, and broke it into 200 pieces. On the coast a tree was actually pulverised. The electric discharges were accompanied by a fall of hail which covered the ground with an ice layer 5 centimetres in thickness. The stones were homogeneous and transparent. Jan 79

(10) J. A. H. asks: 1. Is there any advantage in what lightning rod men call "circuit" rods—that is, two ground rods to one point? What do you think of such rods put into the ground 8 or 10 feet, ground tolerably dry? A. The only advantage in such an arrangement is that it affords a better ground surface. If the ground connections terminate in dry earth, the lightning rod will not prove effective. 2. Are horse shoe magnets better than common points, or should points be magnetized so as to lift small needles? A. There is no advantage in a magnetic point. 3. What is your opinion of tin roofs as a protection against lightning? How should they be connected with the ground? A. Tin roofs, if connected with the lightning rod having good ground connections, may prove an additional protection. The ground end of the rod should be forked and buried in earth that is continually moist. The effectiveness of the rod may be increased by filling the hole around the rod with pounded coke or charcoal. The ground end of the rod should be bent away from the house. 4. Is it safe to put a rod into a well? A. Yes. 79

Effects of Lightning May 1879

A REMARKABLE electric discharge occurred on Sir Robert Gordon's estate of Letterfourie in a small wood about four miles to the south-east of this place on November 16 last about 12.45 A.M. The accompanying sketch (scale $\frac{1}{24}''$ = one yard), where



the trees (common fir and larch) *struck* are represented by black dots, will give you an idea. The soil and trees were slightly covered with snow, which had been falling at intervals since sunset on the 15th. On that night I observed two or three flashes of lightning accompanied by thunder, and a few days afterwards

I was told by a local medical gentleman, who had visited the spot, that some eleven or twelve trees had been struck among the hills under peculiar circumstances. The snow was lying so deep at the time that the place was well nigh inaccessible, and owing to want of leisure and the continued severe weather, I had no opportunity of visiting the wood in question until a few days ago. I then ascertained from a farmer living 150 yards south-east of the spot, that the trees must have been struck simultaneously.

Between 9 and 10 P.M. on the 15th a flash of lightning, followed by loud thunder, was seen by him in the north and clear of the wood altogether; besides, the interval between flash and peal showed it to be at a comparatively great distance. The man, being an invalid, never slept, when about 12.45 A.M. on the 16th a blinding light immediately followed by a tremendous thunderclap made him think his own house was struck. The next and last flash and peal occurred a quarter of an hour afterwards at a considerable distance away to the west.

The effect of the lightning on the trees was observed from the window on the following morning, and as the spot was daily visited by the inmates of the house for the purpose of drying clothes, there could be no doubt but the damage had been done during the previous night. All the fourteen trees, varying from six to nine inches in diameter, and not visibly higher than the immediately adjoining ones have lost the bark over a width of one half to one inch, and the wood is slightly split.

Buckie, Banff, N.B., May 12 G. W. CAMPHUIS

63

It is the elementary part of a subject which is always so badly taught, chiefly because it is a general belief that any one can teach a child. We are, therefore, pleased to welcome in Parts I., II. and III., an exceedingly clear statement as to what sections of arithmetic should be taught, and how they should be taught to young children.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to ensure the appearance even of communications containing interesting and novel facts.*]

A Machine for Drawing Compound Harmonic Curves

IN NATURE (vol. xx. p. 103) there appears an abstract of a paper by Prof. E. W. Blake on a machine for drawing compound harmonic curves. Prof. Blake is doubtless not aware that this machine is based on a plan proposed by Prof. Perry and myself in our paper on "the music of colour and visible motion," read before the Physical Society, November 23, 1878. In that paper, after the description of our own motion-compounder, will be found the following:—"But it is possible that in our new machine we shall adopt a totally different plan, and one which we think is new. If the two extremities of a long rigid rod have parallel motions perpendicular to the rod, the middle of the rod has a motion equal to half the sum of the extremities. Thus the parallel motions of 2, 4, or 2^n points may be compounded. Similarly for 3 points, one-third of the sum of parallel motions is obtained from the centre of a rigid triangular piece of which the points are the corners; so that by bars and frames of simple construction it is easy to get the sum of the parallel motions of any number of pieces."

But I think that this method which we suggested, and which is the one now described by Prof. Blake, is inferior to the roller-cam principle employed by us in the instrument we constructed, and explained to the Physical Society, in that with the latter in its complete form we can alter, while the machine is actually in motion, the *amplitude* as well as the *phase*, by any *desired* amount, of *any one* of the component vibrations. This facility, although not possessed, as far as I am aware, by any other motion compounder, is extremely desirable for the varied description of compound curves, whether these curves be merely intended, as in the ordinary forms of such instruments, to show the resultant of two or more vibrations, or be designed, in accordance with the plan of Mr. Perry and myself, to work on the emotions, in the rendering of a new genus of music, by the varied, yet controlled, motions of the body, or bodies, describing these curves.

W. E. AYRTON

Lightning Conductors

ON the night of Wednesday, May 28, shortly after ten o'clock, my father's house at Caterham, in Surrey, was struck by lightning. We had not noticed any thunder before going to our bedrooms, but shortly after doing so we saw a very vivid flash, followed by thunder after an interval of perhaps five seconds; three or four minutes after this there came with a terrific crash the flash which struck the house, and afterwards no more thunder or lightning sufficient to attract our attention while we were intent upon investigating the mischief done.

The house stands high, upon a hill upwards of 700 feet above the sea; it is somewhat higher than any house or other object in its immediate vicinity. Roughly speaking, it may be described as a square block surmounted by a steep tiled roof, the ridge of which runs north and south, and astride upon the ridge stand two chimney stacks of equal height; from one corner of the square block runs away an extension, the roof and chimney stacks of which are upon a somewhat lower level.

Upon the northern chimney stack, at its eastern end, was the lightning conductor, which consisted of the usual hollow rod ($\frac{5}{8}$ inch) at the top, continuous with a flat plaited rope of copper and zinc wire (1 inch in width), carried through glass insulating rings along the slope of the roof, over the rain-water gutter, and down the side of the house into the ground.

The flash first struck the lightning conductor, hurled the rod down, and shattered the chimney-pots and a little of the brick-work; it seems to have followed the chimney-stack down to the ridge of the roof, and there to have divided. That portion of the discharge which passed down the eastern slope of the roof seems to have followed the chain portion of the lightning conductor as far as the rain-water gutter (iron); this it slightly broke, and broke also two panes of glass immediately beneath it, but this portion of the flash could be traced no further, and dead leaves, &c., about the remainder of the lightning conductor would seem to indicate that none had passed down that, at least not any large quantity.

The greater part of the discharge seems to have utterly left the guidance of the conductor, and to have first followed the lead flushing of the chimney stack down the western slope of the roof; a foot or so below the end of the flushing the roof was perforated, and the tiles broken and thrown down; thence, without any disturbance of the intervening tiling the discharge leapt a distance of some 15 feet, perforated horizontally a 9 inch-brick wall, covered on its exterior by weather tiling, and so reached an iron water cistern immediately within this wall. The woodwork about the cistern was started, but not much splintered; thence the discharge passed downwards by way of the water pipes, down two stories to a force-pump in the scullery, and thence, probably, by the pipes, down into the subterranean water-tanks.

But the pump in the scullery was provided with a pipe and tap over the sink, and there was also a small "tell-tale" pipe from the cistern above, designed to show when the cistern had been filled. This also terminated over the sink. Along these some part of the discharge was led, and not being safely conducted away, threw down and shattered the slate about the sink.

The perforation in the brick wall was circular, large enough to easily admit one's finger, and was blackened on its interior; when first found, eight or ten minutes after the occurrence, it was still quite hot.

The practical question that presses for an answer is, what did the lightning conductor do for us? Its selection as the point struck seems as though it brought the discharge upon the house; certainly it, although I believe of the usual construction, was utterly inadequate to carry off, or even direct the course of, the discharge, for a most copious and violently destructive discharge passed altogether from it and down over the opposite or western slope of the roof.

On the other hand, the iron water-tank and its pipe system proved adequate and safe conductors of the electric fluid, which left not the smallest trace of its passage along them until it reached the scullery sink, and there would presumably have done no harm, had it not been for the existence of the tap pipe, which led a portion of it astray. And on both faces of the house the iron gutters and rain-water pipes seem to have proved efficient conductors, for no violently destructive effects were manifested, save the breaking of two panes of glass after the electric fluid reached them. But as I am no electrician I can add nothing useful to the bare narration of the facts. I should add that the soot was very completely and violently ejected into the rooms from the chimneys of the stack struck.

CHARLES S. TOMES

P.S.—Subsequent closer examination of the portions of the lightning-conductor showed that there were traces of fusion of the hollow copper rod at its junction with the rope which had been inserted into it; the sectional area of copper here available for carrying the discharge seems to have been less than that in either the rod or the rope. Slighter traces of fusion existed here and there in the whole length of the rod. In its passage round the water-gutters the discharge cracked each one at its junction with the next segment; that is to say, the iron was cracked wherever the interposition of a little red lead to make the joint tight offered increased resistance to its passage, and the lead flushing of the roof was fused below the perforations in the brick wall, indicating that the whole discharge did not go through the wall to the iron water-tank.

THE effects produced by the recent thunderstorms are so interesting and instructive that I think it worth while to record the results of investigations which I have made personally or had made for me.

On May 31 there was published in the *Times* particulars of the damage done to the church at Laughton-en-le-Morthen, and the conductor was described as a thin corrugated tube of copper made

64

Copper and Iron Lightning Conductors.

What should be the relative sectional areas of lightning rods in order that neither metal should be more liable to fusion by the passage of an electrical discharge through it than the other? Mr. R. S. Brough (whose recent death in India we regret to announce) has answered this question in the May number of the *Philosophical Magazine*. The relation usually given—viz., that an iron rod should have four times the sectional area of the copper rod—is based on the fact that copper conducts electricity six times as well as iron, while the melting point of iron is about 50 per cent higher than that of copper, and $\frac{6}{1\cdot5} = 4$. This simple treatment is incomplete, June 79 because it neglects the following important factors: (1) The influence of the rise of temperature in increasing the electrical resistance of the metal; (2) the difference between the specific heats of the copper and iron; and (3) the fact that the iron rod being made several times more massive than the copper rod, it will require a proportionally greater quantity of heat to increase its temperature. Taking these considerations into account, Mr. Brough finds that the sectional area of an iron rod should be to the sectional area of a copper rod in the ratio of 8 to 3. For the same efficiency iron rods are therefore cheaper than copper rods.

THE MECHANICAL ACTION OF LIGHTNING.

Engineer July 2 1880

WITHIN the last few days England has been visited by several thunderstorms of considerable severity, and deaths caused by lightning have taken place in three or four localities. Trees have been rent, animals slain, houses injured, and there is some reason to conclude that the summer of 1880 may become rather remarkable for the manifestations of electric disturbance taking place in Great Britain. Although it is well understood that thunderstorms are always to a certain extent dangerous; and although most buildings, public or private, of abnormal height are provided with lightning-conductors to protect them, very few persons know accurately what lightning is. That portion of the general public which is fairly well-informed, holds that a flash of lightning is a discharge of electricity from a cloud to the earth. The country journalist regards it as "a discharge of the electric fluid." The ignorant peasant speaks of a thunderbolt, and believes that an invisible something concealed in a "flash of fire," comes from the sky and slays or rends. If we turn to text books for information we shall find very little. "Lightning," writes Professor Fleeming Jenken, "is an enormous electric spark passing between two clouds, or from a cloud to the earth." We shall see in a moment what it is that Professor Jenken calls a spark, and we shall be able to judge whether the conditions are such that an electric spark and lightning are one and the same thing. But before going further we must ask our readers who may care to peruse this article to think a little for themselves. It is not probable that they can thus find out what a flash of lightning is, and it is certain that we cannot tell them, but we can at least show that it is possible to construct a theory concerning the phenomenon which is consistent throughout.

We may start by saying that lightning is unquestionably a form of electrical discharge, and it produces effects in all ways analogous to those produced by a discharge from a Leyden jar or other reservoir of high tension electricity. It has recently been urged that electricity is a mode of force. It is very difficult though not impossible to form a mental conception of a pure force, isolated and apart from matter; but be electricity what it may, it makes its presence known to our senses by its effect on matter; and there is, furthermore, reason to believe that matter which may be invisible or imponderable is first acted on, before that kind of matter with which mankind is more or less familiar. Let a Leyden jar—one large enough to hold about two quarts of water will answer very well—be fully charged, and then discharged through a sheet of thick pasteboard. If matters are properly managed a hole may be punched in this way through a thickness of about $\frac{1}{4}$in. If this hole be examined it will be found that, although the edges may be singed, it has not been burned through, but punched through. The hole will be very like in its character to those made by a charge of No. 9 shot fired at a distance of 20 yards through a similar sheet of pasteboard. It is very difficult to conceive that such a hole has been made by the passage through the pasteboard of a pure force; all the evidence goes to show that something, that is to say, some form of matter, has gone through the cardboard and made the hole. If a piece of the pasteboard target, with one shot hole only on it, and the piece of card punched by the electric spark, were handed to a man who did not know anything of how the holes were made, he would say of both that something, either a shot or a rather blunt metal instrument, had been driven through the material and left the holes behind. There is, however, this to be noted, that in many cases the hole appears as though it had begun within the substance of the paper, and not at one side or both. It has been laid down that when an explanation of any phenomena or occurrence is available which satisfies all the conditions, it is unnecessary and illogical to offer theories based on any second hypothesis. The electrically punched hole is just such a hole as would be made by the passage of something material through the paper, and so far we have reason to believe that something material has passed through. Now, if we compare the effects of a Leyden jar spark with those produced by lightning, we find a strict similarity between them. The lightning is different from the Leyden jar spark not in kind but in magnitude. When stone is ground to powder, or a tree split, we are justified in asserting that matter in some form or other came in contact with the stone and powdered it. It is supposed that trees are split by the production of steam from their juices by the heat of the electric discharge; and when lightning strikes sand it often produces curious tubes of fused quartz called Ligurites. But allowing for this, a sufficient number of cases occur in which the effect produced is certainly not due to heat. At first sight these statements will perhaps seem to a few of our readers as extremely heterodox. They will say that we have here a theory of material thunderbolts, such as the ignorant peasants hold. Our reply is that there may be thunderbolts and thunderbolts, but that the peasant according to his lights has spoken and reasoned wisely. He has assumed that a great hole cannot be dug in the earth unless something of which the soil can take cognisance has operated upon it. We cannot form any conception of a hole being dug in a field by a pure force. Nor can we imagine such a mundane thing as a block of granite reduced to powder save by the impact or influence of something very different from a pure force. There may be forms of matter, however, susceptible to the operation of pure forces. We neither assert nor deny that such is the case, but it is more reasonable to suppose that when a stone is shattered or a hole pierced, or an excavation made, that it is made by some form of moving matter than by anything else. Lest it should be said that in assuming that the electric spark is a manifestation of matter in motion we are standing alone, we shall support our opinions by the following quotation from Prof. Fleeming Jenken's "Electricity and Magnetism." "The distribution of electricity over bodies which have points or angles is such that the electric density becomes very great on these points as it would on a very small sphere, even when the potential is not high. The result is a great repulsion of the electricity for itself, or rather a great repulsion between the neighbouring parts of the matter charged with it. We then frequently see *the electrified matter passing off in the condition known as the electric spark*." Again, in another place he writes:—"The electricity has such a repulsion for itself that if it accumulates sufficiently the force becomes great enough to break down the pressure of the air, and *highly electrified particles of the conductor and of air fly off the point. Every electrical spark seen is an illustration of this convection. Lightning is one example.*" The italics are ours. We are apparently justified then in saying that the hole was punched in our card by a volley of missiles despatched from the surface of the ball of the discharger, and that the mechanical effects of lightning are in like manner possibly due to a volley of missiles dis-

A NEW THEORY OF TERRESTRIAL MAGNETISM.

Engineering July 9 1880

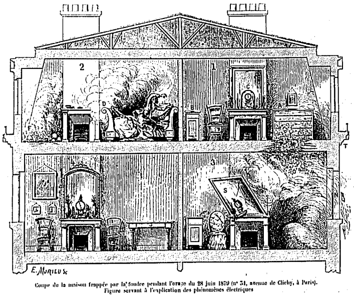
When Professor Rowland, of Baltimore, proved that a moving charge of electricity, such for example as might be obtained by rotating an electrified metal ball, behaved like a dynamic current, and had power to deflect a magnetic needle, Professors Perry and Ayrton based upon the fact a theory of the earth's magnetism in supposing that the earth was highly electrified, and became a magnet by virtue of its axial rotation. Professor Rowland, who had himself entertained the theory, however, showed that the terrestrial charge required by this theory was enormously greater than that believed to exist on the earth, and thus, though he did not completely dispose of the theory, at least did a great deal to discredit it as solely accounting for the earth's magnetism. A somewhat similar theory is now put forth by Professor Lemström, of Helsingfors, and founded on a like experiment. M. Lemström finds that when a ring of insulating material is rotated round its axis, it acts as a galvanic current, and produces a magnetic field within it. He explains this effect, according to Edlund's hypothesis, by supposing that the ether permeating space is dragged along by the ring, so as to create a vortex at the centre of the latter, and thus constitute a magnetic pole. In the same manner the earth being composed mainly of non-conducting materials, and constantly rotating, magnetic poles would be produced at or near the poles of motion.

La Nature July 12

pait, après avoir fait sauter une persienne. Une petite fille, qui s'était abritée sous la porte, a été violemment jetée à terre, mais n'a heureusement eu aucun mal.

A Suresnes, place Henri IV, la foudre, tombant dans le restaurant Dubois, a effondré la toiture, démoli une cheminée et détérioré le compteur à gaz; une fuite de gaz considérable s'est produite.

Nous avons examiné en détail une des maisons qui a été atteinte par la foudre, celle de l'avenue de Clichy, nº 34; elle a été le théâtre de phénomènes très remarquables, dont le lecteur se rendra compte en jetant les yeux sur la gravure ci-dessous. La foudre paraît avoir pénétré dans la maison par un tuyau d'écoulement des eaux, situé du côté de la cour en T; elle a suivi la solive qui sépare le quatrième étage du cinquième. Dans la chambre nº 1, les carreaux du plancher ont été soulevés sous la commode A, dont le marbre a été cassé. Le globe de la pendule C a été percé d'un trou rond à travers lequel on peut passer le poing, le balancier de la pendule a été décroché et tordu, le marbre de la



Coupe de la maison frappée par la foudre pendant l'orage du 28 juin 1879 (nº 34, avenue de Clichy, à Paris). Figure servant à l'explication des phénomènes électriques

table de nuit B a été brisé. Une vieille dame qui buvait un bol de lait dans cette chambre a senti une secousse violente. Le plafond de la chambre du dessous (nº 3) s'est effondré, tout a été mis en pièces dans cette chambre, et les carreaux de la fenêtre N ont été brisés au milieu d'un nuage de poussière formé par les platras. La foudre a pénétré en même temps au cinquième étage dans la chambre nº 2. Une brave femme qui y habite, effrayée par les coups de tonnerre, s'était assise sur le bord de son lit et caressait son chien pour le rassurer; tout à coup la foudre a brisé son lit, le sommier est tombé à terre, et le pied du lit D a été haché comme à coups de tranchet. Les carreaux de brique, du sol de la pièce, ont été brisés en E et en F. Le témoin de ce phénomène raconte que le bruit a été effroyable, et que le dégât s'est accompli au milieu d'un nuage de fumée accompagné d'une forte odeur de poudre. La chambre du dessous, nº 4, n'a pas été atteinte. Le concierge de la maison a vu le coup de foudre; il se trouvait dans la cour, quand une lueur a passé devant ses yeux. Il a ressenti une vive commotion, et pendant plusieurs jours il s'en est trouvé incommodé.

GASTON TISSANDIER.

Le Propriétaire-Gérant : G. TISSANDIER.

10826. — Typographie A. Lahure, rue de Fleurus, 9, à Paris.

66 Sc. Am. Aug 2 1879

REMARKABLE FIRE CAUSED BY LIGHTNING.

In the storm of June 11th, at 10.30 A.M., lightning struck on the extensive wharf, of 1,000 feet front on the Schuylkill river, at the petroleum refinery of the Atlantic Refinery and Storage Co., located at Point Breeze, about four miles south of Market street, Philadelphia. This company has the most extensive petroleum refinery in the United States, and perhaps the largest in the world. Some accounts state that the electricity first struck the can store-house on the wharf. Others, with more probably correct statement, declare it struck first an immense pile of about 30,000 tin cans containing refined petroleum, exposed uncovered on the wharf, ready for shipment. Each wooden case contained two five gallon cans.

The *American Exchange and Review* says: The pile of cans was more probably the point of origin of the fire, because there was in it a great mass and large surface of metal to attract electricity, while all the buildings and tanks were well protected by lightning rods.

[There was, of course, the usual percentage of leakage from the cans, and we think it probable that the light vapor from the petroleum, which rises to a great height, formed the conductor which directed the lightning to the cans.]

The fire spread rapidly all over the wharf to the large packing and store houses and the superintendent's dwelling. Though great efforts were made to save the ships and barks lying at the wharf, five of them were consumed, two having full cargoes of oil on board. There were in a pump-house five or six large steam-pumps in excellent order, and there was no scarcity of water. Among the buildings and fixtures the fire burned over about 25 acres of space, covering the neighborhood for miles with dense black smoke, and the flames were not under control until about 5 P.M. A force of 40 men from the neighboring city gas works succeeded in beating back the flames from the piles of bituminous coal—partly with water, but mainly by shoveling earth upon them. This saved the gas works and tanks.

Sc. Am Aug 2 1879

Only a small portion of the buildings, but many of the most valuable fixtures of the Atlantic Company were saved. Fortunately several large tanks containing 30,000 barrels each of petroleum, and partly sunk in the earth, escaped, though 12,000 barrels in a similar tank very near them were consumed. The destruction was about as follows:

Five ships and barks, owned in Europe; value, with two cargoes, say $125,000.

30,000 5-gallon cans of refined oil on the wharf.

One story packing house, 80x80 feet, and contents.

Two story can, soldering, and storage building, 50x100 feet.

Three story brick dwelling of superintendent.

One story frame cooper shop, 120x300 feet.

Boiler house.

Two story store house on wharf, 80 feet long.

Pump house, with 5 or 6 large steam pumps.

Many minor tanks full of oil, refining stills and boilers, and innumerable fixtures.

About 40,000 empty barrels were burned, and 20,000 were saved by the Schuylkill harbor police. The tugs New Castle and Churchman saved the large bark Magnum by towing her down stream. Various other vessels were saved.

It is stated that there was no insurance on the property of the refinery; $50,000 having expired last autumn and not renewed. The ships and cargoes were insured in part in Europe. The steam pumps and two stand pipes and 400 feet hose were all in good working order, but the fire so soon burned the pump house that the pumps were of no use.

The fire at the works of the Atlantic Refining Co., though subdued among the buildings on Thursday, the 12th, continued to burn among the cargoes of the ships Huron and Ilion. An effort was made on the 13th to tow the latter on to the mud flats of the western shore; but, by a sudden lurch of the burning vessel—she breaking in two—several hundred unburnt barrels of petroleum rose from her hull, ignited, and exploded. Instantly the river, for a long distance, was covered with blazing oil, so that the tugboat, Wave, escaped with difficulty. A strong westerly breeze blew the flames to the wharves of the Atlantic Petroleum Storage Co., on the east bank of the river, and these wharves and many sheds and their contents were burned. One storage shed was 500 feet in length, and contained a tank holding 500 barrels oil, and there were besides 1,000 barrels ready for shipment. The flames soon reached the sheds of the Empire Storage Company, and destroyed 40,000 empty barrels. Then 1,000 cords of pine wood, belonging to Lecompte & Perkins, were burned, and many thousand feet of rough planking.

About 2,500 feet of wharfing were consumed in this second fire; and all the losses in the two cannot be much short of $1,000,000. The oil continued to burn in some places, and on board the two vessels during June 14th and 15th. Several minor fires commenced in various places of the neighborhood, but were fortunately extinguished, and the great oil tanks, which were in such peril, and 200,000 barrels of oil at Point Breeze, were saved from destruction.

The wisdom of locating petroleum refineries and storehouses a long distance from the built-up portion of the city, is fully shown by this catastrophe.

Sc. Am Aug 2 1879

Telegraphic Ignition.

Sc Am Aug 2

The telegraph wire as a fire risk has, perhaps, not received the attention it is entitled to. During a thunder storm which began at Council Bluffs, Iowa, soon after 11 o'clock, night of June 10, the freight office and warerooms building of the Chicago, Burlington and Quincy Railroad Company was burned to the ground, though most of the contents were saved. It was supposed that the fire was caused by a heavy charge of electricity entering the building along the telegraph wires. Probably all this loss would have been prevented had the ordinary lightning arrester been provided upon the posts near the building. The arrester is simply a wire that has one extremity placed very near but not in contact with the telegraph wire. The other extremity of the arrester terminates in the ground. When lightning gets on the telegraph wire it leaps to the arrester wire and passes into the ground.

LIGHTNING RODS NOT INSULATED.—Insulators should not be used in putting up lightning rods on buildings for protection against the electric current. The rod should be fastened directly against the building. But the most important precaution is to make sure that the bottom end of the rod has a large conducting surface in contact with the earth. Better have no rod than simply to stick the end a few feet down into dry earth; the proper way is to solder the bottom end of the rod to a metal water pipe or gas pipe in the ground. If there are no pipes, then make a long trench and put in some good conducting material, such as fine charcoal, or hard coal dust, iron ore, or old iron, making a good connection between the bottom end of the rod and this conducting material.

Mining & Sc Press Aug 2 1879

LIGHTNING RODS.—Mr. R. S. Brough has been discussing, in the *Philosophical Magazine*, the proper sectional areas of iron and copper lightning rods. So far as mere conductivity is concerned, a comparatively thin wire of either metal would suffice for any conductor; but such a thin conductor would be dangerous, because it would be fused by a heavy discharge of lightning. Iron being more liable to be fused than copper, Mr. Brough sought to determine the relative sectional areas of rods of two metals, so that neither would be more liable to fuse than the other. Ordinarily, it is stated that the iron rod should have four times the sectional area of the copper rod. Mr. Brough shows that these areas should be as eight to three; or since the rods are invariably made circular, and circular areas are to each other as the square of their diameters, the diameters of iron and copper rods of equal effectiveness should be in the proportion of 1.63 to 1. Iron is, therefore, much the cheaper metal for lightning rods.

Mining & Sc Press Aug 26 1879

A NEW METHOD OF LOCATING LIGHTNING RODS.

The Brockton (Mass.) *Weekly Gazette* contains a long account of a so-called wonderful discovery which has been made by Messrs. George S. and A. R. Prescott, of Merrimac, Mass. These gentlemen have ascertained that "lightning never strikes the earth except in localities directly over what may perhaps be best described as electrical currents on or below its surface, with which currents the electrical discharge invariably communicates. This has been determined by a multitude of tests made in localities widely separated. It follows, therefore, that in places where these currents are not found to exist, no danger need be apprehended, as in upward of four thousand instances, where tests have been made during the past three years, no record can be found of any exception to this universal rule."

This is certainly a wonderful discovery and merits careful attention. The subject is in the domain of science, and it can be reasonably presumed that the Messrs. Prescott have some knowledge of electricity, especially of earth currents, since their work is claimed to be in the detection of such currents. Moreover, these gentlemen must have made use of scientific methods, which past experience has shown to be indispensable; or they must have created a new method which rests on a scientific basis and is not dependent upon the freaks of the observer.

On careful inquiry we have ascertained that the Messrs. Prescott lay no claim to a knowledge of science. They are farmers, and have gained their knowledge of agricultural operations from actual practice in this pursuit, and not from mere theories. Whatever success they have obtained in farming has been due to the experience which has been handed down to them and by a lifetime of labor in their chosen pursuit. Without any knowledge whatever of electricity, they have suddenly made a discovery which puts to the blush the labors of scientific men in meteorology; have curbed, so to speak, the thunderbolts of Jove; have within their reach an immense fortune; and, more than all, have demonstrated that honest ignorance can discover what skilled education has overlooked. Their method also has never been employed or even thought of by scientific men. We shall first describe it in practical operation, and then devote a few words to its theory. Having cut a forked stick from a tree—any kind of wood will answer, although the discoverers prefer a forked stick from an apple tree, an elm, or a hazel—the two forks are grasped firmly with both hands, leaving the portion above the fork projecting skyward and not earthward. With the stick held in this manner, and with a look which may be described as sublunar, the operator walks over the ground to and fro, here a little and there a little, until he perceives that the projecting part of the stick begins to point downward. Then he stops and announces that there is an earth current beneath him. He does not know what an earth current is, nor how it usually manifests itself, nor what tests are usually employed, nor does he need to know, for the green apple tree stick decides the point. He must not, however, wear rubber boots; leather boots are preferable. In this way four thousand tests have been made and repeated; sometimes with a green apple stick, sometimes with an elm stick. Changing the character of the stick, however, appeared to make no difference. Further experiments, however, are needed to clearly establish this point.

When the stick points to the ground it is clear evidence that a lightning rod must be led to this point. If no earth currents are found by this method, the house in this locality is pronounced to be safe, and does not need lightning rods. The Messrs. Prescott form a marked exception to the old adage that "a prophet is not without honor save in his own country and among his own kindred," for no other "lightning rod man" is employed in the neighborhood of their native town, Merrimac, and their fame has spread far and wide. Treasurers and presidents of banks, city engineers, teachers in academies and schools, proclaim that, however impossible it may seem, they have been witnesses to the Messrs. Prescott's skill—perhaps we should say to Mr. Prescott's skill, for one of the brothers excels the other in this matter—and no amount of scientific skepticism can change their faith in Mr. Prescott's discovery. Hundreds of people are ready to testify to the fact that Mr. Prescott has repeatedly discovered places where lightning has struck in the past; and on being led by the oldest inhabitant into places remote from the Prescott homestead, has infallibly proclaimed to the awestruck observers, "Lightning once struck within four feet or less of this point." So much for the practice. Now for the theory.

67

It is claimed that "the human frame is the most sensitive to electrical influences of any organized form. Indeed, so far as cognizant to the sense and present knowledge, electricity seems to be the factor of the mysterious principle of life in the work of the human system." Mr. Prescott has a wonderfully sensitive organization. He has the hitherto unknown "electric sense," and he can, to speak metaphorically, smell electricity or taste it in the air or earth. He is not, however, the only person who has claimed to have this power. If he and his friends will procure a copy of Baron Charles von Reichenbach's "Physico-Physiological Researches in the Dynamics of Magnetism, Electricity, Crystallization, and Chemism," published in Partridge & Brittain's Spiritual Library, it will be found that Mr. Prescott belongs to the class called sick sensitives; in other words, to a class of persons whose systems are supposed to be peculiarly sensitive from disease to general cosmical phenomena. In the same book will also be found a long account of the use of a forked stick, which use is there called Blétonism, from the name of an agricultural laborer who had great success in its use. It is evident that agriculture is about to assert itself in the cognate field of electricity and magnetism. An account of the forked stick can also be found in Dr. Hutton's Mathematical Recreations, which is a translation with additions of Montucla's improvement of Ozanam's Recreations. An account of the virtues of the forked stick can also be found in Dr. Herbert Mayo's "On the Truths contained in Popular Superstitions" Letter XII. (London, 3d ed., 1851). It may interest Mr. Prescott to know that his forked stick has various names. It has been called divining rod, virgula divina, baculus divinatorious, baquette divinatoire, and the wonders accomplished by its use have been testified to by thousands of people for more than a century. If Mr. Prescott is a reader of fiction, he will also find an account of Douster Swivel's use of the forked stick in Walter Scott's novel "The Antiquary."

It is said by Mr. Prescott's believers that if he did not use such an absurdly simple contrivance as a forked stick he would have more followers and make a greater fortune. Indeed, it has been proposed that he should get up a complicated contrivance with a maze of wheels and electro-magnets, which should have nothing, however, to do with his method; but walking forth in boots (leather), with the stick and the machine, he should attribute the discoveries to the machine. Pessimists claim that he would then be in entire sympathy with the age.

Briefly let us sum up the claims of the Prescotts. We shall put the claims against the evidence in the following table:

CLAIMS.	EVIDENCE.
A forked stick in the hands of a sensitive person is a scientific instrument capable of detecting earth currents.	No evidence has ever been submitted to men capable of judgment on this point. The belief is supported only by invalids, and is an evidence of invalidism.

Mr. Prescott belongs to the class called "sick sensitives."	No medical school of any standing believes in the powers of the "sick sensitives" to discover occult phenomena. No master of his profession believes in such powers.
Earth currents have a determinate direction, and under the action of thunderstorms will always take the same direction.	Earth currents do not have a determinate direction, and the influence of a thunderstorm does not determine their direction.
The electric discharge seeks to unite itself with earth currents.	No evidence. This can only be determined by electrical tests, which Mr. Prescott and his friends are incapable of making, from utter ignorance of the subject of electricity.

The above is our statement of the case, and it is only justice to Mr. Prescott and his followers to state his case in the same manner, with a few comments, which can be taken or rejected.

CLAIMS.	EVIDENCE.
Four thousand test cases, more or less.	Tests made of twigs from three or more kinds of trees, all taken from different localities, and cut by unprejudiced observers.
The testimony of innumerable people, including teachers in high schools, civil engineers, and prominent business men of high standing and respectability. They have seen with their own eyes. They have been convinced beyond all doubt.	Respectability has always had great weight in deciding upon scientific matters. It is reasonable to suppose that if a bank president or cashier maintains his good standing in the community, his judgment on any subject, even on one to which he has paid no attention, is of value. Civil engineers and teachers can be summoned as experts in matters of scientific evidence.
Mr. Prescott has eminently the air of an honest man. He has been known man and boy by his neighbors for many years.	Honest looking men have never deluded themselves or deluded their neighbors.

In conclusion, the use of the forked stick is recommended to mining speculators and prospectors. Thousands of respectable persons in the past have testified to its efficiency in discovering lodes of precious metals, and it is one of the strangest facts in human history that mankind has stubbornly refused to discover precious metals by the use of such a simple means, and have forced themselves into what may be called complicated and theoretical scientific methods.

SECTION A—MATHEMATICAL AND PHYSICAL

Nature 1877

On Lightning Protectors for Telegraphic Apparatus, by W. H. Preece.—For many years it was not the practice in England to protect telegraphic apparatus from the injurious effects of atmospheric electricity because the damage done was so insignificant, and because the remedy was found to be worse than the disease. But as telegraph systems increased, as the country became enveloped in one vast network of wires, it was found that the damage done became considerable, until, in fact, about 10 per cent. of the apparatus in use were in one year damaged.

Lightning protectors then became essential. Many forms were tried based on the fact that when a discharge takes place through a non-conductor such as dry air, at the moment of discharge the resistance along the line of discharge is practically nothing, and therefore all the charge is conducted away. According to Faraday, "the ultimate effect is exactly as if a metallic wire had been put into the place of the discharging particles" ("Researches," series xii.). Most of those tried failed.

The survival of the fittest has been exemplified in the "plate" protector. In this form—one of the earliest introduced—one thick plate of brass is in connection with the earth, and another similar plate in connection with the line, is placed above it, but separated from it by paper, or by insulating washers. The lightning entering the wire bursts across the paper or air-space in preference to passing through the apparatus, and thus escapes to earth.

An important modification of this plate discharger has been made by Dr. Werner Siemens, who, by serrating, or grooving with a pointed tool the opposing faces of the two plates at right angles to each other, converted them into a conductor which was supposed to be one composed of an infinite number of opposing points. The remarkable action of points in facilitating discharge is well known, and their introduction into lightning protectors occurred very early in the annals of telegraphy by Mr. C. V. Walker, F.R.S.

Messrs. Siemens's arrangement, very pretty in theory, never carried conviction of its value to the mind of the author, because protectors so prepared never singled themselves out as evidently superior to others that were not so prepared, and while the intersection of the grooves certainly formed mathematical points, they did not form physical or mechanical points, and it is upon the action of this latter kind of points that such remarkable electrical effects are produced.

Dr. Warren de la Rue having very kindly placed his well-known battery of 11,000 cells at the disposal of the writer, he prepared four plate-protectors identical in dimensions, excepting that two were serrated, and two were not. The two plates were separated from each other by narrow ebonite washers ·01 inch thick. The upper plate was placed in connection with the positive pole, and the lower plate with the negative pole. The number of cells were increased until a continuous current of electricity flowed.

1.—*Plain Plates*

Number of Cells.		Effects produced.
1,000	...	Slight sparks commencing on completing circuit.
1,080	...	Sparks evident.
1,200	...	Sparks frequent and abundant.
1,500	...	Continuous arc.

2.—*Serrated Plates*

Number of Cells.		Effect produced.
1,000	...	Sparks just commencing on making contact.
1,080	...	Sparks evident.
1,200	...	Sparks frequent.
1,500	...	Continuous arc, but fitful.

2,000 cells in each produced a continuous stream of electricity. The effect with 1,500 cells was decidedly more marked with the plain plates than with those serrated. The experiments were extremely pretty, and very decided in their character. Hence it appears that grooving is not only of no use, but that it rather deteriorates the value of the protector.

These experiments confirm very decidedly the accuracy of the figures obtained by Dr. Warren de la Rue and Mr. Müller on the striking distance between two flat disks given by them in their paper read before the Royal Society (*Phil. Trans.*, vol. 169), where it was shown that 1,200 cells struck across ·012 inch. Here 1,000 struck across ·01 inch, which agrees perfectly with the curve produced by those observers.

It is the practice in the Post Office telegraph department to keep these plates apart by thin paraffined paper ·002 inch thick, so that the air surface is really much thinner than that experimented upon, and the striking difference of potential only 250 volts.

Messrs. De la Rue and Müller have shown that for points and various kinds of surfaces opposed to each other, plane surfaces act the best for potentials less than 1,500 volts, and that points are only efficient for high potentials. Now as it is doubtful whether atmospheric electricity causes much higher potential than 1,000 volts, it is clear than plane surfaces are the most effective for protecting apparatus. It is quite certain that such plates, plain and smooth, separated by an air space ·002 inch thick, will form very efficient lightning protectors.

The author is very much indebted to Dr. Warren De la Rue for the performance of the experiments in his laboratory.

MÉTÉOROLOGIE ÉLECTRIQUE

Faits démontrant le développement de l'électricité avec la condensation des vapeurs.

Electricity

LETTRE Aug 20

à la Rédaction de la Revue scientifique illustrée L'ÉLECTRICITÉ 1879

Je ne peux pas laisser passer, sans une protestation de ma part, les paroles de l'illustre astronome français M. Faye, que je lis dans les *Comptes-rendus de l'Académie des Sciences*, 28 juillet 1879, page 107, quand il dit : « Quant à l'électricité, il n'est nullement établi que la condensation des nuages ou leur évaporation soit la source de leur électricité. »

Je prends la liberté de rappeler quelques faits que j'ai constamment observés, et qui ont été depuis confirmés par les expériences faites dans le cabinet :

1° Les grandes tensions électriques de l'atmosphère qui ne se peuvent plus mesurer avec les électromètres, que nous enregistrons avec le symbole de l'influ. et qui se traduisent par de vigoureuses tensions étincelles, se tirant des conducteurs isolés bien exposés, ont lieu exclusivement avec la chute des grandes pluies de neige ou de grêle. Ces chutes doivent se produire sur le lieu de l'observation ou à une distance qui, d'après mes observations, n'excède pas de 50 à 70 kilomètres. Ces fortes tensions naissent, disparaissent avec la pluie, durent autant qu'elle et s'évanouissent avec elle, suivant la loi que j'ai établie, et sur laquelle je ne crois pas nécessaire de revenir.

Franklin a vu, la première fois, l'étincelle au moment de l'apparition de la pluie, et les fortes étincelles de Dalibard, de Romon et de Richman correspondaient, sans doute, à des pluies, des grêles ou des neiges à distance.

En conséquence, une nuée qui se réduit en pluie est une vraie source d'électricité, de laquelle peuvent sortir de nombreux éclairs, sans qu'elle soit épuisée. Mais, à la fin de la pluie, les énormes tensions disparaissent et, sous la nuée, on trouve moins d'électricité que par un ciel serein.

Les nuées ne sont donc pas des conducteurs qui s'électrisent par influence, mais des corps qui produisent l'électricité quand ils se résolvent en eau et en neige ; et, quand cette électricité ne trouve pas moyen de se dissiper facilement par l'humidité de l'air ambiant, elle se traduit par des éclairs.

2° Les vapeurs aqueuses qui sortent d'un cratère volcanique, avec une énorme tension correspondant à une température de plus de 1.000 degrés centigrades. A cause de l'abaissement de température qu'elles éprouvent en entrant dans l'atmosphère elles se convertissent en panaches de fumée très-denses et elles développent une grande quantité d'électricité qui, dans certaines conditions, se manifestent sous forme d'éclairs, pareils à ceux que Pline le Jeune décrit dans son récit de l'éruption du Vésuve an 79, et que nous avons revu, à plus de cent fois différentes, briller au-dessus du cratère du volcan.

3° L'observatoire vésuvien se trouve lui-même bien des fois enveloppé de nuages, et jamais, quand ces nuages ne se résolvent point en pluie, je n'ai constaté de tension électrique supérieure à la normale du lieu.

4° Lors des rapides augmentations de l'humidité relative de l'air dans les nuits de forte rosée, j'ai toujours constaté de plus fortes tensions de l'air.

5° L'été, saison d'évaporation plus que de condensation, présente moins d'électricité que les autres stations ; mais comme un même abaissement de température de l'air chaud et humide produit une précipitation plus abondante que dans l'air sec de l'hiver, les manifestations orageuses sont plus faciles et partant les coups de foudre plus nombreux.

6° Les vapeurs qui s'élèvent du sol doivent subir plus facilement dans les régions plus élevées une condensation par abaissement de température, condensation qui, sans troubler la pureté du ciel, peut augmenter l'électricité de l'air et agir sur les conducteurs exposés à son action, et donner des indications visibles dans les électromètres.

Les phases des périodes diurnes dépendant visiblement des mouvements des vapeurs dans l'air, il en résulte que le maximum du matin qui, à Naples, correspond à peu près à 9 heures, est à 8 heures à la hauteur de l'observatoire. Il en est de même pour le maximum du soir qui, à l'observatoire du Vésuve, précède également d'une heure le maximum de Naples.

7° Pour confirmer ce fait et beaucoup d'autres, que je néglige pour ne point allonger démesurément cet article, j'ai été conduit à tenter une expérience

(1) Nous renverrons l'auteur à ce que dit M. Poisson, tome I[er], seconde édition, contre l'usage impropre de ce mot, *force d'inertie*. Il est enseigné partout, du reste, que *l'inertie est une propriété de la matière qui consiste en ce qu'aucune molécule ne peut trouver en soi une cause de mouvement.*

70

ON LIGHTNING PROTECTORS FOR TELEGRAPHIC APPARATUS.

By Wm. Henry Preece, Electrician General Post Office.

Journal of the Telegraph Sept 16 1879

[Read before Section A, British Association, 1879.]

For many years it was not the practice in England to protect telegraphic apparatus from the injurious effects of atmospheric electricity, because the damage done was so insignificant, and because the remedy was found to be worse than the disease.

But as telegraph systems increased as the country became enveloped in one vast network of wires, it was found that the damage done became considerable; until, in fact, about ten per cent. of the apparatus in use were in one year damaged.

Lightning protectors then became essential. Many forms were tried, based on the fact that when a discharge takes place through a non-conductor, such as dry air, at the moment of discharge, the resistance along the line of discharge is practically nothing, and, therefore, all the charge is conducted away. According to Faraday, "the ultimate effect is exactly as if a metallic wire had been put into the place of the discharging particles." (Researches, series XII, 1406.) Most of those tried failed.

The survival of the fittest has been accomplished in the "plate" protector. In this form—one of the earliest introduced—one thick plate of brass is in connection with the earth, and another similar plate in connection with the line is placed above it, but separated from it by paper, or by insulated washers. The lightning, on entering the wire, bursts across the paper or air space in preference to passing through the apparatus, and thus escapes to earth.

An important modification of this plate discharger has been made by Dr. Werner Siemens, who, by serrating, or grooving with a pointed tool the opposing forces of the two plates at right angles to each other, converted them into a conductor which was supposed to be one composed of an infinite number of opposing points. The remarkable action of points in facilitating discharge is well known, and their introduction into lightning protectors occurred very early in the annals of telegraphy, by Mr. C. V. Walker, F. R. S.

Messrs. Siemens' arrangement, very pretty in theory, never carried conviction of its value in the mind of the author, because protectors so prepared never singled themselves out as evidently superior to others that were not so prepared; and while the intersection of the grooves certainly formed mathematical points, they did not form physical or mechanical points; and it is upon the action of this latter kind of point that such remarkable electrical effects are produced.

Dr. Warren de la Rue having very kindly placed his well known battery of 11,000 cells at the disposal of the writer, he prepared four plate protectors, identical in dimensions, excepting that two were serrated, and two were not. The two plates were separated from each other by narrow ebonite washers .01 inch thick. The upper plate was placed in connection with the positive pole, and the lower plate with the negative pole. The number of cells was increased until a continuous current of electricity flowed.

1.—PLAIN PLATES.

No. of cells.	*Effect produced.*
1,000	Slight sparks just commencing on completing circuit.
1,080	Sparks evident.
1,200	Sparks frequent and abundant.
1,500	Continuous arc.

2.—SERRATED PLATES.

No. of Cells.	*Effect Produced*
1,000	Sparks just commencing on making contact.
1,080	Sparks evident.
1,200	Sparks frequent.
1,500	Continuous arc, but fitful.

2,000 cells in each produced a continues stream of electricity. The effect with 1,500 cells was decidedly more marked with the plain plates than with those serrated. The experiments were extremely pretty, and very decided in their character.

Hence it appears that grooving is not only of no use, but that it rather deteriorates the value of the protector.

These experiments confirm very decidedly the accuracy of the figures obtained by Dr. Warren de la Rue and Mr. Muller on the striking distance between two flat discs, given by them in their paper, read before the Royal Society (Phil. Trans., p. 169, 77), where it was shown that 1,200 cells struck across .312 inch. Here 1,000 cells struck across .01 inch, which agrees perfectly with the curve produced by those observers.

It is the practice in the Post Office Telegraph Department to keep these plates apart by thin paraffine paper, .002 inch thick, so that the air space is really much thinner than that experimented upon, and the striking difference of potential only 250 Volts.

Messr. De la Rue and Muller have shown that for points and various kinds of surfaces opposed to each other, plain surfaces act the best for potentials less than 1,500 Volts, and that points are only efficient for high potentials. Now, as it is doubtful whether atmospheric electricity causes much higher potential in telegraph wires than 1,000 Volts, it is clear that plain surfaces are the most effective for protecting apparatus. It is quite certain that such plates, plain and smooth, separated by an air-space .002 inch thick will form very efficient lightning protectors.

The author is very much indebted to Dr. Warren de la Rue for the performance of experiments in his laboratory.

71

USEFUL AND SCIENTIFIC NOTES.

Eng Mechanic Dec 26/79

Case of Lightning-stroke.—A paper was read at a late meeting of the Clinical Society by Dr. G. Wilks, of Ashford, on a remarkable case of lightning-stroke, which occurred on June 8th, 1878. A farm labourer was struck by lightning while standing under a willow tree, close to the window of a shed in which his three fellow-workmen had just taken shelter from a violent storm of rain. His companions found the tree partly denuded of its bark, and the patient's boots standing at its foot. The patient himself was lying on his back two yards off, and though he was fully clothed previously, he was now naked, with absolutely nothing on except part of the left arm of his flannel vest. He was conscious, but much burnt, and his leg was badly broken. The field around was strewn with fragments of the clothing; the clothes were split or torn from top to bottom, the edges of the fragments being often torn into shreds or fringes; they only showed evidences of fire where they came in contact with metal, such as his watch and the buckle of his waist-belt. There were no laces in the boots. The left boot was torn and twisted into fantastic shapes, but the sole was uninjured, and there was no sign of fire upon it; the right boot had the leather much torn and the sole rent and burnt. The watch had a hole burnt through the case, and the chain was almost entirely destroyed. The stockings were split down the inner side; the hat was uninjured. The patient stated that he was struck violently on the chest and shoulders, became enveloped in a blinding light, and was hurled into the air, coming down on his back "all of a crash," and never losing consciousness. The hair of his face was burnt, and the body was covered with burns. Down each thigh and leg was a broad crimson indurated band of burning, passing along the inner side of the knee, and ending below the left inner ankle and at the right heel; a lacerated wound, with a comminuted fracture of the os calcis. The bones of the right leg were fractured, and the tibia protruded through the skin in the course of the burn. He was discharged healed twenty weeks after the occurrence. Dr. Wilks remarked on the almost complete exemption from injury of the nervous system and on the probability that the clothes being wet acted as good conductors, and so diverted the electric current from the great nervous trunks, thus saving the man's life.

The Great Northern Railway Company has adopted a system of lighting railway carriages for long distances by gas, compressed in vessels containing naphthaline.

ATMOSPHERIC ELECTRICITY.

Electrician Aug 7/80

Notwithstanding numerous researches, some of which already date a century back, the laws by which atmospheric electricity varies, are not yet established. Nevertheless, a knowledge of these laws is the first step towards the understanding of the true cause of this important phenomenon. A valuable contribution to the subject has just been made by M. Mascart, and communicated to the French Academy.

The apparatus employed by him consists of a Thomson quadrant electrometer, in which the movements of the needle are transmitted by mechanical means to a pencil which draws lines on a band of paper at very close intervals. Both pairs of quadrants are maintained at equal potentials and contrary signs by the poles of a battery, whose middle plate is connected to earth, and the needle is in connection with an insulated vessel which

... of water to flow into the outer air. In short, the ... nected to the well-known "water-dropping collector" of ... am Thomson's design.

The ... angement presents the advantage that the deviations of the ... are equal on both sides of zero for changes of equal and c... rary sign. The angular displacement of the needle is small enough under ordinary circumstances to remain sensibly proportional to the potential of the needle, that is, to the potential of the air at the point where the vein of water issuing from the vessel breaks into drops.

The curves then obtained have not the continuity which belongs to most other meteorological observations, and they often present sudden variations ranging from one end to another of the scale within a few minutes of time.

The examination of these curves, from the point of view of accidental changes, confirms a number of facts already known. The potential of the air is generally positive, particularly when the sky is pure. In cloudy weather the potential diminishes, shows rapid changes in degree, and is occasionally negative in kind. Rain almost always gives great negative deviations. The approach of a storm betrays itself oftenest by a great negative variation, followed by oscillations of great extent in the two directions, with a marked predominance of negative potentials. Positive rains are extremely rare, and never occur without storms.

It is manifest that accidental variations, great and little, ought not to enter into the reckoning if it is desired to find the normal course of the phenomenon. The simple appearance of the graphic lines on the paper permits of this course being readily seen; and the mean of a number of observations can be readily determined.

The phenomena observed by M. Mascart since January last are in agreement with the results obtained by him last year. The apparatus is installed at the College of France, that is to say, in the heart of a great city, and it might be objected that different results would be obtained in the open country. But M. Mascart affirms, on the strength of numerous experiments, that, save in the case of great perturbations, the seat of active electric masses is very far distant from the surface of the soil, and it is probable that the influence of a city does not cause much disturbance on the daily course of atmospheric electricity.

In its mean condition, the potential of the air, always positive, is much more elevated, and more uniform by night than by day. From nine in the evening to three in the morning it varies little. It lowers at sunrise, takes a minimum value at three p.m., rises rapidly afterwards, and attains a maximum about nine p.m.

There is thus only one minimum during the day and one maximum, almost constant during a great part of the night. That is to say, there is only one daily period, at least when we consider the most important term of the phenomenon. The amplitude of daily oscillation is notably more feeble during winter. The exceptional cold of December, 1879, would have had peculiar interest in connection with M. Mascart's experiments; but, unfortunately, the precautions taken against the freezing of the water in the collector did not prove sufficient to prevent congelation.

M. Mascart is of opinion that there is a relation between the electric state of the air and the temperature, but it will be necessary to possess several years' observations to establish that relation with rigour, and to study all the details of it.

The existence of the maximum of the night is in disaccord with the rule generally adopted. It is generally believed, since the experiment of M. Quetelet on the subject at Brussels, that there exists two daily maxima of atmospheric electricity, one in the morning and one in the evening, as well as two minima, one in the day and the other in the night. If M. Mascart's results are to be relied upon, this discordance would seem to be due to the method of observation adopted by M. Quetelet, unless, indeed, there are two maxima and two minima per day at Brussels.

M. Mascart's direct observations were made by day, and the nightly minimum inferred from them without being directly observed. But this minimum has been observed by other experimenters, either directly or by means of registering apparatus.

One cause of error which M. Mascart deems too frequently neglected is the insulation of the apparatus. An electrometer electrified by a temporary influence, and put in communication with water-dropping apparatus, only falls short by an unknown fraction, sometimes very slight, of the potential that it ought to have were the loss by the supports neglectable. But the insulating power of ordinary supports, stems of glass for example, varies much with the conditions of the atmosphere, and several courses combine to augment their conductivity during the night. It is necessary, therefore, to employ supports having an insulating power as perfect as possible and independent of all atmospheric conditions. Such a source of leakage may account for many misconceptions in similar researches.

J'aurai à vous communiquer des observations ti ressantes sur l'électricité atmosphérique, mes observati sont pas terminées; seulement, ce que je puis vous c'est au sujet des paratonnerres.

Cette question est loin d'être connue comme elle m... rait de l'être, et ce qui m'étonne, c'est de voir des mai... soi-disant sérieuses, vendre et appliquer des anneaux n cristal, qui s'enfilent jusqu'à la base de la tige: je serais bien curieux de savoir de quelle façon ils expliquent l'utilité de cette bague.

Je me réserve de revenir d'une façon toute spéciale sur l'installation des paratonnerres et de leurs effets réels, dès que mes expériences seront terminées.

En attendant, je vous signale que j'ai banni de toutes mes installations de paratonnerres les pointes rondes en cuivre jaune. J'emploie une pointe que j'ai inventée depuis trois ans. Cette pointe est en cuivre rouge forgé et a la forme d'une baïonnette, c'est-à-dire triangulaire de la base au sommet et terminée par une pointe aiguë en platine, quoique je sois ennemi du platine; je lui préférerais l'or, mais la routine est si difficile à vaincre! j'espère cependant, avec le temps, en venir à bout. Du reste, avec cette pointe, telle qu'elle est construite, l'écoulement du fluide électrique se fait aussi bien sur les angles qu'au sommet, suivant la tension plus ou moins grande de l'état électrique atmosphérique. J'ai plusieurs formes de pointes dans le même principe, et vous comprendrez sans peine que toute l'électricité qui peut passer par le conducteur et la tige, s'écoule librement par une pointe de ce système. Du reste, j'en ai appliqué une de ce genre à l'Observatoire du Pic-du-Midi, l'année dernière, et elle paraît bien se conduire, au dire du général de Nansouty.

J'ai apporté plusieurs perfectionnements à l'installation des paratonnerres dont je vous parlerai ultérieurement.

La pointe dont je vous parle plus haut remplace les pointes multiples avec avantage, et le prix en est modique puisqu'elle ne coûte pas plus qu'une pointe ronde.

J'ai aussi à l'étude deux problèmes très-importants:

1° Transformer la chaleur solaire; pouvoir l'emmagasiner et s'en servir quand besoin sera, soit en électricité, lumière ou chaleur.

2° Transformer l'électricité atmosphérique et l'emmagasiner pour s'en servir au besoin; l'électricité tellurique serait dans le même cas. Des expériences préliminaires me confirment que le problème est possible, et je le crois même facile. Si ces expériences peuvent vous intéresser, je suis prêt à vous les décrire; peut-être qu'en les publiant, la question ferait-elle de rapides progrès.

Je retourne au Pic-du-Midi dans le courant d'août pour installer à nouveau un deuxième paratonnerre au sommet du Pic; j'ai préparé des expériences à faire sur place; dès mon retour, je m'empresserai de vous les communiquer.

En attendant, recevez, monsieur, l'assurance de ma considération très-distinguée.

A. Breaux.

Bordeaux, 30 juillet 1879.

Nous recevons d'un de nos abonnés la lettre suivante sur laquelle nous appelons d'une façon insistante l'attention de l'administration:

En ma qualité d'abonné à votre estimable journal, je me permets de vous demander quelques renseignements, voire même quelques réflexions, au sujet de l'affaire suivante:

Une personne de ma connaissance, désirant établir une communication téléphonique entre son établissement et une succursale située à 50 *mètres* de distance, a demandé l'autorisation à l'administration des postes et télégraphes. Voici la copie de la réponse qui lui a été envoyée du ministère des postes et télégraphes et renfermant les conditions moyennant lesquelles il pourra établir la susdite ligne:

« Le concessionnaire d'une ligne téléphonique doit consentir à payer annuellement, à titre d'abonnement et pour droit d'usage, la somme de *cinquante francs* (50 fr.) par *kilomètre de fil* et 25 fr. par poste TÉLÉGRAPHIQUE (sic). Les frais de timbre, d'enregistrement, etc., sont aussi à sa charge.»

La personne en question désirerait savoir si une ligne inférieure en longueur à 1 kilomètre paiera également 50 fr., ou bien si ce chiffre est modifié selon la longueur de la ligne; dans ce cas, une ligne de 50 mètres ne devrait payer que 2 fr. 50. Mais si une fraction de kilomètre doit payer autant que le kilomètre entier, c'est-à-dire 50 fr., il résulte de là que l'installation dont je vous parle coûtera 100 *fr. par an*. Ce chiffre me paraît exorbitant et ridicule, car il dépasse de beaucoup le prix de revient de l'installation téléphonique et, de plus, il faut le payer *chaque année*.

Comme vous voyez, on exige d'abord 50 fr. par kilomètre de ligne pour la location et, en plus, 25 fr. par poste télégraphique. Pourquoi ces 25 fr. par poste et que signifie ce mot TÉLÉGRAPHIQUE que j'ai doublement souligné dans la copie que je vous donne d'autre part? Est-ce qu'il ne serait pas plus exact de dire *poste téléphonique*? ou bien croit-on que, dans chaque poste téléphonique, se trouvera en plus un télégraphe à cadran ou autre?...

Tout cela me paraît singulier, et si M. Cochery a l'intention de grever les installations téléphoniques de pareils impôts, je crois qu'il réussira plutôt à en étouffer la propagation. Les installations téléphoniques doivent payer un impôt; cela semble assez juste; mais cet impôt devrait être *relativement très-minime*.

S'il doit en être autrement, j'espère bien, Monsieur, que votre respectable journal, si éloquent et si juste, élèvera la voix contre un pareil abus. Il réussira certainement à modifier profondément cet état de choses, et j'espère bien qu'un jour les gens de progrès vous remercieront d'avoir contribué à la propagation de l'invention la plus merveilleuse de ce siècle.

Agréez, etc.

A. Dariès.

On nous apprend que le Congrès télégraphique vient de terminer ses travaux. Une nouvelle convention aurait été signée le 28 juillet, et elle remplacerait, à partir du mois d'avril 1880, celle qui est en vigueur jusqu'à présent.

Le changement le plus important serait une modification heureuse entre les États limitrophes. Le tarif par mots aurait été accepté dans ce cas, sauf une surtaxe.

Ce tarif restera forcément en vigueur jusqu'en 1884; c'est au mois de juin 1884 qu'aura lieu la première réunion du congrès qui se tiendra à Berlin. Ce choix n'aurait sans doute pas eu lieu si la presse s'était plus vivement préoccupée des intérêts qui se discutaient à Londres, et si le huis-clos, dont nous nous sommes plaint, n'avait empêché de suivre le détail des délibérations.

Ajoutons que le tarif très-élevé qui est encore en vigueur entre l'Algérie et la France va être modifié grâce à l'initiative personnelle du gouverneur général. La taxe sera réduite à 10 centimes, ce qui conduira, suivant toute probabilité, à un trafic quadruple et nécessitera, nous écrit-on, la pose d'un nouveau câble entre l'Algérie et la mère-patrie. Cette mesure sera considérée comme un bienfait par tous les Algériens, et la pose du nouveau câble, une garantie de plus que les rapports télégraphiques ne sauraient être interrompus.

L'Electricite

HISTOIRE DE L'ÉLECTRICITÉ atmos E

Il est important de faire remarquer que, pendant le triste été que nous parcourons, les grêles ont été très-rares, quoique les pluies aient été presque incessantes et qu'on ait éprouvé un abaissement constant de température.

Cette observation confirme la théorie bien connue de la formation de la grêle par l'influence de l'élec-

Dans ce même numéro, M. Jamin ne donne pas des nouvelles de sa fameuse chandelle, mais il se console de ses déboires en publiant une *note* sur ce qu'il appelle *l'imperméabilité magnétique du fer.* Afin de triompher sans peine, M. Jamin suppose que quelques personnes ont mis en doute la propriété du fer de paralyser l'action magnétisante d'une hélice. Il publie le résultat d'expériences qui convainquent d'imbécillité ces ennemis imaginaires. Mais il ne souffle mot des hérétiques qui se refusent à acclamer les vertus lumineuses de sa bougie miraculeuse !

M. Berthelot publie un nouveau chapitre de thermo-chimie sur les amalgames alcalins et *l'état naissant.* Mais il ne dit pas un mot d'électricité, à côté de laquelle il passe sans détourner la tête.

Cependant, il n'est pas nécessaire d'être doué d'une dose formidable de bon sens pour reconnaitre que *l'état naissant* est un non-sens si l'on ne fait intervenir l'électrisation produite lors de l'action chimique. Tant que les gaz sont chargés de fluides électriques libres, ils sont à l'état naissant. Si on les met en position de conserver leur tension, l'état naissant persiste. La pile est une machine qui recueille l'électricité produite par l'état naissant, etc., etc.

Mais l'explication de ces phénomènes par les réactions *endo-thermiques* ou *exo-thermiques* parait plus simple et plus logique.

Dans le numéro du 16 juin, nous devons signaler une idée émise, il y a quelques années, par un autre physicien, mais développée avec logique par M. Altramare.

Ce physicien cherche à expliquer la suspension des nuages *par leur état électrique.*

Rien n'est plus naturel. En effet, les masses nuageuses semblent former des objets définis dans l'atmosphère. Comme leur surface est conductrice, ils se chargent d'électricité qui agit, soit sur l'électricité négative de la Terre, soit sur l'électricité positive du sol, soit sur l'électricité des autres nuages.

Un ballon, suspendu dans l'air et recouvert d'humidité, doit se trouver dans le même cas.

Qui sait si l'attraction de l'électricité négative du sol n'expliquerait pas certaines chutes rapides quand le ballon est humide, ou quand la surface inférieure est le siége d'une évaporation active, comme lorsque le globe aéronautique passe au-dessus des forêts ? Il en serait de même dans le courant d'une ascension maritime.

Mais, pour avoir une opinion décisive à cet égard, il faudrait que le ballon fût conduit avec une régularité telle qu'on se rendît compte des causes qui peuvent déterminer sa descente ou son ascension.

Malheureusement, l'art n'a point fait assez de progrès pour que l'aéronaute le plus habile soit en état de déterminer la nature des forces troublant l'équilibre qu'il doit avoir établi avec son aérostat.

M. L. Hugo a cru reconnaître que la lumière électrique favorisait l'éclat rouge des pieds du *Nidularium,* et qu'au contraire, l'éclat du rouge du *Caladium* semblait avoir été terni.

Il serait facile de répéter l'épreuve et de se former une opinion à cet effet.

Nous signalons à nos abonnés la question que M. Léopold Hugo a posée au monde savant.

L'Académie a nommé une commission, composée de six membres, pour rédiger un rapport sur les observations que M. l'amiral Serres a recueillies pendant la campagne d'exploration de la *Magicienne.*

La commission daigne nous apprendre que des observations magnétiques ont été faites à bord, mais elle ne croit pas qu'il soit nécessaire d'ajouter un résumé des faits intéressants que les mouvements de l'aiguille aimantée doivent lui avoir révélés.

Quant aux observations électriques, il n'en est point fait mention.

Cépendant, Arago, dans ses *Instructions sur les voyages scientifiques* (Tome IX de ses œuvres), n'oublie pas de mentionner la nécessité d'observer les coups de foudre et les aurores boréales.

Espérons que l'omission est du fait des rapporteurs et que le voyage de la *Magicienne* contiendra un nombre d'observations du plus haut intérêt...

Enfin, nous devons rapporter à l'électricité un mémoire de M. Dieu sur l'*Application inexacte d'un théorème de dynamique pour expliquer le mouvement des ailettes du radiomètre.*

MM. Bertin et Garbe, après avoir établi qu'un radiomètre suspendu par son axe se mettait en mouvement, ont cru avoir le droit de déclarer académiquement *que les mouvements du mobile étaient uniquement dus au fameux bombardement moléculaire du gaz, qu'ils avaient pris tant de soins pour extraire de la bande diaphane.*

Dans quelques pages serrées, M. Dieu a fait justice de cette manière peu logique de raisonner.

Il ne lui a pas été difficile de montrer que les deux associés avaient oublié de tenir compte du mouvement du résidu gazeux qu'il n'ont pu extraire, et dont ils ne devraient point faire abstraction, surtout avec la théorie bizarre qu'ils ont adoptée.

Il a montré ensuite que les forces extérieures ne sont pas du tout nulles, comme le supposent les équations des deux associés.

Enfin, il a montré l'importance d'une autre condition essentielle, dont ils oublient de tenir compte, quoiqu'ils l'aient, si nous avons bonne mémoire, signalée au monde savant.

Si l'on arrête le mouvement de l'aiguille dans sa chappe, le mouvement du tourniquet est paralysé.

Aucune de ces observations ne s'oppose à ce que le mouvement de la roue de mica soit produit par l'électricité.

M. Dieu termine sa très-intéressante communication en demandant :

1° Que l'on varie les substances de chaque palette et de ses faces en cherchant à étudier l'influence des pouvoirs réfléchissant, phosphorescent ou calorifique des deux faces;

2° En modifiant la nature des rayons lumineux, et notamment en les polarisant;

3° En suspendant le globe sur des pointes très-fines et en le renfermant dans un récipient en verre où l'on ferait le vide.

Il est bon de noter que M. Crookes s'abstient d'envoyer dorénavant à l'Académie les communications insignifiantes à l'aide desquelles il bombarde *non moléculairement* la Société royale de Londres.

On peut considérer cette abstention comme un premier succès; car il est déplorable de voir l'inventeur d'un si admirable appareil s'attacher à diminuer sa gloire, à l'anéantir, en s'acharnant à soutenir une théorie contre laquelle proteste le bon sens, ce grand instrument d'analyse dont personne au monde, fût-il à la fois membre de l'Académie des Sciences de Paris et de la Société royale de Londres, ne saurait se passer, quel que soit son génie.

L. Electricité

Lightning

MÉTÉOROLOGIE ÉLECTRIQUE

La Météorologie électrique au Congrès météorologique international de Rome

Lettre du directeur de l'observatoire Vésuvien aux secrétaires de la Rédaction du journal *l'Electricité.*

Puisque les actes du Congrès météorologique de Rome n'ont point été régulièrement publiés (1) avec l'extension qui serait nécessaire, j'ai pensé à informer la rédaction de votre excellente Revue, de ce qui s'y est passé, relativement à l'observation de l'électricité atmosphérique.

Au Congrès de Vienne, on avait eu quelques discussions sur les méthodes et sur les appareils les plus propres à ce genre d'observation. Il y eut des membres qui proposèrent l'électromètre Peltier et d'autres l'électromètre Thompson avec la veine descendante; enfin, quelques-uns recommandèrent mon électromètre bifilaire avec l'appareil à conducteur mobile. Le professeur Cantoni fut chargé d'étudier

(1) Nous demanderons de quel droit les commissaires se sont abstenus de mettre le monde savant à même d'apprécier la profondeur de leur science et la sagesse de leurs délibérations. Tant de modestie dépasse leur mission.

mas empêchera l'insecte qui sèche les feuilles de sécher nos fleuves et de changer son nom de phylloxera en potomaxera (1).

P. DESMARETS.

L'Electricité

L'orage du 6 septembre à Laigle

Nous avons eu occasion de contrôler par nous-même la parfaite exactitude des renseignements renfermés dans l'article suivant, dû à la plume d'un praticien distingué, qui a fait de l'étude de la nature le but de ses loisirs. Il serait bien à désirer que l'exemple donné par M. Jules Rouyer, ancien maire de la ville de Laigle et auteur de nombreuses observations météorologiques, fût plus fréquemment suivi.

Dans la nuit du 6 septembre, un orage est venu s'abattre sur la ville de Laigle, vers deux heures du matin. Dès une heure, les éclairs ont commencé à illuminer le ciel vers l'Ouest, puis, en se rapprochant, ont été promptement suivis des grondements du tonnerre, tantôt sourds et prolongés, tantôt secs et éclatants. A deux heures et demie, la pluie tombait par torrents, et l'eau venait affluer abondamment dans les parties basses de la ville. Tout semblait fini, ou du moins tirer à sa fin, lorsqu'un second orage, venant de la même direction, est venu ranimer la scène d'une façon plus énergique; ce second orage se trouvait en plein au-dessus de la ville de Laigle. Vers trois heures et demie, une nouvelle pluie diluvienne est survenue, plus abondante que la première. On entendait les coups de tonnerre plus rapprochés, plus éclatants.

A quatre heures et demie, la foudre est tombée dans le quartier de la Porte-Rabel, sur une des maisons placées au bord de la route de Mortagne.

Cette maison, qui appartient à M. Lacroix-Verrier, est occupée par deux ouvriers fondeurs, MM. Godet père et fils et par deux enfants; elle se compose de deux pièces au rez-de-chaussée, et elle est surmontée d'un petit grenier. Elle forme la moitié d'un corps de bâtiment complété par un autre logement de même disposition.

La foudre est tombée sur une cheminée qui forme une pointe regardant le sud-est; la cheminée a été démolie à sa partie supérieure et les débris sont tombés dans le grenier, au-dessous de la pointe, et par le conduit de la cheminée, puis la foudre a continué son trajet en descendant par la cheminée, démontant un tuyau de poêle qui y aboutissait.

Arrivé au sol, à *un mètre* seulement du lit où étaient couchés le père et le fils, le fluide électrique fit éclater plusieurs carreaux en terre recouvrant le sol, et un fragment assez gros fut lancé sur la tablette de la cheminée.

En même temps, les carreaux volèrent presque tous en éclats.

On remarque aussi plusieurs carreaux de faïence enlevés à un potager placé près de la cheminée, du côté opposé au lit.

(1) Phylloxera vient de deux mots grecs dont le premier veut dire « feuille » et le second « sécher. » « Potamos » veut dire « fleuve ». Ce qui permet de comprendre le jeu de mots que nous nous permettons.

La foudre passa de là dans la seconde pièce, où se trouvaient couchés deux enfants, dans le même lit, et, sans causer aucun dégât, sortit par un carreau de la fenêtre, remontant sur l'entablement et suivant une gouttière en fer-blanc jusqu'à une lucarne placée près de l'autre extrémité du bâtiment. On remarque quelques briques enlevées et projetées au loin, provenant du bas de cette lucarne; quelques tuiles sont cassées à son sommet.

Les quatre personnes habitant ces deux pièces, d'ailleurs assez petites, n'ont pas éprouvé le moindre mal.

L'examen des lieux et l'innocuité de la foudre en ce cas semblent indiquer qu'il s'agit d'une variété de la foudre connue sous le nom de *tonnerre en boule*.

D'ailleurs, un des enfants déclare avoir vu passer sur le sol un corps lumineux, *gros comme un petit ballon*.

Dr JULES ROUYER.

Nous ajouterons que la présence du poêle en fonte qui, comme on le voit plus haut, se trouvait dans la cuisine, et le voisinage du fil télégraphique peuvent avoir été les causes déterminantes de la chute de la foudre.

Car on sait que les masses métalliques constituent un danger spécial, lorsqu'elles cessent d'être en rapport avec le réservoir commun.

On nous a affirmé qu'il n'y avait, dans toute la ville de Laigle, petite ville excessivement industrieuse où le travail du fer est si répandu, qu'un seul paratonnerre, tant l'usage de ces appareils est encore peu répandu dans une contrée montagneuse où le travail des métaux est une industrie florissante.

Dans de pareilles circonstances, on ne doit point s'étonner que les observations fulgurales soient fréquentes, et nous sommes persuadé que M. Jules Rouyer aura plus d'une fois l'occasion de nous communiquer des faits dignes d'être signalés.

Puissent-ils ouvrir les yeux à ses concitoyens sur la nécessité d'avoir recours au système de protection découvert, il y a plus d'un siècle, par le bonhomme Franklin, physicien de génie, dont quelques-uns d'entre eux ont peut-être quelquefois entendu parler.

Le coup de foudre de la Porte-Rabel n'est pas le seul qui ait signalé l'orage du 6 septembre. Le fluide est également tombé à Aube sur la maison de M. Avenel, fabricant de chaussures, et à Saint-Symphorien-des-Bruyères, où elle a brisé une porte d'une écurie faisant partie de la ferme du Hameau et appartenant à M. Lecomte.

Ces deux coups de foudre se trouvaient l'un et l'autre à cinq ou six kilomètres du coup principal que nous avons examiné. On n'a pu préciser l'heure exacte à laquelle les explosions avaient eu lieu. On ignore également si les instruments du télégraphe ont été dérangés, ce qui n'a pu avoir lieu que si le coup de foudre a eu une grande intensité, car les employés avaient pris la précaution de mettre leurs appareils *sur terre* en se retirant.

La veille du jour de l'orage, on prétend avoir aperçu sur la pointe de l'unique paratonnerre de la ville de Laigle une étincelle brillant comme le ferait un feu Saint-Elme et indiquant, par conséquent, l'énergie de la tension électrique à laquelle toute la contrée se trouvait soumise.

Nous renverrons le lecteur à ce que nous avons dit dans nos *Eclairs et Tonnerre* sur les moyens d'employer les paratonnerres à avertir de l'imminence des orages. Mais, en voyant l'indifférence grossière avec laquelle la météorologie officielle a traité une suggestion aussi simple, aussi naturelle, nous ne pouvons nous empêcher de faire remarquer combien il est peu probable que cette observation nouvelle ait le pouvoir que n'ont pas eu ses aînées.

Le paysan chez lequel la foudre est venue prendre ses ébats avait eu l'heureuse idée de placer une assiette sur une chaise à l'entrée de sa demeure. Chacun des visiteurs y mettait son offrande, de sorte que le petit sinistre a pu être réparé sans bourse délier, et est même devenu, pour une pauvre famille, une source de profits.

~~Manufacturer & Builder~~ November 1879

Humbug No. 5.—The Chambers National Lightning Protection Co. of Cincinnati.

A company calling itself the Chambers National Lightning Protection Co. of Cincinnati, Ohio, has lately patented a new method of putting up lightning rods, which is nothing but a confession of ignorance on the part of the patentees in regard to the laws of electricity. This new patent lightning rod consists of a horizontal rod running over the ridge of the building, with a point at each end projecting upward, while it is supported on large glass insulators, and has no connection whatsoever with the ground.

The patentees evidently do not know that a stroke of lightning from a cloud to the earth is nothing but the neutralization of two opposite states of electricity—a positive electric cloud and a negative electric earth, made strongly so by the well established law of mutual induction. Every time the electric spark flies over between the two, a part of the charge becomes neutralized, and this neutralization can only take place by the earth receiving the electricity from the cloud and the cloud receiving the opposite electricity from the earth. Frequently these explosions take place between clouds mutually, as often some clouds are positively charged and others negatively; for this we do not want lightning rods; but when the discharge takes place between the earth and the clouds, and a house, tree, or man happens to be in the path of the discharge, the effects are often very destructive. Now, as an electric current prefers a metallic path, metal being a better conductor than any other substance, it is advantageous to give the lightning such a path, by making a metallic connection between the moist and conducting earth below and any spot above where the lightning is likely to fall in its downward course to the earth. Such a metallic connection is a lightning rod, not the point above, which may even be omitted; neither is it necessary to isolate it from the building with glass supports, as is done by ignorant lightning rod men; on the contrary, it should be connected above with the metal of the roof of the house, so that should the lightning strike the roof, it will find through the rod at the side of the house a ready downward path to the earth, without damaging the building. A good earth connection is the principal thing, upon which the greatest care must be bestowed; this is often neglected, and has proved to have been the cause of the failure of many lightning rods to give the expected protection.

Now this ground connection—this most essential feature of all lightning rods—is intended to be left entirely out by the learned Chambers National Lightning Protection Co. of Cincinnati; not only this, but the lightning rod is isolated. The result must be that if a stroke of lightning strikes such a rod from a cloud say 2,000 feet above the house, and overleaps a space of 2,000 feet through the air, it will also easily overleap the 100 feet or less between this new fashioned patent (so called) lightning rod and the ground, and the house, being in its path, will suffer, and the people in it may suffer also.

There is a journal issued by the Iowa Agricultural College, in which recently Prof. Macombes of that college is seriously questioned as to the possibility of protecting a house against lightning by isolating it on glass legs. How stupid! as if a stroke of lightning which descends from a cloud, perhaps half a mile above the roof of the house, could not overleap the distance below the house to the earth, even if the glass legs were 20 feet high.

Tel Journ Sept 15 1879

Report of the Committee on Atmospheric Electricity in Madeira.

Tele. Journ Sep 15/79.

By DR. M. GRAHAM.

REMARKABLE fluctuations of the electric potential were noticed at the time when the maximum potential is reached, which takes place at 11:30 a.m.; this fluctuation the writer ascribes to masses of cloud on moist air. The daily formation of a thin stratum of cloud during fine calm weather which varies slightly in altitude in accordance with temperature and barometric pressure was described. The electricity below this cloud is always positive and moderately strong. In the cloud itself it is more feeble but of the same sign. Above the cloud at the station where the observation was taken it was very feeble and irregular but always positive. In warmer weather the vapour does not condense into cloud but appears as a blue transparent haze from above, and presents the same electrical indications.

The highest potential was observed upon a rock ninety feet high, a few metres from the shore in the Bay of Funchal.

The thinness of the currents of air constituting sea breezes was demonstrated by flying a kite vertically beyond into the true wind blowing in a contrary direction. Abortive attempts were made to bring down the upper electricity through the lower currents. The electricity of the general north east wind which is identical with the trade wind was found on the heights at the east end to be uniformly moderate and positive.

At the approach of rain-clouds at the termination of a period of fine weather the atmosphere invariably gives increased readings and no negative observations were recorded.

The L'este, a kind of sirocco to which Madeira is occasionally subject, electrically gives no indication of any change whatever except by faint fluctuations about the earth-reading.

During the prevalence of L'este wind, the writer noticed a very highly electrical condition of certain clouds which lie quietly among the mountains, though tossed and tumbled on their upper surfaces; he hopes to be able to connect their forms and immobility with their electrical change.

78

English Mechanic

LIGHTNING-CONDUCTORS.*

THERE are many points upon which electricians do not agree among themselves, but perhaps no branch of their study has been the cause of so many conflicting opinions as lightning-conductors. If you find two electricians who agree as to the theory of the lightning-conductor, they will in all probability differ completely as to the manner of its application and the dimensions most suitable for a given purpose. The bibliography of the subject is extensive, and includes a number of papers from the most distinguished physicists of the present and the last century; but we doubt whether any practical information of much value is to be obtained by a perusal of the whole library, while the reader would certainly acquire a very confused notion of the subject unless he had already received a preliminary training in the principles. The author of the work before us seems to have felt the need of just such a book as he has produced, and his practical experience in planning out lightning-conductors has enabled him to produce a really useful guide to architects, clergymen, municipal officers, and others upon whom may devolve the duty of protecting public and other buildings from injury by lightning. Mr. Anderson has not given us any pet hypothesis of his own as to the nature of lightning, but has judiciously consulted the works of the best authorities, and has furnished us with a readable history of the lightning-conductor, and probably a correct description of the nature of the effects it is intended to prevent. The practical part of the work is, however, the more valuable portion, as it supplies non-technical readers with informa- that many have desired to obtain. It commences with Chapter V., on Metals as Conductors of Electricity, in which the author has, rather uncharitably, exposed the liability of the most distinguished scientists to make serious errors. The relative conductivity of metals is known nowadays with tolerable accuracy; but the figures given by such as Humphrey Davy, Becquerel, Ohm, Lenz, and Pouillet, are in some cases inexplicable. Davy taking copper as a standard at 100, found the conducting power of silver to be 109, and iron 14·6, while Becquerel, adopting the same standard, put silver at 73·5 and iron at 15·8, the comparative similarity in the one case making the discrepancy in the other all the more remarkable. The figures given by Lenz are, however, more noticeable still, for he found silver to have a conducting power of 136 and iron of 17·7, while as if to render the subject more mystifying still, Ohm rated silver at 35·6 and iron at 17·4. Pouillet's figures are: silver 81·3, iron between 15 and 18. It will be seen that while the five distinguished experimenters gave very varying results for silver, as indeed they did also for gold, the figures apportioned to iron agree in a very remarkable manner, and there can be no doubt

* Lightning-conductors: their History, Nature, and Mode of Application. By RICHARD ANDERSON, M.S.T.E. London: E. and F. N. Spon.

that by taking iron at 16½ and copper at 100 we have a probably accurate estimate of the relative conductivity of the two metals best adapted for making lightning-conductors. In the chapter on the Character of Lightning and Thunderstorms allusion is made to the statement that Solomon overlaid the Temple within and without with pure gold, and thus, unwittingly perhaps, took the best possible means of preserving the edifice from injury by lightning. According to Josephus, Solomon ordered the whole roof to be ornamented with sharply-pointed and thickly-gilded lancets of iron, presumably to prevent birds settling there and soiling the roof. That these points played an important part in protecting the building there can be little doubt, for all experience has indicated the use of points and large surfaces of metal in the attempt to protect buildings from lightning. The chapter on Inquiries into Lightning Protection is a useful, though necessarily brief, account of experiments and reports hitherto made with the view of obtaining some definite data upon which to work, and that is followed by a chapter recounting the experiments of Sir W. S. Harris. It is not impossible that more has been learnt from the failures of conductors than from a study of the theory of lightning, and there can be little doubt that copper is, all things considered, the best material for conductors. The remarkable discrepancies in the conductive power of metals alluded to above were, in all probability, mainly due to the use of impure samples, for Prof. Matthiessen found that if pure copper were taken as standard 100, best American would be only 92·5; Australian, 88·8; Russian, 59·3; and Spanish Rio Tinto only 14·24. Objections were formerly urged against copper on account of its expense; but a more potent reason for its neglect was the simple fact that a suitable copper conductor could not have been obtained. It is essential that the copper should be as pure as possible, for as it is six or seven times the price of iron, it is advisable to take full advantage of the greater conductive power of the more costly metal, which it will be seen nearly balances the difference in price. So far it may be said that iron and copper are practically equal, but there are two other points to consider, and in both of these copper is by a very long way the superior of iron, viz.: durability and flexibility. We can readily agree with Mr. Anderson, then, that copper is the best material for a lightning conductor, and it is not impossible that the wire ropes made by Newall and Co., which have, we believe, a guaranteed conductivity of 93 per cent. of pure copper, are the most suitable things in the market. Chapter X. describes what has been done at the Hotel de Ville, Brussels, and at Westminster Palace, the former building being probably the best protected of any in the world. It is covered on a plan devised by Professor Melsens, consisting of a perfect net-work of metal with numerous points and ample and perfect earth-contacts. The descriptions of the measures taken to protect these buildings will serve to show what is considered good practice, and the practical details under the head of weathercocks, and descriptive of practice in France and America, will help to make the subject clear. The chapter devoted to an explanation of Newall's system is, however, an epitome of the whole subject, and as numerous examples are given, the reader perceives clearly what is required for a barn, a house, a factory chimney or a church steeple. The system advocated by Melsens, of many small rods, instead of one large one is adopted by Mr. Anderson, but it is tolerably well understood nowadays that advantage should be taken of the presence of any considerable piece of metal in a building to bring it into the circuit of the conductor. Thus a church, for instance, instead of ridge tiles should preferably have a ridge of iron, which could be connected to the conductor, and so save the expense of running a copper rope from end to end. Several illustrations of the arrangement best adapted to special cases are given by the author, who also gives particulars of such minor details as fastenings, which should preferably be copper clamps built into the wall, in the case of a chimney for instance, though simple staples nailed to the wall will do very well in the case of the smaller and lighter conductors employed on houses. Not the least interesting portion of the book are the illustrations of the effects of lightning as seen in the case of churches and other buildings that have been injured by lightning, an engraving of the monument to General Baird, on the summit of Tomachaistle, near Crieff, serving as a frontispiece, and an excellent example of the disruptive power of a lightning stroke. The "earth connection," very appropriately, has a whole chapter to its consideration, and there are several engravings showing the most approved methods of insuring that at all times the earth wires shall be capable of distributing the discharge. A chapter urging the necessity for frequent inspection and testing of all lightning conductors, brings the work to a close—a very full bibliography forming an appropriate appendix. The book is well printed on good paper, and will, no doubt, become the standard textbook for use by those who are engaged in erecting lightning-conductors.

79

Reviews.

Lightning Conductors, their History, Nature, and Mode of Application. By RICHARD ANDERSON, F.C.S., F.G.S., Member of the Society of Telegraph Engineers. London: E and F. N. Spon.

JUDGING from the long list of books and pamphlets dealing more or less with the subject of lightning conductors, and given by Mr. Anderson at the commencement and end of his work, it might be imagined that but little more could be added to the existing stock of knowledge regarding the theory and practical construction of the lightning rod; such, however, is not the case, and Mr. Anderson's excellent new book will really prove a most valuable addition not only to a scientific library but also to the library of every architect or other person concerned in the construction of every kind of building.

The amount of ignorance that exists on the subject of lightning conductors is very great; the means that have existed for obtaining information regarding the same has hitherto been equally great. No good English work, with the exception of the one now before us, has been written. This want has now been supplied, and well supplied, too.

The amount of damage effected by lightning in this country alone is very considerable, and not a year passes but we hear of a large number of buildings being struck and greatly damaged; in some cases the mischief done is irreparable. The destruction of ancient buildings inseparably connected with historical associations is in every case a deplorable disaster, and one which no amount of money will repair. Some of our finest ancient structures—Windsor Castle amongst others—are either totally or insufficiently protected from lightning, and may some day be witnesses to the folly or apathy of those to whom their preservation is practically entrusted. Every possible care is taken to protect such structures from fire, and large sums are spent for the purpose, but the few pounds necessary to erect lightning conductors are either grudged or are not expended from pure ignorance of the importance of the means of protection.

In the commencement of his work, Mr. Anderson has written in an entertaining manner an account of the early discoveries made on the subject of electricity; in the narration of which the name of the immortal Franklin is, of course, prominently noticed; how thoroughly this philsopher grasped the truth of the identity of electricity and lightning is well pointed out, and we see that from the date at which this fact was made manifest, namely, at the middle of the last century, the history of lightning conductors practically commences.

The first lightning conductor ever constructed was set up by Franklin himself at his house in Philadelphia. The spread of the system was at first slow, in Europe notably so; in many cases personal enmity checked the progress; an ignorant priesthood, which scented heresy in an attempt to draw lightning from the clouds, for a long period waged war against the heretical rods, but as time went on, and the protective effects of the rods were seen, the opposition ceased, and the disputes took the form of controversies on the proper terminations to give to the protectors, *i.e.*, whether points or balls were most effective. The controversies ran so high that they resulted in the resignation by Sir John Pringle of the Presidency of the Royal Society. Subsequent experiments proved conclusively the superiority of the pointed conductor.

In Chapter V., Mr. Anderson deals with the subject of metals as conductors of electricity, and he gives tables of the comparative values of the various metals as determined by different physicists; the want of agreement is considerable, though the superiority of copper is in all cases agreed upon.

The conductivity of the material employed for the rods is easily determined previous to the fixing of the same, but after their erection their continuity requires testing to detect faulty joints, &c.; for this purpose Mr. Anderson has designed a simple and handy instrument, which consists of a three-cell battery of low resistance, a galvanometer, and a set of three resistance coils. Five keys are attached to the apparatus; by depressing one key the battery is put through the galvanometer direct, another key closes the circuit through a known resistance, a third key interposes a higher resistance, and a fourth key inserts a resistance of a still greater value;

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So far it may be said that iron and copper are practically equal, but there are two other points to consider, and in both of these copper is by a very long way the superior of iron, viz.: durability and flexibility. We can readily agree with Mr. Anderson, then, that copper is the best material for a lightning conductor, and it is not impossible that the wire ropes made by Newall and Co., which have, we believe, a guaranteed conductivity of 93 per cent. of pure copper, are the most suitable things in the market. Chapter X. describes what has been done at the Hotel de Ville, Brussels, and at Westminster Palace, the former building being probably the best protected of any in the world. It is covered on a plan devised by Professor Melsens, consisting of a perfect net-work of metal with numerous points and ample and perfect earth-contacts. The descriptions of the measures taken to protect these buildings will serve to show what is considered good practice, and the practical details under the head of weathercocks, and descriptive of practice in France and America, will help to make the subject clear. The chapter devoted to an explanation of Newall's system is, however, an epitome of the whole subject, and as numerous examples are given, the reader perceives clearly what is required for a barn, a house, a factory chimney or a church steeple. The system advocated by Melsens, of many small rods, instead of one large one is adopted by Mr. Anderson, but it is tolerably well understood nowadays that advantage should be taken of the presence of any considerable piece of metal in a building to bring it into the circuit of the conductor. Thus a church, for instance, instead of ridge tiles should preferably have a ridge of iron, which could be connected to the conductor, and so save the expense of running a copper rope from end to end. Several illustrations of the arrangement best adapted to special cases are given by the author, who also gives particulars of such minor details as fastenings, which should preferably be copper clamps built into the wall, in the case of a chimney for instance, though simple staples nailed to the wall will do very well in the case of the smaller and lighter conductors employed on houses. Not the least interesting portion of the book are the illustrations of the effects of lightning as seen in the case of churches and other buildings that have been injured by lightning, an engraving of the monument to General Baird, on the summit of Tomachaistle, near Crieff, serving as a frontispiece, and an excellent example of the disruptive power of a lightning stroke. The "earth connection," very appropriately, has a whole chapter to its consideration, and there are several engravings showing the most approved methods of insuring that at all times the earth wires shall be capable of distributing the discharge. A chapter urging the necessity for frequent inspection and testing of all lightning conductors, brings the work to a close—a very full bibliography forming an appropriate appendix. The book is well printed on good paper, and will, no doubt, become the standard textbook for use by those who are engaged in erecting lightning-conductors.

* Lightning-conductors: their History, Nature, and Mode of Application. By RICHARD ANDERSON, M.S.T.E. London: E. and F. N. Spon.

7 82 Science ~~Sept~~ 18 1880

ON THE AURORA AND ZODIACAL LIGHT OF MAY 2, 1877.

37

By Henry C. Lewis.

A simultaneous appearance of an aurora and the zodiacal light appeared on this evening, and a comparison between them is here given. The various changes of the aurora are given in detail. A remarkable feature was the formation of a bright streamer which maintained its position relative to the earth for nearly an hour. Meanwhile, the Zodiacal Cone, which was bright early in the evening had moved past the streamer and passed below the horizon. The streamer had remained, like the great pointer, fixed to the earth, and marking its motion, while the heavens revolved past it. This fact was conclusive evidence of the terrestrial character of the aurora and of the cosmical character of the zodiacal light. Another fact leading to the same conclusion was the character of their spectra. That of the zodiacal light was continuous, and that of the aurora was a line-spectrum—the former is such as would be given by sunlight reflected from matter in space; the latter would be given by an electric discharge through a gas.

Science Aug 7 1880

GENERAL NOTES. 37

Curious Electric Phenomenon.—At about 4.30 P. M. this day a severe thunder storm with a deluge of rain came up from the north-west, and lasted about an hour. At 5.30 my wife was standing at the window watching the receding storm, which still raged in the south, just over Leicester, when she observed, immediately after a double flash of lightning, what seemed like a falling star, or a fire-ball from a rocket, drop out of the black cloud about 25° above the horizon, and descend perpendicularly until lost behind a belt of trees. The same phenomenon was repeated at least a dozen times in fifteen minutes, the lightning flashes following each other very rapidly, and the thunder consisting of short and sharp reports. After nearly every flash a fire-ball descended. These balls appeared to be about one-fifth or one-sixth the diameter of the full moon, blunt and rounded at the bottom, drawn out into a tail above, and leaving a train of light behind them. Their color was mostly whitish, but one was distinctly pink, and the course of one was sharply zig-zagged. They fell at a rate certainly not greater than that of an ordinary shooting star. I have never witnessed a phenomenon of this kind myself, but my wife is a good observer, and I can vouch for the trustworthiness of her report.

F. T. Mott.

Bristal Hill, near Leicester, June 22, (Nature).

Protection from Lightning.

E R R Jones Sept 18/1880

37 A knight of the olden time, in full armor, was probably as safe from the effects of a thunder storm as if he had a lightning rod continually beside him; and one of the Roman Emperors devised a perfectly secure retreat in a thunder storm in the form of a subterraneous vault of iron. He was probably led to this by thinking of a mode of keeping out missiles, having no notion that a thin shell of soft copper would have been quite as effective as massive iron. But those Emperors who, as Suetonius tells us, wore laurel crowns or seal-skin robes, or descended into underground caves or cellars on the appearance of a thunder storm, were not protected at all. Even in France, where special attention is paid to the protection of buildings from lightning, dangerous accidents have occurred where all proper precautions seemed to have been taken. But on more careful examination it was usually found that some one essential element was wanting. The most common danger seems to lie in fancying that a lightning rod is necessarily properly connected with the earth if it dips into a mass of water. Far from it. A well constructed reservoir full of water is not a good "earth" for a lightning rod. The better the stone work and cement, the less are they fitted for this special purpose, and great mischief has been done by forgetting this.—*Nature.*

The Best Form for Lightning Conductors. 37

The best form for Lightning Conductors was the subject of a paper read by Mr. W. H. Preece before the British Association at its recent meeting. The point to be determined was whether the lightning conductor should be a solid rod, or tubular, or flat. Some gentlemen—among them Snow Harris, Prof. Henry M. de Melsens and M. Guillemin—advocated straps of extensive surface. It was Faraday's opinion in his lifetime that there was no advantage in tubular or flattened forms, as the surface had nothing to do with the conduction of the electric fluid. Faraday's opinion seems to be borne out by the experiments of Mr. Preece, which were as follows:

He obtained the use of Dr. De la Rue's magnificent batteries, and had procured conductors of equal material, length and weight, but differing in form. A condenser charged from 3,400 cells afforded a very powerful source of electricity, more than forty-two microfarads being thus available to produce an enormous spark. Experiments made by heating and deflagrating wires through the different conductors left no doubt that these discharges do obey the law of Ohm, and therefore that the additional surface of flat and tubular conductors is of no advantage in their conductivity.

Prof. Osborn Reynolds rather doubted the conclusions of Mr. Preece, on account of our not knowing the conditions under which the electricity passes from the air into the surface of the conductor. Prof. Ayrton thought the experiments should be tried with much greater difference of potential. The 3,000 cells would not produce a free spark of more than 1-40th of an inch long, whereas flashes of lightning might extend over miles.

Mr. Preece, in replying, pointed out that increased surface, though increasing its inductive capacity, did not add to its efficiency, which depended only on its conductivity.

Mr. Preece also communicated an observation on the peculiar behavior of copper wires. Very powerful discharges of electricity were found to increase the conductivity of newly-drawn copper wires by an appreciable percentage. Leaden wires showed no such changes. In the subsequent debate it appeared that the opinion was that the effect of the first current was to anneal the wire.

Scientific American.

Correspondence. Sept 25 1880

37

Protection from Lightning.

To the Editor of the Scientific American:

In your paper of August 28 is an article written by Professor Kirchoff, on connecting lightning rods with gas and water mains, in which, after citing a case of lightning destroying several lengths of cast iron water pipe in Basch, he proceeds to state that if the said pipes had been joined with *lead* instead of pitch, no mechanical effects could have been produced.

That the assumption of Professor K. is not justified by the facts is proved by the following cases:

A church in Terre Haute, Indiana, was struck by lightning, the rod knocked down, after which the electricity followed the gas pipes in the church to the mains in the street, and melted the *lead* joints for upwards of one thousand feet.

Another church in Iowa City, Iowa, received a heavy discharge, which damaged the rod, ran on the gas pipes, and thence to the main, and for a distance of several hundred feet every particle of the *lead* joints was burned out.

Other cases might be cited, but these are sufficient to prove that *lead joints* do not prevent mechanical effects when lightning passes over gas pipes.

Another correspondent, in the same issue of your paper, J. C. M., of Bradford, Pa., writing on the subject of protecting oil tanks from damage by lightning, says:

"We would only be too glad to learn of some method other than the old theory, by which we could protect our property from lightning, as that has been demonstrated beyond a doubt to be a failure. We want information on the subject."

J. C. M. is only one of many thousands seeking such information, and it certainly should be forthcoming from some of our scientists. Of what practical value to the human family has been the vast amount of knowledge accumulated on the subject of atmospheric electricity within the last forty or fifty years? Our scientists have studied its modes of action until all agree upon the laws which govern it; yet, so far as protection from lightning is concerned, this knowledge has not helped us forward one single step. The scientific world has demonstrated clearly, and have taught us by their writings for half a century, that what is known as *electric induction* is a universal mode of electric action.

Scientists have also clearly proved that Franklin knew nothing of this law of electric induction, hence that his theory regarding the action of atmospheric electricity was erroneous. Is it not strange, then, that our scientists should to this day countenance a system of lightning protection (so-called) suggested and recommended by Franklin, and which, by him, was based upon what has been so clearly proved to have been an erroneous theory? Is it reasonable or logical to expect protection from a system founded upon such a basis? Had the great Franklin understood electric induction, his wonderful intuition would have enabled him, without doubt, to suggest the proper method of constructing apparatus for protecting our property from lightning.

Electric induction is theoretically acknowledged and taught by all scientific authorities, yet when the subject of devising some practical system of protection from lightning is under consideration, these same authorities as completely ignore this law of electric induction as did Franklin, who, they prove, knew nothing about it.

Before we can hope for any efficient system of protecting our property from the dire effects of the lightning stroke, it must be clear to inquiring minds that we must no longer ignore this wonderful law of electric action known as electric induction, but must keep it ever before us and recognize it as an all-important and indispensable factor in our investigations. Any other course must result in the future, as it has in the past, in total failure.

J. H. A.

Electrician Sept 11, 1880

83

ON THE NECESSITY FOR A REGULAR INSPECTION OF LIGHTNING CONDUCTORS.†

BY RICHARD ANDERSON, F.C.S., F.G.S.

One of the most valuable suggestions which has been made in connection with lightning conductors was that by M. W. de Fonvielle in his paper "On the Advantages of Keeping Records of Physical Phenomena connected with Thunderstorms," read before this Association in 1872. In that paper M. de Fonvielle referred to the steps taken by the French Government for having maps drawn of the course followed by thunderstorms; and he reminded the Association that the French Academy of Sciences as far back as 1823 recommended the Government of France to establish a record of cases of damage by lightning to buildings which had been supplied with lightning conductors. He pointed out that the efficiency of lightning conductors had been questioned, and that in Manchester a conference held on the occasion of Kersal Church being struck had arrived at the conclusion that lightning conductors were worse than useless.

Although it was suggested by M. de Fonvielle that this Association should establish some organisation for the collection of such data, no results have, so far as I am aware, been published.

In my paper "On Lightning Conductors, and Accidents by Lightning," read before this Association in 1878, I cited two cases of damage to buildings provided with lightning conductors, which, on a careful investigation of the facts, showed that the lightning rods were inefficiently erected. On the present occasion I wish to bring under the notice of the Association a few cases which have come under my own observation of damage resulting to buildings which had lightning conductors attached. The adducing of such cases furnishes the best argument, I imagine, not only for a record being kept of all accidents; but of a regular inspection of buildings which have lightning conductors attached to them.

On the 10th of October, 1878, a furniture repository situated at the back of Victoria Station, Westminster, was struck by lightning, although a conductor was attached to the building. The warehouse, which is built of brick, is 110 feet, by about 80 feet wide, the roof is flat and covered with lead. At the south-east corner, a slate covered tower with four feet of iron cresting rises to the height of 20 feet above the roof. To this ornamental iron-work a solid copper band lightning conductor $\frac{3}{4}$" broad × $\frac{1}{8}$" thick, and weighing ·43lbs. per foot was attached. A terminal made of $\frac{5}{8}$" dia. copper tube, with three discharging points 6 inches long, screwed into the rod 3 inches from the top, rose three feet above the iron cresting. The rod was attached to the ironwork by means of copper wire, and the band to the slates and brick work by gun metal clips. The copper was of very good quality, having a conductivity of 92·00 per cent. The electric discharge fell on the point of the lightning conductor, bending it, driving out two of the discharging points and twisting the third. The iron cresting was shattered, and considerable damage done to the tower. Part of the discharge was, no doubt, carried off from the lead roof by the rain water pipes, which were in metallic communication with it. On testing the conductor shortly after the accident, I got no deflection of the galvanometer needle, and on opening out the earth terminal found the conductor carefully insulated in concrete.

On the 10th of June last, lightning struck the point of the conductor at St. Mark's Church, Skelton, slightly bending it; but did no further damage. The conductor was made of $\frac{5}{8}$" dia. copper rope, and had a conductivity of 52·50 per cent. On testing the conductor, while rain was falling, I found the resistance to be 600 ohms. The conductor was buried 9" among bricks, lime, &c., and carried 15 feet from the building.

On Saturday, the 26th of June, 1880, a heavy thunderstorm passed over South Lambeth, the lightning doing considerable damage to All Saints' Church. A stone cross 4 feet high stands on the apex of the west gable of this building, and another of similar size stood 92 feet 6 inches from it on the east end of the nave, a ridge of red tiles separating them. A $\frac{3}{4}$" dia. copper rope conductor consisting of 49 wires was attached to the cross on the west gable, a 5 feet point made of copper tube rising 18 inches above it. On the afternoon of the 10th lightning was observed to strike the point of the conductor, then dart to the stone cross on the east nave, throwing it down and injuring the roof of the north aisle. On testing the conductor a few days after the building was struck I found the lightning rod had no "earth" whatever, the rope being simply stuck 2 inches in loose rubbish. The copper was very impure, the conductivity being only 32·10 per cent., or about double that of iron.

* The electromotive force of the chloride of the silver cell is 1·03 volt.

† Read before Section A of the British Association at Swansea, Aug. 27, 1880.

84

In July last about half-past five in the morning, lightning struck one of the chimneys of Normanhurst Court, near Battle, Sussex, notwithstanding a lightning conductor was attached to it. There were two lightning conductors on the buildings. One on an octagonal tower, which rises from the S.W. angle, having a balcony and a lofty stone spire, about 120 feet high, the other on the S.E. chimney, which was struck, about 120 feet distant from the tower. The lightning conductors consisted of twelve copper wires, 15 B.W.G. woven into the form of a band an inch broad, and weighing ·36lb. per foot. The air terminal, which rose 3 feet above the chimney coping, consisted of an iron point 12 inches long, covered with a composition which on scraping appeared to be lead, this was attached by means of a coupling joint to a copper tube 6 feet long, and weighing ·28lb. per foot. The copper band was connected to the rod by another coupling joint. The chimney coping consisted of eight ornamental stone pinnacles 3 feet high and 2 feet square at the base. The terminal rod was placed on the centre of the chimney—and insulated from it. The lightning discharge struck the chimney, destroying three of the pinnacles, which falling through the roof below did considerable damage. The air terminal was bent, and the composition on the point melted 3 inches. The wires near the terminal point were likewise partly fused, and on taking out one wire 25 feet below the terminal rod, I found it so irregular in thickness that it had to be redrawn before the conductivity could be determined. On testing the earth terminal I could get no deflection of the galvanometer needle, the conductor being buried in dry earth within a stone wall 8 feet above the fosse, or asphalted area. The conductor on the tower had "good earth." The conductivity of the copper was 80·5.

From the instances quoted, it is evident that it is not sufficient merely that rods of copper should be attached to a building, but it is necessary that once put up they should be regularly inspected to see if they are in good order, so as to be really efficacious. That this is rarely done is one of the main reasons why accidents by lightning occur in places nominally protected by conductors. It is, perhaps, not too much to assert that at present not one in a thousand of our public buildings in England is regularly tested.

There can be no manner of doubt that in the matter of lightning conductors they manage things better on the other side of the Channel than with us. The French Government are in the constant habit of consulting the most eminent scientific men on the subject of protecting public buildings against the destructive influence of lightning. There is scarcely an instance in which a British Government ever did such a thing. It is true the Houses of Parliament had lightning conductors erected upon them at a very great cost and under scientific advice; but all who understand the subject practically agree in saying that it is very doubtful whether the magnificent pile of buildings in which our legislators assemble is really—that is efficiently—protected. At all events I understand the earths have never been tested since the conductors were erected in 1852. That the Victoria Tower should have been struck in June, 1868, and slightly damaged tends to show that the conductors at that time were not in an efficient state.

From the examination I have made I am pretty correct in stating that one-half of our cathedrals and three-fourths of our churches have not even nominal protection. For all that science has done the Queen might any day be killed in her apartments at Windsor Castle, the Prince of Wales in Marlborough House, and the Prime Minister in Downing-street. To see the difference between England and France in this respect, one has but to cross the Channel between Dover and Calais. At Dover there are huge barracks of great length, on the top of high hills, exposed to the full fury of storms sweeping across the Channel, and the few conductors to be found upon them at long intervals are certainly not numerous enough for efficient protection against lightning, and their efficiency has never, so far as I can learn, been tested. The contrast in this respect on crossing the Channel is of the most striking. At Calais, the Hotel de Ville, in the Grand Place, literally bristles with lightning conductors, and so all the churches and chief buildings in the town. The same all over France, Germany, and Belgium. Without slavishly imitating our scientific neighbours, we might yet bestow some of the care they do upon the protection of our property as well as of our lives against the terrible effects of the electric force.

During a recent thunderstorm at Hamburg the British Consul, Mr. Pogson, observed the phenomena of St. Elmo's fire playing above the tip of the spire of a church three-quarters of a mile away. Twenty times within one hour a pale-bluish ball of light resembling in tint the flame of burning potassium was seen. It appeared to be spherical in form, and from three to six feet in diameter. It seemed to hover above the spire without touching it, and lasting about forty seconds at each time of appearance. 37

ELECTRICIAN, SEPTEMBER 11, 1880.

Curious Freak of Lightning.—*Le Petit Marseillais* is answerable for the following:—"St. Etienne, Aug. 23. Last Thursday, during a violent storm, a young man was walking along the Richelaudière road, having in his hand a carriage lamp, unlighted. Suddenly he experienced the sensation of a violent shock in his arm, and concluded that the lightning had either struck him or fallen close to him. But what was his astonishment to find that his lamp had been lighted! Several persons who were behind him on the road observed this curious phenomenon." 37

Mining Press Oct 16 1881

The Course of a Lightning Flash.—Prof. Tait, of Edinburgh, insists that when people think they see a lightning flash go upward or downward they must be mistaken. The duration of a lightning flash is less than the millionth part of a second, and the eye cannot possibly follow movements of such extraordinary rapidity. The origin of the mistake seems, he says, to be a subjective one, viz., that the central parts of the retina are more sensitive, by practice, than the rest, and therefore that the portion of the flash which is seen directly affects the brain sooner than the rest. Hence a spectator looking towards either end of a flash very naturally fancies that end to be its starting point. 37

Report of the Committee on Erratic Blocks, presented by the Rev. H. W. Crosskey. (Abstract.)—Although the destruction of erratic blocks is proceeding with considerable rapidity, the Committee were able to report the discovery and preservation of some important specimens.

One of the most remarkable blocks of Shap granite yet observed is described by Mr. J. R. Dakyns at Seamer Station, near Scarborough. It measures roughly 5 ft. 8 in. × 4 ft. 10 in. × 4 ft. 3 in., and was fairly imbedded in gravel, forming the summit of a well-marked terrace 225 feet above the sea-level. This boulder is specially interesting in that it is the only boulder of Shap granite in the neighbourhood whose position in the beds is known; and this position shows that at the age assigned to the gravels (which is a comparatively recent one) icebergs must have been floating about. It has been preserved in the garden of the Station House.

The report records particulars of boulders discovered in the neighbourhood of Urmston, near Manchester, and also of a large number both of isolated boulders and groups of boulders observed in Leicestershire by Mr. J. Plant.

Mr. Pengelly furnishes a very interesting part of the report in an account he gives of some transported blocks and accumulations of blocks which he has observed in South Devon, the transposition of which it does not seem altogether possible that the action of water alone could have effected. A block of greenstone occurs in the village of Kingston, South Devon, measuring 4 × 2 × 2 feet, and weighing upwards of a ton. There is a mass of greenstone figured on the map of the Survey, extending to about a mile west-north-west of Kingston, where it makes its nearest approach to the village. Blocks of quartzite have been found in great abundance in the parishes of Diptford and Morleigh. They can be traced to their source on the higher levels of the neighbourhood; a bed of quartzite identical in character with the travelled blocks being interbedded conformably with the ordinary slaty Devonian rocks of the district. There can be no doubt that the blocks have been transported from south to north, and from higher to lower ground. The gradient, however, is very slight, and as almost all the blocks are very angular as well as large, it is difficult to suppose that their transportation was the result of nothing more than running water.

A block of greenstone occurs near Diptford Court, weighing fully 1·75 ton. A mass of igneous rock apparently of the same kind is found at a distance of five miles due south of the boulder, and another about the same distance north.

The blocks locally termed in South-Western Devon "Whita-

50

Review 1880 85

kers", are described in the report. They are composed of white opaque quartz, having in some cases a laminated structure, and traversed occasionally with veins and crystals of the same material. That the blocks have travelled a considerable distance cannot be doubted; and that their transportation was not effected by the action of water only appears proved. The blocks are all more or less rugged and sub-angular, although without any decided traces of glacial polish or scratches. They occur most plentifully on the higher ground.

They have been so largely utilised by the farmers and for artificial rockeries that it is to be feared, unless care is taken to prevent it, those now remaining on the spots they have so long occupied undisturbed may altogether disappear.

The report concluded with an appeal to local observers to report upon the erratics still unrecorded before the work of destruction is completed, and evidence throwing light on difficult problems of glacial geology is destroyed.

Report on the Exploration of Caves in the South of Ireland, by Prof. A. Leith Adams. Includes a Report by Mr. R. J. Ussher.—Describes caves at Carrigea Gower, four miles south of Middleton. Stalagmite floor on sandy clay; beneath the stalagmite was much charcoal, the roof had an opening to the surface, down which much kitchen rubbish had been thrown, associated with hammer stones, flint flakes, iron implements, and remains of recent animals. A report was read on the implements, by Mr. R. Day, which are of no great antiquity; one piece of pottery was believed to have a Roman (capital) letter inscription.

Report on the Carboniferous Polyzoa, by W. G. R. Vine.—Discusses the character of the genus and species and the views held on them by the earlier workers, and after a comparison of the specific forms he relegates to each of these the precise genera to which they belong.

Report on the "Geological Record," by Mr. W. Whitaker.—Four volumes have been published, each of which gives an abstract of all geological work done throughout the world, for one year; they contain an average number of 20,200 entries in each volume.

Sixteenth Report of the Committee appointed to Explore Kent's Cavern, by Mr. Pengelly.—The deposits passed through in the cavern were:—

Iron and Bronze.		Black Mould. Roman Remains (Ovine).
Palæolithic	Newer Type.	Granular Stalagmite, 5 feet. Extinct Animals.
		Cave Earth. Extinct Animals. (Hyæna).
	Rougher Type.	Crystalline Stalagmite, 12 feet. (Bears).
		Breccia.

Work commenced in March, 1865, by excavating down to 4 feet throughout the whole cavern; finished in November, 1879, the floor had at that time been so excavated, at a cost of 1,850*l.* to the Association. A further grant was then given to lay bare the limestone floor; and subscriptions from private sources amounted to 51*l.* received, which enabled the base of the cave deposit to be excavated for a length of 132 feet. Occasionally stalagmitic fragments occurred on the base of the breccia, resting on the rock. On June 19, 1880, the work was suspended, it having only yielded seventeen finds—amongst them a flint nodule, which had not been touched by the implement maker—which are of greater rarity. Archæological finds were more numerous than remains of animals; the implements correspond to those of the oldest river gravels in type. Referred to the good work done by Mr. George Smerdon, the foreman of the workmen during sixteen years, who has become crippled with rheumatism, brought on by execution of the work, and suggested the desirability of raising subscriptions to purchase for him an annuity of 10*l.* a year.

Report of the Committee, consisting of Mr. James Heywood, Mr. Shaen, Mr. Stephen Bourne, Mr. Wilkinson, the Rev. W. Delaney, and Dr. J. H. Gladstone (Secretary), appointed for the purpose of reporting whether it is important that H.M. Inspectors of Elementary Schools should be appointed with reference to their ability for examining the scientific specific subjects of the Code in addition to other matters.—The Committee nominated at Sheffield for the purpose of considering "whether it is important that H.M. Inspectors of Elementary Schools should be appointed with reference to their ability for examining the scientific specific subjects of the Code in addition to other matters," have received a considerable amount of evidence upon the subject, and beg to report as follows:—

1. It has come to their knowledge that the teaching of the scientific specific subjects is practically discouraged by the incapacity of many of H.M. Inspectors to examine in them.

2. This incapacity is explained by the fact that the Inspectors are not generally chosen so much for their fitness to judge of such educational work, as on account of their high scholarship, or through political patronage.

3. In the opinion of this Committee there might be an examining body for H.M. Inspectors, composed of three of the most experienced of the present senior Inspectors, associated with a similar number of the Science Examiners of the Science and Art Department. The examination should be thrown open to elementary teachers, and the candidates might be tested in the practical work of examination in one of the Central Elementary Schools in London.

4. The Committee believe that the opening of the Inspectorship to fully qualified elementary teachers would tend to raise the *esprit de corps* of the profession, and improve the character of both inspector and teacher.

5. The Committee are further of opinion that while a university degree may be fitly regarded as a test of scholarship, it is not a test of the particular qualifications for an examiner, and therefore is not sufficient in itself to guarantee the holder thereof as worthy the position of Inspector. There appears to be no reason why academical honours should be made an indispensable condition of appointment.

6. The Committee recommend that a memorial be presented to the Lords of the Committee of Privy Council on Education embodying the above conclusions.

Report of the Committee, consisting of Dr. Pye-Smith, Prof. M. Foster, and Prof. Burdon Sanderson (Secretary), appointed for the purpose of investigating the Influence of Bodily Exercise on the Elimination of Nitrogen (the Experiments to be conducted by Mr. North).—During the past year four series of preliminary experiments, each of several weeks' duration, have been made by the Committee on the subject, the expenses of which have been met from other funds. In the course of these experiments unexpected difficulties have been encountered relating to method. The most serious of these difficulties having now been for the most part overcome, we are in a position to proceed with our inquiries next winter, and have therefore to request that the sum of 50*l.*, previously granted to us, may again be placed at our disposal.

d of time almost incone[illegible]y short, and that the full effect of

on the eye is not produced until after the lapse of a considerable

on of a second. Professor Swan has estimated this interval at

one-tenth of a second; and he has proved that the apparent in-

y of illumination for shorter intervals is nearly proportional to

uration.

84

In July last about half-past five in the morning, lightning struck one of th…
Sussex, not…
it. The…
on…

4. If June, July, August, or December be *warm*, the next month will probably be a warm one also.

5. Two months, June and July, tend, when very *dry*, to be followed by dry ones. On the other hand, a dry August indicates the probability of a *wet* September.

6. A *wet* December is apt to be succeeded by a wet January.

In addition to the foregoing, there are also a few instances in which the rainfall of certain months appears to be definitely related to antecedent extremes of temperature, and *vice versâ*. Thus

7. If August or September be *warm*, the ensuing September or October inclines to be wet. If, on the other hand, September or November be *cold*, the succeeding October or December is likely to be a dry month.

8. If February, June, or July be very *dry*, the next month has a strong tendency to be warm.

9. If January, March, or April be *wet*, we may also expect the next month to be a warm one. But a wet May or July gives a strong probability of cold weather in June or August respectively.

Preece 3

Mr. W. H. Preece read a paper *On the Best Form to give to Lightning Conductors*. The question was whether the lightning conductor should be a solid rod, or tubular, or flat. Snow Harris, Prof. Henry, M. de Melsens, and M. Guillemin advocated straps of great surface. Faraday strongly maintained that there was no advantage in strap or tube forms, as the surface does nothing in conducting the current. Mr. Preece had obtained the use of Dr. De La Rue's magnificent batteries, and had procured conductors of equal material, length, and weight, but differing in form. A condenser charged from 3,400 cells afforded a very powerful source of electricity, more than forty-two microfarads being thus available to produce an enormous spark. Experiments made by heating and deflagrating wires through the different conductors left no doubt that these discharges do obey the law of Ohm, and therefore that the additional surface of flat and tubular conductors is of no advantage in their conductivity.

Prof. Osborne Reynolds rather doubted the conclusions of Mr. Preece, on account of our not knowing the conditions under which the electricity passes from the air into the surface of the conductor. Prof. Ayrton thought the experiments should be tried with much greater difference of potential. The 3,000 cells would not produce a free spark of more than $\frac{1}{16}$ of an inch long, whereas flashes of lightning might extend over miles.

Mr. Preece, in replying, pointed out that increased surface, though increasing its inductive capacity, did not add to its efficiency, which depended only on its conductivity.

Mr. Preece also communicated an observation on the peculiar behaviour of copper wires. Very powerful discharges of electri-…

$\frac{3}{4}$-inch by $\frac{1}{8}$-inch copper band lightning-conductor and a tube of $\frac{5}{8}$-inch diameter rising above the iron crestings on the tower. The lightning shattered the cresting and bent the point of the lightning-rod, besides doing other damage to the building. On testing, the author found the resistance very great, and on opening out the earth-terminal found it imbedded in concrete.

On June 26 last, lightning struck All Saints Church, Lambeth, doing considerable damage, although there was a $\frac{3}{8}$-inch diameter copper-rope conductor on the west gable, with a copper tube rising 18 inches above. A stone cross about 50 feet from the conductor was thrown down, injuring the roof of the north aisle. On testing the conductor, the author found that it had no "earth" whatever, the rope being simply placed in 2 inches of loose rubbish. The copper was of very inferior quality; conductivity being 32·10 per cent., or about double that of iron.

The author quoted also a few cases from his recent work on "Lightning-Conductors, their History," &c:—

In August, 1878, the Powder Magazine at Victoria Colliery, Burntcliffe, Yorkshire, was struck by lightning, though furnished with a conductor, 13 feet above the building, and terminating in 13 feet of clayey soil. The building was blown to pieces. On testing the conductivity of the copper, it was found to be 39·2, instead of 92 to 94 per cent. The conductor was insulated from the building and from a large iron door, which it ought not to have been.

The author concludes from this evidence that it is not sufficient merely that rods of copper should be attached to a building, but it is necessary that after being fixed they should be regularly inspected, to see if they are in good order, so as to be really efficacious.

Sir Wm. Thomson gave a communication *On a Method of Measuring Contact Electricity*. Sir W. Thompson had devised this method at the time when Hankel published his results in 1861. A method identical with it had lately been described by M. Pellat, and consisted in employing a small electromotive force in connection with a dividing resistance slide, to give a counterbalancing electromotive force to that produced by contact. 6

Sir W. Thomson next described *A Method of Determining without Mechanism the limiting Steam-Liquid Temperature of a Fluid*. This was a simple apparatus, consisting of a closed glass tube containing liquid sulphurous acid filled to a sufficient height to insure that the liquid in the lower half will expand to the top. Prof. W. Ramsay criticised the proposal, and stated that he had found an apparatus in which a screw was employed to produce increase of pressure instead of using the expansion of the liquid itself. With this apparatus he had repeated Andrews' research on a large number of substances.

Mr. G. F. Fitzgerald read a paper *On the Possibility of originating Wave-disturbances in the Ether*. This was a mathematical paper, in which, by comparing the equations of Maxwell's theory of the propagation of electric action through a medium with those of direct action at a distance, he deduced the conclusion that electric currents and systems cannot originate in the ether such disturbances as those of light.

Mr. R. M. Shida gave an account of *A New Determination of the number of Electrostatic Units in the Electromagnetic Unit*. The value V of this ratio he deduced was $294{\cdot}4 \times 10^8$. 6

M. Wilfrid de Fonvielle exhibited his magnetro-electric gyroscope, which has been already described in our pages.

M. Janssen sent a communication to the Section, which was read by the Secretary, upon his recent researches *On the obtaining Positive Photographs by Prolonged Exposure*.

Mr. Wiesendanger showed a new electromotor, which will be described hereafter in our pages.

Mr. Philip Braham exhibited an ingenious adaptation of limelight for microscopic illumination, and also described a simple instrument for detecting polarised light.

On the Best Form of Magnet for Magneto Machines, by W. Ladd.—At the British Association meeting at Dundee in 1867, I made some remarks upon different forms of magnets, and exhibited these diagrams, showing, by the "lines of force" naturally arranged, the great superiority of the circular magnet where an armature is to be employed. 17

Since that time some thousands of that form of magnet have been made for medical, mining, and other purposes.

Some months ago, in conversation with M. Bregnet of Paris, I showed him these same diagrams, and he was very much impressed with their importance; he has since then constructed a machine, using the Gramme armature, and with a smaller quantity of steel in the magnets he has made a far more powerful

From the examination I have made I am pretty correct in stating that one-half of our cathedrals and three-fourths of our churches have not even nominal protection. For all that science has done the Queen might any day be killed in her apartments at Windsor Castle, the Prince of Wales in Marlborough House, and the Prime Minister in Downing-street. To see the difference between England and France in this respect, one has but to cross the Channel between Dover and Calais. At Dover there are huge barracks of great length, on the top of high hills, exposed to the full fury of storms sweeping across the Channel, and the few conductors to be found upon them at long intervals are certainly not numerous enough for efficient protection against lightning, and their efficiency has never, so far as I can learn, been tested. The contrast in this respect on crossing the Channel is of the most striking. At Calais, the Hotel de Ville, in the Grand Place, literally bristles with lightning conductors, and so all the churches and chief buildings in the town. The same all over France, Germany, and Belgium. Without slavishly imitating our scientific neighbours, we might yet bestow some of the care they do upon the protection of our property as well as of our lives against the terrible effects of the electric force.

During a recent thunderstorm at Hamburg the British Consul, Mr. Pogson, o… the phenomena of St. Elmo's fire playing above the tip of the spire of a churc… quarters of a mile away. Twenty times within one hour a pale-bluish ball … resembling in tint the flame of burning potassium was seen. It appeared to be… cal in form, and from three to six feet in diameter. It seemed to hover above t… without touching it, and lasting about forty seconds at each time of appearance…

Science

ON THE AURORA AND ZODIACAL LIGHT OF MAY 2, 1877.

37 Sept 18

BY HENRY C. LEWIS.

A simultaneous appearance of an aurora and the zodiacal light appeared on this evening, and a comparison between them is here given. The various changes of the aurora are given in detail. A remarkable feature was the formation of a bright streamer which maintained its position relative to the earth for nearly an hour. Meanwhile, the Zodiacal Cone, which was bright early in the evening had moved past the streamer and passed below the horizon. The streamer had remained, like the great pointer, fixed to the earth, and marking its motion, while the heavens revolved past it. This fact was conclusive evidence of the terrestrial character of the aurora and of the cosmical character of the zodiacal light. Another fact leading to the same conclusion was the character of their spectra. That of the zodiacal light was continuous, and that of the aurora was a line-spectrum—the former is such as would be given by sunlight reflected from matter in space; the latter would be given by an electric discharge through a gas.

Scientific Amer Oct 2 1880, 37

The Course of a Lightning Flash.

Prof. Tait, of Edinburgh, insists that when people think they see a lightning flash go upward or downward they must be mistaken. The duration of a lightning flash is less than the millionth part of a second, and the eye cannot possibly follow movements of such extraordinary rapidity. The origin of the mistake seems, he says, to be a subjective one, viz., that the central parts of the retina are more sensitive, by practice, than the rest, and therefore that the portion of the flash which is seen directly affects the brain sooner than the rest. Hence a spectator looking toward either end of a flash very naturally fancies that end to be its starting point.

Engineer Sept 24 1880. Oct 8 1880

ELECTRIC STORMS.—The valley of the Missouri and other districts, which suffered so much from tornadoes, have been examined by Professor Tice, who has come to the opinion that the storms were of an electric nature. He arrived at this conclusion by the fact that the buildings which suffered most were those which were covered with zinc or other metallic roofing, while houses roofed with slate or tiles almost invariably escaped. The iron chimney of a factory was torn off and twisted about in a remarkable manner, while the rest of the building showed no trace of damage; and the same happened to the bell cupola of a large school, which, being made of sheet tin, was completely destroyed. The Professor also noticed that those trees which suffered from the storm were not injured particularly from the windward side, or bent in any direction by the storm, but that the whole of them were stripped of their leaves instantaneously like broomsticks, and that the bark presented an appearance as of scorching. 37

SOME interesting particulars relating to the fact that in some tropical countries the electrical phenomena of the lowest atmospheric layer are much more marked than in temperate climates have been lately given by M. Amat from experiences in the Northern Sahara. Without insulating himself from the ground, he could often get sparks 0·05in. to 0·07in. by simply passing a pocket-comb through his hair or beard. This succeeded best in dry, hot weather, on return from a long excursion over arid plains, the most favourable time being in the evening from seven to nine o'clock. Some lower animals, and especially horses, present electric phenomena still more strikingly. On hot summer days, one sees on Arab horses long hairs diverging from the middle of the tail. Caressing the tail with the hand, a number of crackling sounds are heard, and, if it be in darkness, sparks are seen. The electricity liberated by the tail of horses M. Amat finds to be positive. Man, in direct communication with the ground, does not show such an accumulation of the electric fluid as the horse does, and friction is necessary to develope it. The horn of the horses' hoofs seems to act as an insulator. 37 Engineer Sept 24 1880

Science. Nov. 27.

INTENSITY OF CERTAIN PHENOMENA OF ATMOSPHERIC ELECTRICITY OBSERVED IN THE NORTH OF THE SAHARA.—L. Amat has observed that in tropical countries the electric phenomena of the atmospheric stratum in contact with the soil are more distinct than in colder climates. 37

Stoddard Review Dec 1880 85

THUNDERSTORMS.

Stoddard's review Dec, 1880,

BY PROFESSOR TAIT.*

BY far the most striking of the phenomena of a thunderstorm—at least if the storm come on during the day—is the extraordinary darkness. Sometimes at midday in summer the darkness becomes comparable with that at midnight, very different in kind as well as intensity from that produced by the densest fog. Objects are distinctly visible through it at distances of many miles, whether when self-luminous, or when instantaneously lit up by lightning. The darkness, then, is simply intense *shadow*, produced by the great thickness and great lateral extension of the cloud-masses overhead. Seen from a distance, the mass of cloud belonging to the storm usually presents a most peculiar appearance, quite unlike any other form of cloud. It seems to boil up, as it were, from below, and to extend through miles of vertical height. The estimated height of its lower surface above the ground varies within very wide limits. Saussure has seen it as much as three miles; and in one case noticed by De l'Isle it may have been as much as five miles. On the other hand, at Pondicherry and Manilla it is scarcely ever more than half a mile. Haidinger gives the full details of an extraordinary case, in which the thundercloud formed a stratum of only twenty-five feet thick, raised thirty yards above the ground. Yet two people were killed on this occasion. Other notable instances of a similar extreme character are recorded.

Careful experiment shows us that the air is scarcely ever free from electricity, even in the clearest weather. And even on specially fine days, when large separate cumuli are floating along, each as it comes near produces a marked effect on the electrometer. Andrews obtained by means of a kite, on a fine clear day, a steady decomposition of water by the electricity collected by a fine wire twisted round the string.

The next striking features are the flashes of lightning, which at intervals light up the landscape with an intensity which must in the majority of cases far exceed that produced by the full moon. To the eye, indeed, the flash does not often appear to furnish more than the equivalent of average moonlight, but it must be remembered that it lasts for a period of time almost inconce… short, and that the full effect of light on the eye is not produced until after the lapse of a considerable fraction of a second. Professor Swan has estimated this interval at about one-tenth of a second; and he has proved that the apparent intensity of illumination for shorter intervals is nearly proportional to the duration.

86

Scientific American Oct 9 1880

LIGHTNING CONDUCTORS.*

By Richard Anderson, F.C.S., F.G.S.

On the present occasion I wish to bring under the notice of the association a few cases of damage resulting to buildings which had lightning conductors attached, which have come under my own observation. The adducing of such cases furnishes the best argument, I imagine, not only for a record being kept of all accidents, but of a regular inspection of buildings which have lightning conductors attached to them.

On the 10th of October, 1878, a furniture repository situated at the back of Victoria Station, Westminster, was struck by lightning, although a conductor was attached to the building. The warehouse, which is built of brick, is 110 ft. by about 80 ft. wide, the roof is flat and covered with lead. At the southeast corner, a slate-covered tower with 4 ft. of iron cresting, rises to the height of 20 ft. above the roof. To this ornamental ironwork a solid copper band lightning conductor, ⅞ in. broad by ⅛ in. thick, and weighing 0·43 lb. per foot, was attached. A terminal made of ⅝ in. diam. copper tube with three discharging points 6 in. long, screwed into the rod 3 in. from the top, rose 3 ft. above the iron cresting. The rod was attached to the ironwork by means of copper wire and the band to the slates and brickwork by gun metal clips. The copper was of very good quality, having a conductivity of 92 per cent. The electric discharge fell on the point of the lightning conductor, bending it, driving out two of the discharging points, and twisting the third. The iron cresting was shattered, and considerable damage done to the tower. Part of the discharge was no doubt carried off from the lead roof by the rain water pipes, which were in metallic communication with it. On testing the conductor shortly after the accident, I got no deflection of the galvanometer needle, and on opening out the earth terminal found the conductor carefully insulated in concrete.

On the 11th of June last, lightning struck the point of the conductor at St. Mark's Church, Skelton, slightly bending it, but did no further damage. The conductor was made of ⅝ in. diam. copper rope, and had a conductivity of 52·50 per cent. On testing the conductor, while rain was falling, I found the resistance to be 600 ohms. The conductor was buried 9 in. among bricks, lime, etc., and carried 15 ft. from the building. On Saturday, the 26th of June, 1880, a heavy thunderstorm passed over South Lambeth, the lightning doing considerable damage to All Saints Church. The building in question, the style of which partakes of the characteristics of the thirteenth century, consists of a nave 92 ft. 6 in. long, 25 ft. wide, and 36 ft. high to the plate level of the roof, a chancel 31 ft. long, 20 ft. wide, and 48 ft. to the ridge, also north and south aisles 13 ft. 3 in. wide. A stone cross 4 ft. high stands on the apex of the west gable, and another of similar size stood 92 ft. 6 in. from it on the east end of the nave, a ridge of red tiles separating them. A ⅝ in. diam. copper rope conductor, consisting of 49 wires, was attached to the cross on the west gable, a 5 ft. point made of copper tube rising 18 in. above it. On the afternoon of the 10th, lightning was observed to strike the point of the conductor, then dart to the stone cross of the east end of the nave, throwing it down and injuring the roof of the north aisle. On testing the conductor a few days after the building was struck, I found the lightning rod had no "earth" whatever, the rope being simply stuck 2 in. in loose rubbish. The copper was very impure, the conductivity being only 32·10 per cent., or about double that of iron.

In July last, about half-past five in the morning, lightning struck one of the chimneys of Normanhurst Court, near Battle, Sussex, notwithstanding a lightning conductor was attached to it. Normanhurst stands on high land, and commands a magnificent view of the whole channel from the South Foreland to Beachy Head. The buildings are constructed of hard blue stone, roofed with Brosely tiles; and are in the style of the age of Francis I. There were two lightning conductors on the buildings; one on an octagonal tower, which rises from the S. W. angle, having a balcony and a lofty stone spire, about 120 ft. high, the other on the S. E. chimney, which was struck, about 126 ft. distant from the tower. The lightning conductors consisted of 12 copper wires, 15 B. W. G., woven into the form of a band 1 in. broad, and weighing 0·36 lb. per foot. The air terminal, which rose 3 ft. above the chimney coping, consisted of an iron point 12 in. long, covered with a composition which on scraping appeared to be lead; this was attached by means of a coupling joint to a copper tube 6 ft. long, and weighing 0·23 lb. per foot. The copper band was connected to the rod by another coupling joint. The chimney coping consisted of eight ornamental stone pinnacles 3 ft. high and 2 ft. square at the base. The terminal rod was placed on the center of the chimney, and insulated from it. The lightning discharge struck the chimney, destroying three of the pinnacles, which, falling through the roof below, did considerable damage. The air terminal was bent, and the composition on the point melted 3 in. The wires near the terminal point were likewise partly fused, and, on taking out one wire 25 ft. below the terminal rod, I found it so irregular in thickness that it had to be redrawn before the conductivity could be determined. On testing the earth terminal, I could get no deflection of the galvanometer needle, the conductor being buried in dry earth within a stone wall 8 ft. above the fosse, or asphalted area. The conductor on the tower had "good earth." The conductivity of the copper was 80·5.

In my recently published work on "The History and Application of Lightning Conductors," the following cases among others are given:

On the 6th of August, 1878, lightning struck the powder magazine at the Victoria Colliery, Burntcliff, Yorkshire. At the time of the explosion the magazine contained about 2,000 lb. of gunpowder. The magazine was an oblong building of brick, 9 ft. long, 5 ft. wide, and 6 ft. high (internal dimensions), and it had a uniform thickness of three bricks. At the end was a heavy iron door, and at the other a lightning conductor, consisting of a copper wire rope seven-sixteenths of an inch in diameter. The point of the terminal rod was about 18 ft. above the top of the building, and a similar length was carried into the ground, and terminated in clayey soil at a depth of 3 ft. The conductor was fixed to a pole distant about 2 in. from the end of the building opposite to that in which the iron door was fixed. *It was not connected with the iron door in any way.* On testing the conductivity of the copper rope it was found to be only 39·2 instead of 93 or 94 per cent. The conductor should not have been insulated, but brought down the pole, carried along the roof down the iron door post, and so into the ground.

In August, 1879, lightning struck one of the pinnacles of the tower of Cromer Church, Norfolk, although on another pinnacle only 27 ft. 6 in. distant, a good copper conductor, having a diameter of ⅝ of an inch was placed. On testing the conductor by means of a galvanometer, I found it and the earth connection in thorough order. In this case, a point should have been placed on each of the pinnacles, and joined the main conductor.

In May, 1879, the steeple of the church at Laughton-en-le-Morthen was struck by lightning and damaged. The spire, 175 ft. in height, had attached to it a thin tube made of corrugated copper, about ⅝ of an inch in external diameter, and ⅜ internal; the copper being 1-32 of an inch in thickness. It was made in short lengths joined together by screws and coupling pieces, but there was no metallic contact whatever between the pieces, which were much corroded. The conductor was not in contact with the building, but was kept at a distance of 2½ in. by twenty-one insulators. The earth contact was obtained by bending the tube and burying it in the ground at a depth of from 6 to 18 in., the soil being dry loose rubbish, the earth terminal being only 3 ft. It was placed in a corner formed by a double-stem buttress, which came between the conductor and a lead-covered roof attached to the spire; the distance between the conductor and the lead roofing being about 6 ft. 6 in. The lightning appears to have come down the conductor a certain distance, and finding the road to earth bad, it passed through the buttress, dislodging about two cartloads of stone, and then down the cast iron pipes leading from the lead covered roof, and so to earth.

From the instances quoted, it is evident that it is not sufficient merely that rods of copper should be attached to a building, but it is necessary that once put up, they should be regularly inspected to see if they are in good order, so as to be really efficacious. That this is rarely done is one of the main reasons why accidents by lightning occur in places nominally protected by conductors. It is, perhaps, not too much to assert that at present not one in a thousand of our public buildings in England are regularly tested.

There can be no manner of doubt that in the matter of lightning conductors they manage things better on the other side of the Channel than with us. The French Government are in the constant habit of consulting the most eminent scientific men on the subject of protecting public buildings against the destructive influence of lightning. There is scarcely an instance in which a British Government ever did such a thing. It is true the Houses of Parliament had lightning conductors erected upon them at a very great cost and under scientific advice. But all who understand the subject practically agree in saying that it is very doubtful whether the magnificent pile of buildings in which our legislators assemble is really, that is efficiently, protected. At all events, I understand the earths have never been tested since the conductors were erected in 1852. That the Victoria Tower should have been struck in June, 1868, and slightly damaged, tends to show that the conductors at that time were not in an efficient state.

From the examination I have made I am pretty correct in stating that one-half of our cathedrals and three-fourths of our churches have not even nominal protection. For all that science has done, the Queen may any day be killed in her apartments in Windsor Castle, the Prince of Wales in Marlborough House, and the Prince Minister in Downing Street. To see the difference between England and France in this respect, one has but to cross the Channel between Dover and Calais. At Dover there are huge barracks of great length, on the top of high hills, exposed to the full fury of storms sweeping across the Channel, and the few conductors to be found upon them at long intervals are certainly not numerous enough for efficient protection against lightning, and their efficiency has never, so far as I can learn, been tested. The contrast in this respect on crossing the Channel is the most striking. At Calais the Hotel de Ville, in the Grand Place, literally bristles with lightning conductors, and so all the churches and chief buildings in the town. The same all over France, Germany, and Belgium. Without slavishly imitating our scientific neighbors, we might yet bestow some of the care they do upon the protection of our property as well as of our lives against the terrible effects of the electric force.

* Read before Section A of the British Association at Swansea, Aug. 27, 1880.

87

Dec 11

ON PROTECTION FROM LIGHTNING.

Scientific Amer. Dec. 11

The condition that determines the direction of an electric current is difference in potential between the two points, the current always being from the point of higher potential to the point of lower potential.

Upon the surface of the earth and within it electricity is constantly being generated by various means: by the friction of the wind upon it, by running water, by heat at the junction of two dissimilar substances, by magnetic disturbances, and so forth. The electricity so generated is quickly distributed to points of lower potential, and the whole is ultimately metamorphosed into that molecular vibration called heat. Let an ordinary magneto-telephone be properly attached to a wire a hundred feet long, and the two ends of the wire be stuck into the earth almost anywhere, and the ear may detect the presence of electric currents by the well known sputtering sounds. These are called earth currents, and sometimes they are very troublesome in telegraphy.

Professor Trowbridge, of Harvard College, found last summer that the ticking of the observatory clock could be detected at the distance of a mile from the line wire that goes to Boston furnishing the time service, and this when the terminals of the experimental line were no further than fifty feet apart. This shows that the observatory battery charges the earth for a great distance every time the circuit is completed by the seconds pendulum.

Suppose now that the positive terminal of a battery or of a dynamo electric machine should be grounded at any place, and the negative terminal at a distant place, say a half mile or more away, the developed electricity would charge the first place to a potential higher than any other neighboring place, and a charged thunder cloud immediately overhead could not discharge itself there so easily as at any other place at a distance, for, as stated at first, it is *difference of potential* that determines the direction of an electric current, and the difference of potential is less in this supposed case than elsewhere. If the potential could be raised as high as that developed in the cloud, it would be absolutely impossible for any discharge to take place between the cloud and the earth at that place, no matter how near they might be together.

Now, the potential of any ordinary battery is relatively weak, but whatever its source may be, it may be raised in various ways: by providing points, by employing secondary coils, by increasing the resistance in the primary circuit. In whatever way it might be done the effect of induction by the cloud would be lessened by it so that the reaction upon the charged cloud would be either to necessitate the discharge at some other place where there was a greater difference in potential, or else to delay it until the potential had been raised still higher, which would only make it still easier to strike elsewhere. The evidence gathered from places where lightning has struck seems to indicate that the conditions which determine the stroke are comparatively trivial. For instance, a comparatively low limb upon a tree may be struck instead of the topmost part, and it is here argued that the charging of the earth at a given place with positive electricity may be a sufficient guard against lightning stroke, while at the negative end of the circuit it would be more likely to strike than elsewhere. This end of the circuit could be so arranged that lightning could harm nothing.

It is also taken for granted that lightning is always positive, and that all appearances of the so-called up stroke are optical delusions. The source of lightning in a thunder cloud appears to be always the same, the so-called latent heat of the watery vapor, the energy of which must be accounted for, and where the precipitation is rapid there is no time for distribution by convection or by conduction.

Perhaps the cost of such a method would render it altogether impracticable for ordinary buildings, but for powder magazines, oil tanks, etc., the cost might not be considered too great.

Sun. Aug. 13. 1881

DESTROYED BY LIGHTNING.

A BOLT STRIKING A MILL IN ST. LOUIS AND EXPLODING INSIDE.

The Walls Rent and the Mill Instantly in Flames—Men Blown Out of Doors and Windows—Several of Them Seriously Hurt.

St. Louis, Aug. 12.—At 7½ o'clock to-night the Atlantic Flouring Mills, at Main and Plum streets, of which George Bain, Esq., is President and Manager, was struck by lightning, and is now a mass of ruins, scarcely a brick or stone of the splendid structure remaining. An explosion seems to have instantly followed the stroke of lightning, and nearly all of the upper part of the mill burst open, and its walls were cracked and riven from top to bottom.

The bolt had scarcely touched the building when fire burst from its every part, and in half an hour the mill and its entire contents were completely destroyed. A number of men at work on different floors were blown through the doorways and windows, receiving serious and perhaps fatal injuries. It is feared that several perished in the flames, but of this nothing is definitely known as yet. The fire spread immediately to the Future City Oil Works, extending on Plum street from Main street to the river front.

The works are now burning with intense fierceness and fury. A warehouse, containing rosin and turpentine, on the same block, is also in flames, and the Plum street depot of the Iron Mountain Railroad, on the opposite side of the street, is in great danger.

Later.—There are about seventy men employed in the mill, all of whom, it is said, are accounted for. Several were very badly burned, however, and were sent to the hospital or taken to their homes. Their names and injuries will probably not be learned to-night.

Wenzel Ratzeker, a Bohemian barrel maker, jumped from the second-story window, his clothing all ablaze. He was badly burned on the upper portion of his body, and the skin peeled from his hands. Robert Lorimer jumped from the fourth story and escaped with a broken arm.

Mr. Bain says the loss on the mill will be $140,000; insured for $120,000, mainly in Eastern offices. The future city oil works have been damaged to the extent of about $45,000, the principal damage being to the refinery. The whole establishment is insured for $45,000. The loss on the rosin warehouse is not known.

The stables and storage house for bottles of Anheuser Bros.' Brewing Company, corner of Eighth and Pestalozzi streets, about a mile and a half from the Atlantic Mills, were struck by lightning at the same time and damaged to the amount of about $5,000; fully insured.

ATMOSPHERIC ELECTRICITY.

By David Brooks.

One can scarcely conceive the quantity of electricity that passes from the heavens to the earth through the medium of a thunderstorm, especially so when the storm is one usually designated as severe or violent. One flash or discharge will melt or deflagrate an inch or more of the platinum point of a lightning rod. It does this in an inconceivably short space of time. The quantity of electricity is measured by the effects it produces, and heat is one of those effects. It will produce a certain amount of heat in a certain or measured length of time. A certain quantity of electricity will produce the amount of heat in thirty seconds that half that quantity would produce in a minute. The shorter the time the greater must be the quantity to produce a given effect. The platinum point is melted in an immeasurably short space of time; then immeasurably great is the quantity required to produce this effect. I have spoken of one atmospheric discharge, and must take into consideration the fact that in very violent storms these discharges take place as often as once per second, and have been known to occur in such rapid succession as to enable one to read ordinary printed matter in the night time for minutes without intermission. Reference is made to one thunderstorm, but how many thousands of these storms are there in active progress during every moment of time, when we take into consideration the whole face of the globe? In the same latitude thunderstorms are more frequent on some portions of the earth than others. Travelers in Africa and Asia refer to their great violence and frequency. The Dutch give, as the statistics of the island of Java, that three hundred human beings are killed annually by lightning; and what an insignificant patch upon the earth's surface is the island of Java!

This is one way in which lightning comes from the heavens; but it has been proven that every drop of water falling during a thunderstorm is charged with electricity, and also that there is a current of electricity coming from the heavens at all times in this latitude.

When we contemplate this immense quantity of electricity coming in different ways from the heavens to the earth, we are naturally led to inquire how this electricity is generated. Two theories have been suggested: one that it is produced by the evaporation of water from the earth's surface, and another by the friction of the winds upon the earth's surface. Reasoning from analogy or experiment, very little can be produced by evaporation, because, under that condition, the earth's surface, or that portion of it where evaporation takes place to the greatest extent, is not an insulator, or insulated. When the steam boiler is insulated from the earth, and steam escapes, then electricity is generated; otherwise the quantity of electricity generated is not observable—indeed, scarcely appreciable.

Evaporation is produced to the greatest extent upon the surface of the earth most affected by the rays of the sun, consequently the portion nearer the equator and farthest from the poles. Neither the earth nor the air can be considered insulators, particularly the earth. The air is less an insulator on account of its warm temperature and the amount of moisture it contains. I therefore abandon this theory as producing any considerable amount of electricity.

Now, regarding the friction of the air on the earth's surface, reasoning from analogy, very little can be produced upon that surface of the earth that is not in the nature of an insulator. Whether that surface is the ocean or the land, the surface is a conductor in this latitude, or any latitude where the temperature is above the freezing point. But if we go beyond that point of temperature, toward the poles, then the air and the earth's surface partake of the nature of insulators, the more so as we approach the poles. The ices of the ocean have very little saline matter in them, and water in the form of ice is an insulator in the ordinary sense, and water in the form of snow and ice upon the land is formed simply of rain water, which is still more pure, and still more partakes of the nature of an insulator, with all that the term implies. The insulating properties of rain water, or congealed rain water, double for every ten degrees of Fahrenheit that the temperature is reduced. When we come to consider the very low temperature of the ice in the region of the poles, I have every reason to believe that it is specifically a greater insulator at —50° Fahrenheit than the purest glass at a temperature +60° Fahrenheit. The same law governs the air in its nature as an insulator; it must be immensely higher in that extremely low temperature than any known substance in ordinary temperature.

With the friction of those two bodies, under these conditions, reasoning from analogy, an immense amount of electricity must be produced.

Therefore, presuming that it is produced at the poles, it would naturally rise and accumulate in the upper stratum of air which, becomes a conductor by rarefaction. It is believed that the electricity so produced at or near the poles rises to that region, and then travels or moves toward the equator and returns to the earth in the manner described at the commencement of this article, and when the air, rarefied as before mentioned, is surcharged with electricity, it produces the phenomena of aurora borealis and aurora australis; that the two poles of the earth are immense Holtz machines, generating this almost inconceivable amount of electricity, which we are trying to consider, and that the aurora is simply a visible stream of it from the poles to the equator; that this stream of electricity as it comes to the earth, certainly is positive in its nature, and if there is a current through the higher regions of the heavens from the poles toward the equator, there must necessarily be an equal amount of negative electricity flowing toward the poles on the earth's surface. Now, have we any evidence that such a current of negative electricity is flowing in that direction? We think we have.

We have said toward the equator, but we have no evidence of its *flowing or moving* in that direction farther south than *forty-five degrees* of north latitude in summer, and perhaps not so *far*, though it keeps that direction farther south in winter.

The magnetic needle points north and south. It has been supposed to take that position from the fact that the earth itself acts upon it as a magnet. Another theory is, that it is held in position by electric currents passing in a line parallel to the equator.

In either case this force is neutralized by what is known as the astatic needle system; that is, placing in such manner that they swing upon a common center with their poles reversed.

When one needle is magnetized to full saturation, and we commence to magnetize the other until it has sufficient magnetism to move the other needle, the first effect is to give the north pole a direction to westward. We might say that it is held in its position by a force, which we will call ten (10), and that the second needle when magnetized to very nearly that force moves it from its line, say one degree; and as you increase this magnetism to a near approach of equality, it moves still farther until it is equal in magnetic force, and the needles become astatic.

As these forces approach equalization, the tendency is always from north to west;* we say always, but we might qualify it and say during cold weather or during the winter months.

At other seasons of the year there is no regularity to this movement of the pair. We think this is evidence of a negative current passing from the poles toward the equator, and is shown in another way, and that is by taking the constant of the galvanometer when the astatic system points nearly north. In winter it is much easier deflected to the west than to the east. When the aurora borealis prevails, the needles, if nearly astatic, take an east and west direction, and are held very strongly in that position, and have the appearance of a weather vane in a stiff breeze, changing quickly by the least variation in the direction of the breeze, although the current, different from the wind, is flowing in right angles to the direction of the needles. It is a fact that aurora borealis and australis are noted by navigators to be almost always preceded by high winds. In the north they are preceded by winds from the north, and in the south by winds from the south. They are most frequent, also, in cold weather, and when the earth is covered with snow.

In January, 1852, we had deep snow and very cold weather, and probably the most remarkable display of aurora borealis seen for many years in this latitude. The telegraph wires were so charged with electricity as to be almost impossible to work; the wires running east and west were much the most affected. At first this would seem to operate against this theory; but if it is considered that the earth and the rarefied air above are the two conductors of an immense Leyden jar, and the air between these conductors acts the part of the dielectric, these telegraph wires would simply be points approaching the outer conductor, upon which would gather electricity of greater density; and if the currents from north to south simply take the earth or the wires according to the law of least resistance, as ordinary electric currents flow, they would not show themselves upon these wire conductors; but the currents travelling through the heavens and through the earth move like currents through vacuum tubes, at a speed sluggish compared with the speed of currents through metallic or ordinary conductors.

Assuming that atmospheric electricity is generated at the poles, and flows in the lines of longitude toward the equator, these currents must necessarily expand and become of less density. As they leave the polar regions they are expanding in proportion as the lines of longitude diverge, and flow until they come to the belt of the earth on both sides of the equator and embracing each of the temperate zones, and it is in this portion of the earth that these electricities unite again and become neutralized; and one of the visible and demonstrative modes of doing so is through the part played by thunderstorms.

We have to consider the earth and the stratum of rarefied air surrounding the earth as the two conducting plates of an immense Leyden jar, and that portion of the air in contact with the earth and between the two as playing the part of the dielectric. This dielectric, in the neighborhood of the poles, has immense insulating or non-conducting properties, owing to the low temperature and the small amount of moisture it contains. But as it approaches the equator it becomes less an insulator, and is the leaky portion of the dielectric, on account of the greater amount of moisture it contains, as well as its higher temperature.

Now comes the part played by thunderstorms. When the air becomes heated it is lighter from expansion, rises upward, and, becoming cooled by the greater elevation, the moisture condenses into the form of vapor. This body of vapor is of itself a conductor in which the electricity of the upper strata gathers, and when surcharged breaks through the air between the vapor and the earth in disruptive discharges known as lightning. If the vapor extends to a great height the more rapid is this concentration of the electricity, and the cloud simply becomes a point of the outer conductor approaching nearest to the earth, and consequently of the greatest density.

I have compared the two poles of the earth to two immense Holtz machines, generating the electricity of the heavens. Now, the thunder clouds and the earth beneath are the points of discharge where these electricities unite. Very few are aware of the height to which a thunder cloud extends; the lower edge averages about two miles, the upper edge between fifteen and twenty-five. I have measured them often; it is one of the simplest problems in plain trigonometry. There is the lower line of the clouds which is clearly defined, and must be separated from the falling drops between that and the earth.

Now, if a person could be placed at the North Pole, and the earth were cut in two at the equator, and the portion between the observer and the equator removed, and this rarefied circle made visible as a conductor in connection with the thunder clouds, the outer circle, or conductor, would have a serrated appearance, with points converging toward the earth. We have here an exact similitude of an electric machine with the spark passing from the clouds to the earth.

I spent the greater portion of the year 1851 in Mexico, much of the time along the line of the Cordilleras, and have often thought of the part played by mountains that extend into the region of rarefied air. During the rainy season they have storms about these mountains that have every appearance of the ordinary thunderstorm except that there is no lightning—tremendous storm, but no lightning—and the reason I assign for this is that the mountains penetrate the clouds, and the electricities combine by means of the mountains, without disruptive discharge. Almost every day clouds pass over the valley of the City of Mexico, which is itself seven thousand feet above the level of the sea. Atmospheric discharges are much less frequent than in this country, or where the earth is less elevated. Never did I see any atmospheric discharge when the cloud was in contact with the mountain, although the rain from these clouds was heavier for the time being than that of any thunder cloud that I have ever seen. Sometimes the clouds would hang about the mountain and the rain come down in torrents not more than a mile from me, not a drop falling where I happened to be; but the roar of the falling water was almost deafening. I have stood by Niagara Falls, and the roar of the waters there has been far exceeded by the roar of the waters falling from the clouds that skirted the mountains forming the dividing ridge between Pueblo and Mexico.

I spent the summer of 1873 in Switzerland without seeing a flash of lightning or hearing a clap of thunder, and I conclude that lightning is certainly much less frequent among high mountain ranges than in comparatively low and level countries.

A thunderstorm is a curious phenomenon. As before stated, the air, after being heated, is expanded, becomes lighter, and rises. When cooled by its great elevation, the moisture is condensed and becomes vapor. It has its similitude in a puff from a steam boiler. When it escapes it is as transparent as the air, but upon cooling it becomes a cloud of vapor; and so does the breath of a whale. This immense animal, warm-blooded, takes in a large volume of air into his lungs, which partakes of the warmth of the body. He rises to the surface and blows it upward, and in cold latitudes it has the appearance of the escape of steam from an engine, on account of the sudden condensation by cooling. The same phenomenon is observable from the breath of a horse in cold weather.

I have spoken of the evidence of negative electricity passing from the poles to the equator by the behavior of a pair of needles; as they become astatic, the north pole tending westward, it is obvious that the needles in latitudes nearer the south pole, under the same conditions, would have a contrary tendency; that is, currents passing from the south pole toward the equator would influence the north poles of those needles toward the east, or should do so to prove this theory correct. The author has never had any opportunity of similar observations in southern latitudes.

If an observer could be placed high above the earth, in a position to view a thunder-cloud, and the electric currents could be made visible to the eye, he would see these currents flowing in all directions toward the thunder-cloud.

Again, if he had in view that belt of earth, the torrid and the two temperate zones, he would find it pitted with thunderstorms; and these are simply points where the positive electricity generated at the poles is discharged to the earth.

I have referred to thunderstorms; but there is another phenomenon not coming under that head, known as waterspouts or whirlwinds. It is generally supposed that these gyratory currents are produced by the action of two currents of air flowing side by side in opposite directions. I believe a better explanation is given by the motion of a liquid poured into a funnel. The air when heated breaks through another stratum of air above, and becoming lighter from expansion, rushes upward with great force, and, to use a paradoxical expression, the air gravitates upward in the same manner and with the same gyratory motion as the fluid in the funnel.

Elderly people are familiar with a picture of the maelstrom. My first geography had a picture of a ship being ingulfed and carried down in this whirlpool of waters somewhere off the coast of Norway; this picture represented a ship going down stern foremost, and the sailor had climbed on the bowsprit, trying to economize the last moment of his life. At this date many doubt that the maelstrom ever existed, and think ancient navigators imposed upon our credulity. I am inclined to take a more charitable view of the case, and believe the hole has long since filled up—that is my explanation of the maelstrom.

Intimately connected with this subject is the lightning rod, concerning which I have written before. Franklin announced that atmospheric electricity was identical with frictional electricity. I think he made a mistake—a very slight one, however—in using the word "identical," but should have said it *was* frictional electricity generated at the poles of the earth, as I have endeavored to explain. The idea of the lightning rod is to provide a better conductor than the object we wish to protect, and a harmless path for the fluid from the heavens to the earth.

But at this date it is sometimes most absurdly applied. Five years ago I happened to cross the Atlantic on the steamer Vaderland, an iron vessel with iron masts and iron stays. Some electrical genius had supplied these masts with lightning rods made of about No. 4 copper wire. They ran from the top of the mast down by the side of the ship and terminated in the water. Now, the idea of providing a better conductor for the fluid than the masts of the ship and its iron stays by substituting this copper wire seemed to me rather absurd. I was then on my way to the Vienna Exposition, and this most absurd provision against the effects of lightning often revolved in my mind. No doubt the person who put up those rods had often congratulated himself that he has saved the Vaderland many times from destruction; but I afterwards found that this quintessence of absurdity more than had its parallel. I ascended the dome of the great iron building at Vienna, the largest building of modern times, and I found that equipped from the top to the bottom with a rod of about a quarter of an inch square. This rod was well mounted with barbed points, and carefully insulated in glass thimbles to keep the current from flying from the rod to the building. Now, as the attraction of these metals is in proportion to the bulk or mass, the idea that the lightning should take this rod in preference to the building itself was an absurdity rather more extravagant than that exhibited in the case of the rods on the steamer Vaderland.

A lightning rod, to be effective, should be a better conductor of electricity than the objects it proposes to protect. In most cases it is; but in the case of the steamer Vaderland its attraction, in proportion to that of the ship, was less than one to a million, and the chances of its ever becoming the path of an electric discharge are even more remote. In case the lightning struck the masts of the Vaderland or the Exposition building at Vienna, no harm could follow. But rods are erected upon equally absurd principles to protect oil tanks. These immense iron vessels, containing thousands of barrels of oil, are in great danger of destruction.

Concerning these oil tanks, reference was made in an article of mine on lightning rods, published seven years since by the Franklin Institute, from which I quote as follows:

"Oil tanks are usually well connected to the earth—that is electrically—by pipes running to the distilleries, and for the purposes of filling and discharging these tanks, the connecting pipes being buried in the ground. There have been explosions and fires involving great loss connected with the manufacture and storage of petroleum, supposed to have originated by being struck by lightning. Do the lightning rods we see placed so numerously about these tanks have any effect to prevent these catastrophes? In my opinion, not the least.

"These tanks are immense air-tight vessels, with the upper portion in the form of a dome. The lighter portions of these oils rise to the top of the dome. These lighter and more volatile oils are very inflammable, and when mixed with air are as explosive as gunpowder. The iron tank, being electrically well connected to the earth, is a conductor exercising great attraction for the electricity of the clouds, and should a discharge from the cloud take place, the stroke would center upon that portion of the dome most elevated, and directly upon the plate of iron in contact with the explosive compound. The iron becomes instantly melted or intensely heated, causing an explosion of the vessel, followed, most probably, by a frightful conflagration. This tank, which would, upon first sight, seem to be of a material most safe to protect the contents from fire or accident of this nature, is, upon reflection, exceedingly defective, and in imminent peril during times of thunderstorms.

"An iron rod, fastened to the side or bottom of the tank, and made to extend, say twenty or thirty feet above the dome, would be a part of the tank as a conductor. The point of the rod would be the point to receive the discharge. "Lightning might melt an inch or so of the projecting point of the rod, but would not raise the temperature of any portion of the tank proper, or that in contact with the explosive or inflammable contents. Oil tanks could in this manner be safely protected from the effects of lightning."

At the time this article was published the president of one of the largest oil companies sent the article to the superintendent in the oil regions. The superintendent answered the president that he "had read the article, and he did not by any means agree with its author. He had all his tanks surrounded with rods, and although they had at times been under sheet lightning—the most destructive kind—they had served as a perfect protection."

A little later the company called on one of the insurance offices and recovered $60,000 damages from lightning. Whether the superintendent's views have been modified or not I have not taken the trouble to learn; nor have I been able to learn which he now considers the most destructive, sheet lightning or chain lightning, or some other variety.

In the article before referred to I endeavored to show the great difficulty in making a proper connection of the rod with the earth. To be electrically perfect, it should be of immense size or surface. It is simply the joining of two conductors whose specific conductive capacities differ in immense degree.

To illustrate this, I endeavored to show that to join a copper wire with an iron wire of equal conductive capacity, and seven times as large as the copper wire, as it must necessarily be, the end of the copper wire must be enlarged to the full size, or diameter and section, of the iron wire, in order that the joint should have the full conducting capacity of the copper wire. Now, in making a joint with the earth, the end of the lightning rod must be enlarged in as great proportion as the earth's specific conducting capacity is less.

Dr. Matthiessen gives the ratio of the conducting properties of iron to that with sulphuric acid and water, in the proportion of one of water to eleven of acid—the best conducting liquid known—as 1(0,000 to 1. My own researches would make ordinary spring or river water's conducting proportion to this acid solution at best in the proportion of about 1 to 500.

Now, we will suppose that the rod has a section of one-half square inch, and that it terminates in water. The ground-plate, in order to expose a surface to make the joint of equal conducting capacity to a section of the rod, must be two hundred and seventy feet square, allowing that it conducted from both sides; but, in case it was laid horizontally or parallel to the earth's surface, it must, in order to bring the upper surface of the plate into equal conducting lines with the under surface, be placed sixty feet below the surface of the water. Now, as the earth conducts only in proportion as it contains water, this plate must be enlarged still further to make up for the proportion of earth contained in this water. I will draw upon the imagination of the reader to fill the balance, in order to get the ground-plate to the requisite size and depth to which it would have to be buried.

Nine hundred and ninety-nine out of a thousand of the defects in lightning rods are due to this one thing.

For the last twenty years scarcely a week has passed without a number of patents for improvements in lightning rods. The effect of *granting* these patents, without a single exception, is pernicious, because they *enable* the patentee to make the public trust in the rods when they are deficient in the most *essential requisite—complete connection* with the earth.

Considering the amount expended on lightning rods, and the great source of danger they are instead of protection, it would be a mercy to the community if the Government would take the matter in hand, and appoint a commission to go through the country and take down those that cannot be made effective.

I have been a very attentive observer of the effects of lightning upon buildings in this city for the last thirty years, and have never yet known the occupants injured where gas or water pipes were used. The buildings were often set on fire by the lightning flying from the rods to the gas pipes or from metallic roofs to the gas pipes. A person standing upon a metallic roof would be in great danger from this cause; *but* if the person be in the first or second story, or in any portion of the building that is below the gas or water pipes, he would be perfectly safe, unless there happened to be a defective lightning rod attached to the building, and this person happened to be between the rod and the pipes at a point where they approached nearest each other.

Gas and water pipes are the best lightning rods ever erected, because they are, electrically, in perfect connection with the earth.

They should extend to the very top of the building, or be connected by a rod running to that elevation. A lightning rod terminating on a railway track is also perfectly safe; but a rod that is not connected with gas or water pipes or a railway track is defective, unless the terminal is of such size and depth as would make it enormously expensive.

And those who do not believe in this assertion are respectfully referred to the amount of property destroyed annually, in the shape of buildings that have lightning rods attached of the latest and most improved patents.

When the discharge is partially obscured from the observer by a cloud, and so far that the report is not audible, it is often called sheet lightning. We can, with equal propriety, call the light, partially obscured by ground glass or by fog, "sheet light."

Heat Lightning.—In the night-time the flashes of lightning can be seen in the sky, apparently coming directly from the earth or horizon. The thunder-cloud, often hundreds of miles distant, is hid entirely from the observer by the convex surface of the earth. The distance to which the light flashes into the heavens is proof that the atmosphere extends much higher than is generally supposed.—*Journal of the Telegraph.*

* Since this was written I learn the effect of the aurora borealis to deflect a needle to the northwest has been noticed by others. Page 448 in a work entitled "The Atmosphere," by Camille Flammarion, of Paris, published by Harper Brothers, New York, 1874, the following statement occurs: "At Spitzbergen, a magnetic needle suspended horizontally by an untwisted piece of silk thread, is turned toward the west; as soon as the aurora begins, the person observing this needle remarks that, instead of being sensibly motionless, it is agitated, passing to and fro from right to left and from left to right."

90

LIGHTNING RODS ON WAR SHIPS.

37

THE Lords Commissioners of the Admiralty direct that in future the captains and commanding officers of Her Majesty's ships and vessels are to be held responsible for ascertaining that the continuity of the lightning conductors on board the ships and vessels under their command is complete, and also for maintaining such lightning conductors in a state of efficiency. In ships which have galvanometers on board the conductors are to be tested periodically, and in ships which are not supplied with such instruments the commanding officer is to apply for the conductors to be tested, when an opportunity offers, at a dockyard.

Journal of the Tel, Apl 1 1881

5/37

The Protection of Oil Tanks from Lightning.

CINCINNATI, O., *March* 25, 1881.

To the Editor of the Journal of the Telegraph:

I AM glad to notice in the JOURNAL OF THE TELEGRAPH of March 16 the evidence that the subject of protection from lightning is attracting some attention, and hope a free discussion of the subject may lead to a much needed reform in the methods now generally employed. Mr. A. A. Knudson takes exceptions to some points in my article published in the JOURNAL OF THE TELEGRAPH of March 1, which I will reply to, with your permission.* In the first place, he takes me to task for not stating how the rods are, or should be, connected to the earth when placed upon oil tanks. I regret my inability to answer the question *as to how they are connected*, but will plead as an excuse for this lack of information that I did not see a rod of any kind upon an oil tank in traveling from Oil City, Pa., to Olean, N. Y., by carriage, notwithstanding I saw several hundred tanks. The lightning-rod is in bad repute in that country, and not very extensively employed.

So much has been said and written upon this subject during the past few years that I hardly thought it necessary to say that the rods should be connected directly to the tanks. If there is an electrician in the country that advocates insulating them and ending them a few feet below the surface of the ground I will agree to discuss the point with him, but I think it a waste of time and space to argue that which everyone concedes. It is true that insulators are used, but it is simply because somebody else used them fifty years ago, and not because there is any scientific reason for it. If there is any good reason or authority for it I have allowed it to escape my notice. My article was based upon the assumption that the rods were useless upon oil tanks, even when constructed upon scientific principles and under the most favorable circumstances. The only point open for discussion in my mind is, *how far above the tanks does the gas ascend in sufficient quantities to be ignitable.* If this limit is determined and it is practicable to extend the rods beyond it, then they will act as a protection, otherwise I think they will not. I have not examined this question personally, but formed my opinion from information obtained from others. Persons who have had large experience in the oil business informed me that the gas ascends a hundred feet or more above the tanks, and upon a bright day it can be seen in the form of a glimmer. If it is true that this gas is heavier than the air, then I see no good reason why rods, when properly constructed, should not be effective. I think, however, that a careful examination will prove that it does ascend, and to considerable heights. If Mr. Knudson desires to know my views as to how the rods should be placed upon tanks to properly protect them, assuming that the gas cannot be ignited at a greater distance from the tanks than it is practicable to extend the rods, then I will be glad to accommodate him by stating that I would select a good quality of iron in the form of a solid rod, about two-thirds of an inch in diameter, and connect it securely to the most elevated point of the tank, taking care to make the conductivity of the joint equal or greater than any other section of the rod, the location and size of the tanks determining the number of rods required. I would not extend the rods to the ground, but simply connect them securely to the tanks. It is well known that discharges of high potential do not follow Ohm's law in regard to conductivity, when the conductivity is ascertained by making measurements with low tension currents, such as is produced by a battery of one hundred and fifty cells. The tendency of high tension discharges is to pass direct to large masses of metal in preference to following a good conductor some distance out of a direct line. If the rods were insulated from the top and sides of the tanks and connected to the conducting pipes at the bottom, there would be danger of sparks passing directly to the tanks at the points where the rods most nearly approached them. The only effect a rod constructed upon the Chambers theory would have would be to bring the sparks close to the tanks where the gas is most easily ignited. I see no reason why the gas cannot be allowed to escape through a burner in such a manner that a discharge would simply ignite it in the same way that a lighted match ignites coal gas when turned on. If sufficient oxygen is prevented from entering the tanks and rendering the conditions favorable for an explosion, then the danger would be avoided.

I would be glad if some one having access to oil tanks would institute a series of experiments, having in view the object of determining the maximum distance from a tank at which the gas is capable of being ignited.

In conclusion, permit me to add, for Mr. Flannery's benefit, that there is no stone or other foundation under the large tanks. The ground is leveled off and the iron laid upon it. Economy seems to be the great object in their construction.

I. N. MILLER.

91

THE

POPULAR SCIENCE MONTHLY.

FEBRUARY, 1881.

ATMOSPHERIC ELECTRICITY.

BY PROFESSOR H. S. CARHART.

FROM the earliest periods the flash of lightning and the peal of thunder have excited curiosity, stimulated awe, and inspired fear in man; and according to his mythological, religious, or poetic habit of mind has he regarded the latter as the bolt of Jove, the voice of God, or the conscious utterance of the heavens. The explanation of these appearances in the sky is most curious and fantastic, even after the introduction of the modern inductive method. In a "Compendious System of Natural Philosophy," by J. Rowning, M. A., London, 1744, we find the following: "As vapors exhaled from the surface of water are carried up into the atmosphere, in like manner the *effluvia* of solid bodies are continually ascending thither. Now, we find by experiment that there are several inflammable bodies which, being mixed together in due proportion, will kindle into flame by fermentation alone, without the help of any fiery particles. When, therefore, there happens to be a mixture of the effluvia of such bodies floating in the air, they ferment, kindle, and, flashing like gunpowder, occasion those explosions and streams of fire which we call thunder and lightning."

Ever since Franklin identified lightning with the electricity of the frictional machine, an inquiry has been prosecuted into the origin of

Menlo Park Scrapbook, Cat. 1054

No. 38. "Static Induction, Condensers and Plate Glass Machines"

This scrapbook covers the years 1873-1882 and contains clippings about induction and condensers. There are 136 numbered pages.

Blank pages not filmed: 2-5, 44-136.

1054.

State Induction

Condensers / Plate Glass machine

Induction 38

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77

STATIC INDUCTION PHENOMENA PRODUCED BY THE RUHMKORFF COIL.

By M. E. BICHAT.

RUHMKORFF's coil is, undoubtedly, the best apparatus to transform dynamic into static electricity: reciprocally this same coil should be the most suitable apparatus for the inverse transformation of static into dynamic electricity. Indeed, if a series of static-electric sparks, produced from a Holtz machine, are made to pass into the fine wire of the coil, currents are induced in the thick wire which excite attention from the extreme facility with which they decompose water and salts. Theoretically one should expect to induce two currents equal in quantity. Now there is nothing of this: it is known that, the experiment being made with the largest induction coils constructed by M. Ruhmkorff, on the one side of the voltameter almost pure hydrogen is always disengaged, and on the other side oxygen. If, instead of water, sulphate of copper is decomposed, at only one of the electrodes is the copper deposited, and the direction in which this decomposition is effected always indicates an inverse induced current. It seems then, according to this experiment, that there is but one current in contradiction with the known facts regarding induction; and it is this apparent contradiction which my researches have sought to dispel.

It was natural first to enquire what might be the influence upon the production of the phenomenon of the cluster of iron wires, which, in Ruhmkorff's coils, contribute in so powerful a manner to the transformation of dynamic into static electricity. I therefore procured a small coil whose soft iron core was not fixed. First the machine was worked without the core, then a bar and a bundle of soft iron wires were successsively introduced into it, with the following results:—

When the coil is empty the current is always weak, but perfectly appreciable, and it is inverse when an iron bar is introduced; the deflection of the galvanometer corresponding to the inverse current is much increased if the bar is replaced by the bundle of iron wires.

Besides, it is remarked that the gas disengaged at the voltameter's platinum electrodes is extremely weak and insignificant when the coil is empty, but it becomes quite appreciable on the introduction of the soft iron. In short, the gases disengaged, in the experiment made with the large coil, must be attributed almost totally to the influence of the soft iron.

If care is taken to examine attentively the conditions of the experiment, it will be easy to explain these phenomena so whimsical in appearance. Let us take, first, the experiments on the polarisation of the electrodes, and let us suppose the coil empty. It must be remarked, at the outset, that the current from Holtz's machine is obliged to traverse a very long circuit, of small diameter, of considerable resistance. The positive and negative electricities accumulate little by little on the balls of the excitor until the strength being sufficient the spark bursts forth.

We may more simply express this fact by saying that the spark commences slowly and finishes abruptly. There result two induced currents equal in quantity, but of very unequal potential. The potential of the direct current, which corresponds to the break of the primary current, is enormously opposite to that of the inverse current proceeding from the slow establishment of the spark which constitutes the inducing current. The inverse current decomposes the water in the voltameter slowly, and deposits on the platinum a very large quantity of microscopic gaseous bubbles, that are not disengaged, and consequently create polarising currents.

The direct current which afterwards arrives decomposes the water, but, as it lasts a very short time, the result is that this decomposition is effected very rapidly. The gas bubbles are larger, are disengaged immediately from the platinum, and, producing only a very feeble polarisation, are unable to destroy the polarisation of the inverse current.

The apparent production of a single inverse current is due, then, to the difference of potential of the two induced currents; and, hence, we ought to expect to see the galvanometer's deflection lessen if—by any means whatsoever—we can lessen the potential of the direct current: this may be done with the help of diaphragms. If we introduce into the empty coil a tube of continuous copper the galvanometer's deflection immediately decreases. It remains, on the contrary, the same as it was before if we replace the continuous tube with a slit one.

Let, now, a bar of soft iron be introduced into the coil. The phenomena produced will be the same as when the coil was empty; but at the same time the magnetisation of the soft iron will give rise to other induced currents in addition to the first. To comprehend thoroughly what takes place we must remember that of the two currents, direct and inverse, it is the direct which magnetises the strongest, because it has the highest potential. We may, then, say that the magnetisation produced by the first spark is direct. On the other hand, we know that a certain time is always necessary to demagnetise a piece of soft iron. It follows that the sparks of Holtz's machine, succeeding one another with rapidity, the magnetisation produced by the first will not be completely destroyed on the arrival of the next. This second spark adds its effect to that of the first, and augments the magnetisation of the soft iron.

The considerable augmentation of the effects produced by the inverse current when we replace the bar with a bundle of soft iron wires easily explains itself, if, in the phenomena of static induction, as well as in those of ordinary induction, the interposition of diaphragms lowers the potential. The demonstration of this fact I trust I have clearly shown.

To recapitulate:—If an intermitting battery current be made to pass into the thick wire of a Ruhmkorff coil, two currents of contrary directions are induced in the fine wire, and, for a certain explosible distance, there appears to be only one single current produced. This current is *direct*, and the sparks produced therefrom have in all respects the semblance to sparks from static electricity. Reciprocally, if into the fine wire of the coil a series of sparks from static electricity be made to pass, we induce, in the thick wire, currents in all points analogous to those furnished by the battery; and in studying these currents by means of a voltameter there seems to be only one current which is *inverse*.

8

INDUCED CURRENTS AND DERIVED CIRCUITS.

By SAMUEL E. PHILLIPS, Jun.

IN the "Journal of the Society of Telegraph Engineers" I have recently noticed an article with the above heading, extracted from "Silliman's American Journal," in which the writer, Mr. John Trowbridge, seems under the impression that the

in any two cases. The electromotive force being constant, and the internal resistance of the electromotor (whether battery or coil) being so small that it may be disregarded, then it is easy to see that with any shunt we shall in all cases obtain about the same deflection on the galvanometer, a constant deflection in the case of a battery, or an impulse of constant force when dealing with an induced current. The laws of derived circuits apply with equal exactness in each case: this we can clearly show by Mr. Trowbridge's own figures, although he draws a contrary inference from them. He says—"A reflecting galvanometer of large resistance was included in the secondary circuit, and connected by copper wires of very small resistance with the coil in which the secondary currents are produced: *the resistance of these wires was infinitesimal in comparison with the resistance of the galvanometer.*" This is somewhat vague, for it would lead one to suppose that it was only the leading wires which had an infinitesimal resistance in comparison with the galvanometer, and that he had omitted to mention the resistance of the secondary circuit in which the induced current was produced; and one might naturally picture the secondary circuit of an induction coil as the source of current, in which case there would ordinarily be a considerable resistance involved; but a glance at the figures show that this was not the case, and that the infinitesimally small resistance included both the leading wires and the coil under induction; and a little later this is further indicated, for the writer says—"With an inappreciable resistance outside the galvanometer coils, the shunts made no difference in the deflection of the galvanometer needle when the shunts were not less than 3 ohms; below this the current divided"!—the last five words conveying the idea that previously no division had taken place, which is later on contradicted, in instancing one galvanometer shunted by another galvanometer of the same resistance, the same deflection being obtained on each, when joined as a parallel circuit, as upon one alone. How Mr. Trowbridge could have come to this last result, and not have seen the true bearing of the case, it is hard to understand. With his galvanometer of 5880 units resistance he obtains a deflection of 210 divisions, the resistance external to the galvanometer practically equalling 0. And we may express it thus, E being the electromotive force of the induced current—

$$\frac{E}{5880} = 210 \text{ divisions.}$$

On shunting the galvanometer with an equal resistance we have—

$$\frac{E}{\frac{5880 \times 5880}{5880 + 5880}} = \frac{E}{2940} = 420 \text{ divisions;}$$

or, having halved the total resistance in circuit, we get a current of double quantity, which, having two equal channels to flow through, divides into two halves, 210 going through the galvanometer, as in the first case when no shunt was employed, and 210 by the shunt; whereas Mr. Trowbridge would seem to infer that, had the law of divided circuits been correct, we should have obtained only 105 divisions, which would have been quite true if we had been simply dealing with a given amount of current in the several cases. We therefore see that

Tel Journ July 15-76

On the Penetration of Charges in Insulating Bodies, Fixed and in Motion. By M. RIGHI.

WITH certain precautions (specified) it may be shown that an insulating plate, charged by friction on one of its faces, acquires on the other a charge of the contrary sign when the latter touches a conductor, especially an uninsulated one, or when it is touched by the hot gases of a flame or of burning charcoal, or by moist air, or is near a conductor armed with points. In the case of moist air, the induced charge forms spontaneously by degrees. Its limiting value in every case is such that its action on the conductor (or on the neighbouring points of the gas) destroys the opposite action of the rubbed face. If between a rectangular ebonite plate A, charged negatively, and an uninsulated metallic comb parallel to the two small sides of the rectangle, there is a second plate B of the same size and parallel to A, B acquires a positive charge, certainly less in absolute quantity than that of the inductor; but as it occupies a small surface on B, its superficial density may be greater. If the plate B be then moved so as to glide all over the comb, it may acquire a positive charge greater than the negative of the plate A. If the two plates be enclosed together in an insulated conductor, this will appear positive. The induced charge of density greater than the inductor may also form on one or the other of the two faces of the rubbed plate itself. It is sufficient to rub strongly a rectangular plate, and then to make it glide over the comb, to find it afterwards showing the contrary sign. Thus, if between the rubbers and the combs of a friction machine, a comb communicating with the ground be brought near the glass plate, the glass which comes positive goes away negative and the conductors of the machines are charged negatively. These and other experiments described throw light on many phenomena of induction-machines.

Tel Jour Oct 15 76

Professor Melsens, of Brussels, recently constructed a rhe-electrometer on the principle of that of Marianini. It consists of a compass with a coil of wire under it wound on a hollow ebonite cylinder, whose axis is at right angles to the magnetic meridian. One end of the coil communicates with a line of telegraph wire, the other with the ground. A piece of annealed steel wire without polarity is placed in the helix. Immediately the helix receives a current the bar becomes a magnet, and deflects the compass west or east, permanently. A new wire can be substituted for fresh observations. M. Melsens suggested in the Belgian Academy that a system of observations by this means, at a large number of telegraph stations, might throw much light on the electric phenomena above us in the clouds, in our houses, and under our feet in the ground. The hint was acted upon by the Belgian telegraph authorities, and observations are now transmitted regularly from various offices to the central administration. As to the nature of the electrical effects, M. Melsens states that in one observation, during a thunderstorm at Bruges, between 3.48 p.m. and 7.55 p.m., the wire not being changed, the needle passed ten or twelve times from east to west, indicating discharges violent enough to reverse the poles of the wire.

Tel Jnl Feb 15 78

A SIMPLE ELECTROSCOPE.

M. RAMEAUX lately brought before the Société des Sciences of Nancy a very simple and sensitive electroscope. It consists of a fine fibre of white silk, fixed at one end by means of a little wax to any support, and free to oscillate in any direction under its point of attachment.

A single thread would, of course, suffice for the ordinary purposes of electroscopy properly so called, but it is preferable to employ two near each other, taking care to space them so that they cannot foul each other during their swing, or influence each other reciprocally.

One of the threads is charged to strong repulsions by means of a glass rod charged with positive electricity; the other is charged in a similar manner with a stick of resin charged with negative electricity. Every body which attracts one of the threads so charged, and repels the other, is necessarily electrified. Its electricity is of the same sign as that of the thread which it repels.

The sensibility of these electroscopes is greater, within certain limits, as the threads are made finer, longer, and less conducting.

If the finest sewing silk of commerce be untwisted, each of the parts or strands obtained will make an excellent electroscopic pendulum, which, if about sixty centimetres long, is very handy, and suffices for almost all tests. White silk is preferable to coloured.

The motions of these threads, if well charged, are very considerable, even when the bodies presented to them contain but slight charges of electricity. When the threads are not excessively fine, disturbances of the air do not destroy the observations so much as might be supposed. In the first place, these disturbances can be almost entirely removed; and, furthermore, the threads, even when agitated, obey so well any electric attractions and repulsions that it is absolutely impossible to mistake or detract from their evidence.

M. Rameaux has found this arrangement in all cases more sensitive and sure than a carefully-constructed gold-leaf electroscope, which he used for comparison.

This system also recommends itself in several ways, for instance:

1. It is so simple that every one can construct and use it.
2. It costs nothing; no special support being necessary. The threads can be fixed to any projecting piece, as the edge of a table; the only condition being that they may hang freely.
3. It can be set up in a moment, and consequently is at once ready for any unexpected requirement; whereas a gold-leaf electroscope long unused requires to be dried for hours.
4. It works perfectly, whatever the hygrometric state of the atmosphere.
5. It can be employed to show electric phenomena to a numerous auditory. With long, thin fibres and highly electrified bodies, the experiments are very telling.—*Bulletin de l'Association Scientifique de France.*

9

denser, we interpose a layer of alcohol between the mercury and the platinum point. The roaring ceases when we suppress the alcohol, and leaves only a layer of air, also, when the point is dipped into the mercury. These facts indicate that the current, in the first case, passes across the glass, across the alcohol in the second, and that its *passage is intermittent.* The tube of iron submitted to a rapid succession of magnetisations and demagnetisations occasions the feeble roaring sound heard in the coil. A galvanometer indicates only a continuous current, as would be expected when the intermittence is so rapid. I think the cause of the intermittence to be the condensing action of the glass and the alcohol. When the two faces of the insulating substance have acquired a certain electric potential, a discharge takes place across the insulating layer; the magnetism of the core increases during the charge, and decreases during the discharge. The sound is produced during the diminution of the magnetism. Another experiment:—The platinum point is mounted in a fixed hammer. The mercury and point communicate respectively with the armatures of a condenser of 1 square mètre surface. The rest of the circuit is arranged as before. The point being plunged into the mercury, it is gradually raised until the spark just crosses the alcohol. There the point remains fixed, a succession of sparks is established, and continues for some time. The mercury evidently oscillates beneath the point. The possible cause of this oscillation is that the spark is formed by the vapour of mercury. The elastic force of this vapour depresses the level of the liquid. This purely mechanical cause may not be the sole one. The facts would appear to show that *the interposition of a sufficient resistance in a voltaic circuit determines the intermittence of the current.* The laws of this intermittence must be studied with the condenser, in order that the periods may be sufficiently long for observation. We should not neglect ~~to~~ draw the possible inference that a *current ~~is a~~ succession of changes which are accomplished periodically in the circuit.*

Poggendorff's Annalen der Physik und Chemie. No. 7.
Reaction of Secondary Currents in an Unchanged Circuit on the Primary Current of a Leyden Battery.—By M. Riess.—The secondary current has a weakening action on the primary. The reaction of a series of secondary currents decreasing in strength because of the conveying wire being changed, undergoes two phases. In the first (commencing with perfect conduction of secondary current without sensible weakening of the primary), the action increases, and so the primary currents decrease in strength; in the second, the reaction decreases, hence the primary currents become stronger. If we take two secondary currents in the first phase, the weaker corresponds to a weaker primary; if in the second, to a stronger. The latter effect is not remarkable, and the former may perhaps be explained by the weaker secondary having a longer duration, and so obtaining a firmer hold (so to speak) on the primary. For long, there was no other known way of altering the secondary current produced in a secondary wire at given distance from a given portion of the primary than that of altering the wire which closed the secondary circuit. The experiments were made with different secondary wires. Other methods are now known. Thus, suppose, besides the secondary circuit, a second (auxiliary) wire, whose ends may be either connected or free. When they are connected, the secondary current is stronger than when they are free. Greater changes of the secondary current may thus be obtained if the wire used for closing the secondary circuit is not drawn out, but bent in the form of a narrow N. The best way, however, is to arrange the wire spirally (the auxiliary wire having this form also). M. Riess experimented with the arrangement

Over

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Tel Jour Aug 15. 73

Researches on Electric Condensation.—By M. V. Neyreneuf.—Under several circumstances of its use, a condenser formed of a plate of glass is a true electrophorus, giving from its two faces, positive or negative, electricity or both at the same time. We may explain all the ordinary phenomena of condensation by attributing to the insulating plate an exclusive *rôle* in their production. Only one difficulty presents itself—that of the occurrence of free electricity on one of the plates; but it is to be remarked—(1) That this electricity is inconsiderable in quantity; (2) That we can without sensible modification impart, by means of a Holtz machine, free electricity to the two plates at once. The study of the electrophorus is, therefore, the study of the condenser.

Length of Spark.

The spark given by my electrical machine is generally about 6in. in length. A few days ago, however, I contrived to get two additional inches simply by attaching to the ~~P. C.~~ a terminating ball somewhat larger than the one usually employed. I mention this merely as affording an occasion for suggesting to those amateurs of "ours," who are disappointed with the results given by their electric machines, as estimated by the length of spark, the propriety of so varying the spark-taking portion of their apparatus as to give their machines a fair chance of doing their utmost.

Tel Jour Sept 1. 1873

On Electrical Condensation.—By M. Neyreneuf.—Air surrounding an electrified body suffers, like all other insulating bodies, the effect of penetration for the nearest molecules, and of orientation for those the most distant. The first would act, in the production of a spark, not by direct transmission, but like the isolating plate of a condenser, that is to say, by decomposition, by induction. This generalisation of the mode of action of an insulating medium cannot be proved by means of a condenser with a stratum of air, but we can justify it by remarking that a conducting ball, on an insulating stand, electrified, and then discharged by intimate contact with earth, preserves, during a very short time, an electrisation of the same kind, very sensible to the electroscope. By varying the conditions of the experiment, we see without difficulty that the residue observed is not due to the insulating substance forming the support. The fluid which has penetrated a certain thickness of air cannot be instantaneously neutralised, towards the exterior layers, which are at that time able to manifest a repulsion of the gold leaves. If we consider a Ramsden machine, in communication with an ordinary condenser, one derivation is established by the air and one by the condenser. The relative intensity of the two derivations varies with circumstances the most insignificant in appearance, and the charge of the insulating stratum is only constant (to produce a spark at a constant distance) under exceptional conditions of regularity in delivery from the machine. We can much reduce the influence of the derivation by the air, in using a Holtz machine, if we place it in communication with a strong battery. Under these conditions, the charge of the insulating plate soon produces, by an effect analogous to that of the secondary currents of batteries, the discharge of the machine and its charge in an inverse direction. We can assimilate the phenomenon of condensation to a true polarisation of the electrodes, and further this assimilation by means of the charge by cascade. Two condensers placed in cascade easily cause the interversions of charge which one alone was unable to produce. If we place a universal discharger between a Ramsden machine and some condensers in cascade, we prove that the number of sparks which we can cause to spring between the buttons of the discharger is limited, and that this number is as much smaller as the number of the condensers is greater, as if the tension of the secondary current increased with the number of elements. The derivation by the air then goes on increasing, and a Henley pendulum indicates, under these conditions, greater or less divergences. The charge of an insulating stratum varies with the nature of the electricity of the charge. This law, established by Matteuci in the case of feeble quantities, is easily verified for strong charges. The time of a charge, which permits, as we have seen, the penetration of the fluids into layers deeper and deeper, permits also, by lateral conductibility, the propagation of the fluids on the very edges of the insulating stratum. When these edges are sufficiently charged, their effect is added to that of the stratum itself in such a manner that some very irregular perturbations are produced in measures by the electroscope.

11

Proceedings of Societies.

THE SOCIETY OF TELEGRAPH ENGINEERS.

The Meetings of this Society were resumed at the Hall of the Institute of Civil Engineers, Westminster, on Wednesday evening, the 12th inst.

The chair was taken by Mr. Cromwell Varley.

A paper "*On the Quadrant Electrometer,*"* by Mr. John Munro, was read by the secretary. The paper opened by stating that without proper means of measurement no science can prosper and become applied. As every electric phenomenon is primarily due to differences of electric potentials established among matter, an electrometer, or instrument for measuring differences of potentials, is a primary necessary to the advance of our knowledge of electricity, and our application of it to the arts. Since the last century various rudimentary electrometers have been contrived for experimental purposes, but these have been more or less crude and imperfect. The modern electrometer, besides answering the uses of scientific research, should be fitted for the commoner work, and should be adapted to measure alike the agency of a thunder-storm and the variations in the electromotive force of the most constant galvanic element. Its range and sensibility should therefore be great. The quadrant electrometer fulfils all these requirements to a hitherto unequalled extent, and for station employment far exceeds all others in utility. Difference of electric potential or electromotive force is thus defined by Sir William Thomson:—"The amount of work required to move a unit of electricity, against electric repulsion, from any one position to any other position, is equal to the excess of the electric potential with the second position above the electric potential with the first." Thus the difference of electric potential takes the form of mechanical work. The quadrant electrometer is, like all other highly-perfected contrivances, an instance of that process of evolution which goes on among mechanical as well as natural creations. Though so complete and complex in its present form, it had for its progenitor a large iron tank and a three-legged stool, but since that early day it has gone through several improving modifications. The paper proceeded to describe at length the various details of the instrument, and the method of using and adjusting it. These descriptions were illustrated by diagrams, and without such adjuncts would be quite unintelligible. Perhaps the best method hitherto tried of testing submarine cables by the electrometer has been successfully employed by Sir Wm. Thomson and Mr. Fleeming Jenkin in connection with the Great Western Telegraph Company's cables and the Brazilian Cable. This was fully described by Mr. Jenkin in a paper read to this Society on the 26th March. The use of the quadrant electrometer in research gives results of absolute measure. "The first step," says Sir William Thomson, "towards accurate electrometry in every case is to induce, from the scale-readings, numbers which shall be in simple proportion to the difference of the potentials to be determined. The next and last step is to assign the corresponding values in absolute electrostatic measure." These steps can be accomplished by means of this electrometer. Force is measured in grammes weight. The quadrant electrometer has also been long used as a self-recording measurer of atmospheric electricity. Its applications, however, are extensive in the whole range of electric science. In the meteorology of the future it seems destined to play an important part, and doubtless its aid will be invoked in other branches of human knowledge. Its importance as an instrument of electric research, and as an appliance of the telegraph engineer, is rapidly becoming recognised throughout Europe and America.

Mr. W. H. Preece said that he had listened with a great deal of interest to the paper just read. It was very difficult to follow from an oral description the details and architecture of an instrument such as the quadrant electrometer, and especially so when, unfortunately, the instrument itself was absent, although had they had the instrument before them they might not have been much more enlightened, for it was one which required very careful examination in all its parts. It was destined to become a most valuable auxiliary to the electrician, and he questioned very much whether any electrician's or telegraph engineer's apparatus could be complete until he possessed one of these appliances. Certainly no laboratory could be called a laboratory until one was on its shelves. The principles upon which the quadrant electrometer are constructed were, like the principles of all really beautiful instruments, excessively simple, and indications were given by a simple solution of one of the earliest problems taught in all education, the simple parallelogram of forces. The indicator or needle moving in the electric field was actuated in two directions, and it took up the resultant position; and by that means we had depicted upon a scale a spot of light which could be registered with the greatest ease, and which gave an absolute indication of the forces present. The instrument, as had well been remarked in the paper, was an example of that principle which was now gaining so much ground in philosophy in general—the principle of evolution. It was also an excellent example of Darwin's theory of natural selection and the survival of the fittest. All those who had experimented had, at different times, made use of electrometers and electroscopes of various kinds. The old gold leaf, and, in fact, the old straw, had gradually by this principle of natural selection been created into the quadrant electrometer. He did not think that any museum or any school could be complete until it had a kind of historical series of instruments showing the gradual change by which one form had passed into another. Speaking from experience he could say that young hands were far more easily taught to value all the alterations and details of an instrument by being shown the different stages through which it had passed in its career. Hence this society, when it became rich and possessed a museum, as he hoped it would, could not possibly do better than have a series of electrometers giving examples of this principle of evolution by showing all the stages through which the instrument had passed. There was one part of the instrument which was rather cursorily passed over in the description, but which really was one of its most beautiful points; that was the *replenisher*—the simple and easy means by which we were able every moment to keep the instrument up to its proper standard, and by which we were able at all times to obtain comparative and actual results. This replenisher was one of those many inventions of Mr. C. F. Varley. That gentleman being present, he would no doubt explain the replenisher in his usual clear way. The principle of accumulation upon which it was based was fully explained by him in the year 1860. That principle should be understood by everybody, because this was not the only instrument which was based upon it. Holtz's and other machines were based upon the same principle. The uses to which the quadrant electrometer had been put were mentioned in the paper. It had been for some time in use in Hooper's works. Its great merit was that, in testing with this machine, the experimenters could watch with the eye exactly what was going on. It was not as if they used a galvanometer, and had to dodge the cable to get the proper indications. When this electrometer was applied, the

* The full abstract of the paper by Mr. Munro upon the "Quadrant Electrometer" will appear in our next, illustrated.

12

metallic connection with the inductors, each to each. To render the machine self-charging, the last mentioned combs also carry springs or wire brushes, which make metallic contact with studs upon the face of the disc, and in metallic contact with the tinfoil strips upon it, each to each. As soon as the machine is at work, these springs or brushes can be lifted out of contact by means of silken threads, or other convenient attachments.

standards. E, E, are the combs for charging the inductors; they also are insulated, and they are connected by the covered wires E^1, E^1, with the inductors. E^2, E^2, are the springs or wire brushes for making contact with the studs A^2. The contact is made when a finger key (not shown) is depressed. The key acts through silken cords, which draw the brushes or springs forward; when the key is liberated they move back out of contact.

FIG. 1

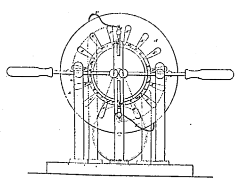


FIG. 2

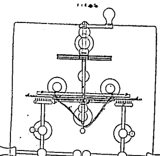


Fig. 1 is a front elevation, and fig. 2 a plan of the electrostatic multiplier. A is the vulcanite disc on an axis B carried by insulating standards. The axis has upon it a pulley which receives a driving cord from a wheel which is rotated by hand; A^1, A^1, are tinfoil strips fixed upon the face of the disc, and A^2, A^2, are studs in metallic connection with the strips A^1; C, C are metallic collecting combs, and D, D, are the inductors; both are carried upon insulating

Mr. Varley proposes to employ his electrostatic multiplier in connection with the electric light, so as to render the latter constant. For this purpose, he places its conductors near the carbon holders, so that a stream of sparks may pass to them constantly so long as the light is being maintained. The high tension electricity, which in this manner is caused to pass between the carbon points, effectually maintains the magneto-electric discharge.

13

Students' Column.

Electrification of Dielectrics.

WHEN a battery is connected with the conductor of an insulated cable, the current which flows into it is observed to decrease from the first moment of contact, until finally, after an hour or so, it arrives at an apparently constant value.

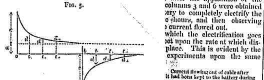
The attention of Mr. Willoughby Smith was first called to this fact during the manufacture of the (1858) Atlantic Cable. Subsequently (1859), quantitative measurements of the apparent increase of resistance due to this so-called electrification, were made at Mr. R. S. Newall's manufactory, at Gateshead, by Mr. Fleeming Jenkin.

The first rush of electricity into a cable core is due to three causes:—

(1). The electrostatic charge;
(2). Electrification or absorption; and,
(3). Leakage through the insulator.

The electrostatic charge lasts only an instant, and its amount depends, other things being equal, upon the ratio between the thickness of the conductor and of the insulator. The electrification, or absorption, at first great, diminishes rapidly, and ceases apparently altogether after some hours. The leakage, however, is constant. In comparing the relative values of these three sources of currents by means of a galvanometer, it is necessary to connect its poles by a shunt in reading the charge, after which the shunt may be removed, and the diminishing deflection due to electrification and leakage observed. After some hours, the electrification being complete, the deflection becomes permanent, and we get the true conductivity of the insulator. If we now remove the battery, and allow the electricity which is within the cable to pass out, through the galvanometer to earth, we get a very high deflection at first on the other side, and this gradually diminishes to zero. The curve obtained by this experiment is shown very roughly in Fig. 5.

FIG. 5.



The ordinates represent the observed currents, the abscissæ the times after contact. At the point, o, the battery being connected to the cable gives the deflection $(a+c)$, due to all three causes—charge, electrification, and leakage—combined. Further on, after an interval, t; the deflection $(d+a)$ is due to electrification and leakage. After t_1, it would be a, due only to leakage. After an interval, b, the battery is removed, and the needle is deflected to the negative side. At the first instant it is $-c$; after an interval, t, from the removal of the battery it is $-d$; and after t', it is $-d'$. Thus we find that (independently of the leakage) the electrification and dis-electrification of a cable go on at the

...te of course varies greatly with ... and with their temperatures

... table, column 1 gives the times ... umns 2 and 5 the rate of influx ... n and leakage; columns 3 and 6 ... rate of efflux of the current, due ... 1; and columns 4 and 7 the dif... rn, or the current due to leakage ... servations were made by Mr. ... on a knot length of French

... at 12° C.		Series II. at 24° C.		
... cable to earth.	a—b Difference due to leakage.	a. Current flowing into cable from battery.	b. Current flowing out of cable to earth.	a—b Difference due to leakage.
.	4.	5.	6.	7.
30	34·5	271	74·0	197
20	34·6	251	54·0	197
40	34·6	239	42·5	197
60	34·3	231	35·0	196
50	34·2	226	30·0	196
60	34·1	222	25·0	197
00	34·1	216	20·0	196
00	34·0	212	16·5	196
10	33·9	210	14·0	196
30	34·3	207	11·5	196
55	34·0	206	10·0	196
00	34·0	205	9·0	196
70	34·0	203	7·5	196
80	33·8	202	5·5	197
10	33·7	200	4·5	196
0	33·3	199	3·0	196
0	33·5	197	2·2	195
0	32·8	196	1·5	195

... lumns 2 and 5 are the direct ... lvanometer scale at the times ..., after the application of the ... columns 3 and 6 were obtained ... ery to completely electrify the ... o hours, and then observing ... current flowed out.

... which the electrification goes ... ot upon the rate at which dis... place. This is evident by the ... experiments upon the same

	Current flowing out of cable after it had been kept to the battery during			
... min.	2 min.	5 min.	10 min.	12 hrs.
13	33	48	63	77
13	19	30	43	56
—	13	21	32	45
7	10	15	25	37
3	7	14	21	31
—	6	12	17	28
—	4	9	13	23
—	3	6	9	18

... during one minute is appa... ischarged after ten minutes, ... d during twelve hours gives ... ge current after an hour. In ... dis-electrification, therefore, it ... have completed the electrifica... tion as far as is practicable.

The following table contains the insulation resistances of a knot of French Atlantic (1869) core at intervals during one hour's electrification at three different temperatures:—

Observations made after.	Apparent Insulation Resistance.		
	At 0° C.	At 12° C.	At 24° C.
1. Minutes.	2. Megohms.	3. Megohms.	4. Megohms.
1	7,540	1,666	369
2	9,650	1,860	399
3	10,900	1,960	419
4	11,900	2,045	433
5	12,300	2,100	443
6	12,700	2,150	451
8	13,370	2,220	463
10	14,400	2,275	472
12	15,200	2,320	477
14	15,200	2,350	482
16	15,800	2,400	486
18	16,200	2,436	489
20	17,300	2,460	492
25	18,100	2,520	495
30	19,500	2,580	499
35	19,500	2,610	501
40	20,000	2,670	502
45	20,600	2,710	—
50	21,200	2,730	506
55	21,200	2,770	—
60	21,800	2,790	509

The rate at which electrification takes place depends upon the temperature of the cable.—When gutta-percha is cold, its apparent resistance increases in a higher degree after the application of the battery than when it is warm. It would appear from this that the softer the gutta-percha the less it is capable of absorbing electricity, and probably it might be warmed up to a point at which it would show no electrification whatever. This is evident by reference to the above table of measurements of a knot of French Atlantic (1869) core; when at 0° C., its resistance, as appears by column 2, was—

After 1 minute = (7,540) = 100
„ 10 minutes = (14,400) = 191
„ 1 hour = (21,800) = 289

The same coil heated to 12° C., and re-measured, gave the following resistance:—

After 1 minute = (1,666) = 100
„ 10 minutes = (2,275) = 137
„ 1 hour = (2,790) = 167

Showing a considerably lower rate of electrification. But this is still more observable at 24° C. (column 4), at which the same coil had a resistance—

After 1 minute = (369) = 100
„ 10 minutes = (472) = 128
„ 1 hour = (509) = 138

It appears from this that the resistance of gutta-percha, when at a temperature of freezing water, increases in resistance between the one minute and one hour 189 per cent, whereas at 12° C., its resistance increases, in the same time, only 67 per cent: and when heated to 24° C., increases only 38 per cent.

FRENCH TELEGRAPHY AT THE VIENNA EXPOSITION.—The telegraphic exhibits include Lenoir's Autographic Telegraph and M. Meyer's Multiple Transmitter, already described in these pages.

14

Elect News Aug 26.75

ON STATICAL ELECTRICITY AND SUPERFICIAL TENSION OF LIQUIDS.

In a memoir recently published, M. Van der Mensbrugghe inquires if statical electricity produces, like heat, variations in the contractile force of liquids. In the first part he gives a *résumé* of researches, preceding his own, which have treated of the relation of static electricity, if not to superficial tension, at least to the cohesion of liquids, which is intimately connected with the contractile force. He finds only two conclusions distinctly enunciated; the first by Erman and by M. Brunner, according to which static electricity exerts no action on the cohesion of a liquid; the second, affirmed by M. Plateau, that capillary forces do not undergo sensible diminution under the influence of electricity. From this it should follow that the tension of a good conducting liquid remains the same whether the liquid be electrified or not; and this is the conclusion to which the author is led by his experiments (described in the second part of the memoir), of which the following are the most important:—

A bubble of glycerine liquid, 6 to 8 centimetres in diameter, is deposited on an iron ring about 2 centimetres radius, supported on three feet, and placed below and at about 20 centimetres distance from the conductor of an electric machine. When the latter is electrified, one observes the effects that have been described by M. Cauderay in the case of soap bubbles; the liquid sheet elongates in the vertical direction, the curvature increases at the upper part, and decreases towards the base; and the more so as the charge becomes stronger. It is evident that then the quantity of electricity developed is greater at the summit than near the base of the film; consequently, if the electric fluid has an effect on the superficial tension, it is at the summit that the variation of this force will be most pronounced. Now, one does not observe in the film, either rapid descent of the liquid or attraction of the lower parts of the bubble towards the top; the colours appear in their usual way, even when a very strong charge is given to the conductor. The effects, then, are just as if the bubbles were forced mechanically to take the form described; and this would not alter their tension.

In order to see if the electric fluid would modify the contractile force of a full liquid mass, the author procured a U-tube of glass, the two branches of which were 12 centimetres in length; the internal diameter of the one was 10 m.m., that of the other only 1 m.m. Having dried the tube carefully, and well moistened the internal walls, he poured in a quantity of distilled water. In the narrow branch the column of water rose to about 27 m.m. above the level of the water in the wide branch. By electrification of the liquid in the latter, he did not produce, apparently, the least displacement of the column, even with very intense electric charges; whence he inferred that the electricity did not cause the tension of the liquid to vary.

If, instead of using a liquid of imperfect conductivity, the experiment be made with mercury, the effect is the same, there is no change through electrification.

Rigorously (M. Van der Mensbrugghe says) these facts might not appear conclusive; for if we electrify the water about the capillary tube, the tension, and consequently the molecular pressure due to the superficial layer of distilled water, might be altered without the capillary column diminishing in height. This was the result of the following experiment by M. Duclaux:—A thin layer of alcohol or oil is poured on the water surrounding a capillary tube, and no change is observed in the height of the column raised. To refute this objection M. Mensbrugghe first endeavours to show that M. Duclaux's experiment may be easily explained by means of Laplace's theory properly interpreted; then that in the case of electrification of water, the conclusion previously stated is the most legitimate one.

He thought it interesting to ascertain if static electricity would influence the equilibrium of a liquid column suspended in a tube, the internal diameter of which was near the maximum limiting value determined by M. Duclaux. This physicist repeated before him one of his experiments with a tube 19·14 m.m. internal diameter; it chanced that the stability of the column was very weak, notwithstanding the difference in value between its diameter and the maximum value realisable, 19·85 m.m. The tube was closed at its upper end by a cork covered with gum-lac; this cork was traversed by a copper rod terminating without in a small ball, and prolonged into the interior of the tube to about 7 m.m. of the open section; the whole of the apparatus serving as support was insulated.

Immediately the liquid column was suspended, the author removed all neighbouring conductors which might have a disturbing action, and then connected the copper rod with the conductor of the electric machine. Notwithstanding the electrification, the weak stability of the column was perfectly preserved; but if any good conductor was brought near the terminal liquid layer, this was sufficient to make the water flow at once.

En résumé, it follows from my experiments that the superficial tension, either of a film, or of a full mass, of good conducting liquid, is not modified by static electricity.

But this conclusion includes implicitly another consequence which seems to me important. It is that static electricity, instead of being expanded in the interior of the extreme layer of good conducting bodies, is found, on the contrary, entirely exterior, and simply applied against the limiting surface of these bodies. Indeed, if, as is commonly believed, the electricity had its seat in the interior of the superficial layer of a good conducting liquid, how are we to suppose that the repulsive forces acting between the same molecules charged with the same electricity would not diminish the tension of the superficial layer? seeing it has been proved that this tension is modified by the slightest causes, such as a very small elevation of temperature. Besides, the mathematical theory of electrostatics leads us to conceive of electric layers distributed in conductors, as being exterior to the surface of these, but immediately applied to them.

15

Elect News 19.75

Les Mondes. Vol. xxxvii., No. 14. August 5, 1875.

On a Transformation of the Electric Spark from Holtz's Machine.—M. Demoyet.—It is well known that the sparks obtained from a Holtz machine are compounded of several continuous streams of luminous filets, of a brilliant white colour. In reality the luminous jets succeed each other, as may be verified by rapidly changing one of the poles, and it is merely the persistence of the retina's image which gives the appearance of several simultaneous jets. Now, let one of the poles of a Holtz machine, or of a coil, be put in connection with a Ruhmkorff insulated metallic circle, in whose interior turns a bent wire terminated by a point or a ball, and joined to the other pole. This wire in turning changes its position parallelly to the metallic circle, the sparks are given out successively, and, if the movement be regular, at equal distances: the effects may be varied by enlarging or contracting the circle, or lengthening and shortening the movable stem. If a resistance be interposed between the two points, by means of an isolating plate pierced with a small hole, the sparks become intermittent, and are accompanied by a reddish nimbus. If a resistance coil of fine wire, two- or three-tenths of a millimetre thick and 50 to 100 metres long, wound on an insulated core, be placed in the circuit (and plunged into petroleum to increase the helix's insulation), intermitting sparks are obtained with a reddish nimbus, in all respects similar to those from the Ruhmkorff coil, and having the same properties. If, instead of winding the wire of the resistance coil upon itself, it be stretched in a straight line, to avoid extra currents, analogous—but less intense—effects to the foregoing are obtained. From this we may conclude that this transformation of the spark is due—(1) to the resistance of the wire; (2) to the induction of the current upon itself. When a soft iron core is used for the coil the results are decreased, on account of magnetisation; and this explains why the results obtained from the fine wire of a Ruhmkorff coil are less than those from a fine wire simply twined around an insulated core. A portion of the electromotive force is employed in producing—(1) a current in the thick wire; (2) magnetisation in the soft iron core.

Elect News Aug 12.75

ON INDUCTION CURRENTS PRODUCED IN TELEGRAPH WIRES.

By M. LAGARDE.
Inspector of Telegraph Lines.

For a very long time induction phenomena have been known to physicists who have, however, only studied them in their laboratories. The difference between their circuits and those of telegraph lines is so great that it is only of late years it has been convincingly ascertained that a current sent on one aërial wire will induce a current in the other when they are near each other for a sufficient extent. Morse, and other machines of that class, were unaffected by these induced charges, hence the belief in their non-existence on telegraph conductors. When, however, Hughes's apparatus came into use, it was noticed in some places that it was not always possible to work at the same time through two neighbouring wires with his apparatus, whilst no obstruction was offered to the use of the Morse on the very same lines. For a long time it was thought this was owing to leakages between the two wires; but it is now recognised that induction is the sole cause. I have undertaken, since 1869, numerous experiments on this subject, and though the results are incomplete, and show scarcely more than the truth of the fact without indicating its law, I put them forth to the world in the hope of completing theoretic conclusions when other facts shall be revealed to me by future experiments. When a derivation exists between two lines, and when a current is sent on one of them, if on the other there is a polarised electro-magnet receiver—such as Hughes—it will work if the derived current is strong enough, and if it is of a suitable direction in the coils of the electro-magnet. The same thing takes place when the two wires starting from the same post are perfectly insulated on the line, but the earth at the post is defective (too resisting): then only one portion of the current flows to earth, the other betakes itself to the second wire absolutely as if they crossed at the two points where the two conductors unite with earth. But when the two wires are parallel and near for a great length, and there is an induction by one upon the other—every time we work by one of them, each emission of current gives rise to two induced currents—one on closing and another on opening circuit. If these currents are strong enough, one of them will necessarily work the polarised electro-magnet. By joining the line wire successively to each of the extremities of the electro-magnet's wire, the apparatus will always act so long as transmission is effected by the neighbouring wire; on the contrary, there is only one extremity of the wire of the coils which can be joined to line so as to work the apparatus from a derivation current (or leak) between the two wires. We have thus, with an apparatus of this kind, a certain means of ascertaining whether, when the transmission sent on one of them affects the other, the influence is due to induction or derivation currents. The experiment, which consists in insulating the two wires at the opposite end, in sending a current upon one of them, and then observing a galvanometer placed in the other's circuit, is insufficient, because it does not give any indication relative to the derivations proceeding from a common bad earth.

In nearly all my experiments I made use of Hughes's instrument, an instrument which a suitable regulation will render very sensitive: the remainder of my experiments were made with other polarised electro-magnet instruments. Very sensitive galvanometers, whose deflection is almost instantaneous, such as Thomson's mirror galvanometer, may be serviceable for these studies in certain cases, but not always.

The first experiments were undertaken in 1869 on the underground line from Paris to Juvisy, at the time when it had just been constructed, and before it was connected with the aërial conductors. The cables of this line are 23 to 24 kilometres long, and the two smallest adjacent and parallel conductors are 8 millimetres from axis to axis. I first took the induced wire, and the inducing wire, in the same cable and contiguous one to the other, and I placed upon each of them at the Paris end one of Hughes's apparatus.

I considered separately the case when the two wires were to earth through large resistances.

In the first case when signalling on No. 1 wire, with a battery of 80 Daniell elements, the signal was recorded by the apparatus attached to the No. 2 wire, whichever end of the exciting coil was in communication with the line: the cause was therefore an induction one. When the battery was of 150 elements, the *induced* current represented the value of a 1 Bunsen element; that is to say, a 1 Bunsen element current sent along No. 2 wire produced the same effect upon the Hughes apparatus as did the induced current. These results ought not to be a matter of surprise, since, by reason of the wires' length and their condensing capacity, there are at the uninsulated extremity of the inducing wire very strong charges which develope currents on the induced wire, one of whose extremities is to earth.

over

over

Electrical News, August 12, 1875.

Duplex Telegraphy.

In the second case, which accords with practice, the other ends of the two wires were in connection with earth through resistance coils of 500 to 800 kilometres; and it was found that induction likewise took place which differed but little from that observed in the previous case. I was unable to ascertain what was the amount of induction at the second end of the wire; but it is nevertheless certain it must be inferior to that at the first end.

On taking two wires in two different cables, induction was still met with, but of much less strength.

In order to ascertain the influence of length upon the intensity of these phenomena I had the two wires, upon which I experimented, cut in halves. By operating as before upon the first half of these conductors, and upon two other conductors contiguous to one another, I found that the induction observed in the second case was greater than that observed in the first, but less than the double of that same induction. This shows that it increases with the length of the wires, but less rapidly than the length. In other respects I have been unable to determine the exact relation of these inductions.

The induction between two wires of one cable is relatively considerable, and this is a strong argument in favour of separating underground and tunnel wires in preference to having them bound up together.

Throughout my studies I have investigated the influence of the soil around a post upon the flow of electricity to earth, and its propagation on the wires terminating there. To get some idea of this influence, I replaced the inducting wire sometimes by a large condenser, and at other times by a different underground line wire going from the central post office to the Lyons Railway, in order to have no induction current between the two wires under experiment. A rheostat was placed between the earth and the point of junction of the battery's negative pole and the "earth knob" of the apparatus on the second wire.

Everything being thus arranged, the following results were obtained:—

(1). On sending a current into the first wire none was observed on the second wire, both of them being insulated at the other end, and without any rheostat resistance.

(2). When 35 resistance units were used, and a current from a battery of 150 Daniell's elements was sent on to the first wire, currents were set up in the second wire capable of working the apparatus, provided, however, its setting was more sensitive than is required for ordinary work. The induced currents would also work the instrument with its customary setting when a rheostat resistance of 180 units was employed.

(3). The extremities of the two wires being to earth, more striking results were obtained, for then the machine on the second wire worked with its ordinary setting from a current induced by a battery of 150 elements, and with only 30 rheostat units.

These results are easily explained by the theory of the propagation of electricity. They supply the means of finding out whether the earth at a post is good or bad. To ascertain this two condensers, or one condenser and a rather long underground wire, are required. The one condenser should be joined to a strong battery by a switch; the second should be joined up to the other pole of the battery through a very sensitive galvanometer or a polarised electro-magnet apparatus: both condensers should lead to different earths, the *latter* communicating with the earth around the post. If, when sending currents upon the first conductor, the apparatus on the second does not act, the earth around the post is good, for it must have too much resistance when the apparatus does act.

In the same year, 1869, I strove to ascertain whether any appreciable induction currents, inconvenient to the service, would be manifested between the aërial wires which were to be joined to the underground cables from Paris to Juvisy. For this object I erected one day in the signal house of the underground line, at Juvisy, when it was fine and the wires were well insulated, a Hughes apparatus on one of them, between Juvisy and Mâcon, which call A, to earth at Juvisy; and for more than half an hour I received in a perfect manner all the messages from Paris for Florence, effected by another wire, which call B, adjacent to that from Juvisy and Mâcon. On making the line current successively enter by each of the extremities of the coils, I assured myself that the currents which worked the apparatus were really due to induction, and were not derived. When Florence sent to Paris upon B, induction currents were found upon A, but they were much less feeble than when Paris sent to Florence. This can also be accounted for by the theory of the propagation of electricity. Between Paris and Mâcon there were upon the route of these two wires underground portions of about 1000 metres length; but previous experiments showed that the induction upon these portions could only have given very feeble currents: the observed induced currents could therefore have been almost due to the aërial parts of the wires alone.

In 1873 I resumed these experiments upon several wires, and notably on two wires (C and D) which were adjacent to one another upon the same posts between Marseilles and Lyons. Stationing myself at Marseilles and placing the instrument on C—disconnected at Lyons —I received (when the instrument was suitably arranged) almost all the messages from Marseilles for Paris sent on D wire. These experiments were made, first when the underground sections from Marseilles and from Paris were in the circuit of wire C, and again when these portions were cut out; the results were almost the same in either case. When Paris sent to Marseilles by wire D, the phenomena of induction were not appreciable in my apparatus.

It was likewise observed on cutting wire C successively at Valence and Avignon, that induction diminished with the length; for when the disconnection occurred at Avignon, scarcely any signals were obtained, as was expected from the results of previous experiments.

Nov. 1.
Elect News 75

Journal de Physique. September 1875.

Some Experiments on Electrostatic Induction. —M. Govi.—These are to show that induced electricity of the first kind has potential. An electrified spherical body is supported under two pith balls, which are hung by linen thread from an insulated ring. At the very first the balls diverge, and the divergence increases when they are made to communicate with the earth. If this divergence (says M. Govi) arose from curvilinear induction by the inducing sphere, as has been supposed, it should cease or diminish, on the induction being suppressed; but this is not the case. On discharging the inductor with an uninsulated metallic point, the two pendula may be made to separate further. The reason is that the inductor, far from separating the balls by curvilinear induction, exercises on them an attraction which tends to bring them together. If we understand by *electric potential* the effort of electrified bodies to approach or withdraw from each other, the separation of the small pendula should still prove the potential of the induced electricity opposed to the inducing, were it even demonstrated that we must attribute it to what Faraday has denominated curvilinear induction. The potential of the induced electricity is still more distinctly manifested when the induced body is terminated by a fine point turned directly towards the inductor. If, in this case, the air being very dry, and the supports of the induced body perfectly insulating, the induction be allowed to act a few seconds, one finds that immediately after discharge of the inductor the induced body retains a perceptible charge of electricity of the same name with that of the inductor. All the other phenomena which have produced in some minds the contradictory idea of an induced electricity without potential are easily explained if we take into account the influence exercised on the inductor by bodies, insulated or not, which are brought near the induced.

L'Electricité Aug 20. 78

Leçons sur l'électricité, professées en 1875-1876 à l'Institution royale de la Grande-Bretagne PAR JOHN TYNDALL, traduites de l'anglais par R. Francisque Michel.

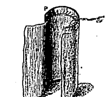
Ce petit volume de 152 pages fait partie de la collection des actualités scientifiques. Il renferme un exposé très-clair, très-savant et très-amusant de toutes les expériences fondamentales.

M. John Tyndall s'est attaché à montrer que l'électricité est une science populaire, non-seulement parce qu'elle est à la portée de toutes les intelligences, mais encore parce qu'elle est à la portée de toutes les bourses. En lisant cet ouvrage que tous les gens un peu intelligents peuvent comprendre sans préparation spéciale, il est impossible de pas être frappé de l'immensité des ressources que l'électricité offre à l'éducation physique d'une nation civilisée.

On se demande pourquoi les grands personnages officiels qui ont présidé à l'organisation de l'Exposition universelle ont opéré comme si l'électricité n'avait point encore été inventée, et s'il n'avait pas existé, il y a quelques années, un certain Franklin, un nommé Priestley, un Italien nommé Volta et des français dont les noms sont Ampère, Arago et Becquerel.

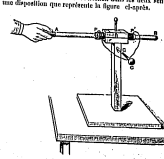
Le propre des abstracteurs de quintescence est d'apporter partout les ténèbres et les complications de leur esprit. Le vrai génie simplifie ce qui est simple et éclaire ce qui est lumineux.

La machine électrique dont se sert M. Tyndall a été imaginée par son préparateur, M. Cottrel, et construite pour ses leçons. Elle se compose d'un simple frotteur, comme on le voit par la figure suivante.



Ce frotteur peut être disposé sur un pied, de manière à produire un effet dans le mouvement en avant et dans le mouvement en arrière.

Cet appareil peut être rendu plus énergique à l'aide d'un tube qui permet d'utiliser la friction dans les deux sens, par une disposition que représente la figure ci-après.



d'un congrès international du génie civil, au nombre de ceux qui constitueront les huit groupes formant le programme d'ensemble officiel des conférences et congrès, pendant la durée de l'Exposition universelle.

Puisque l'Électricité n'a pas eu la faveur d'obtenir une petite place, pour elle toute seule, dans ces programmes officiels, nous croyons savoir que MM. les ingénieurs civils sauront lui accorder une compensation bien autrement précieuse.

Les neuf sections d'études et de délibérations entre lesquelles se répartiront officiellement les matières de ce congrès, comportent en effet bien des applications de l'électricité : son emploi dans les mines comme mode d'éclairage, d'avertisseur, etc., ses services sémaphoriques, les indicateurs du niveau d'eau, les avertisseurs des inondations, la transmission des signaux, les freins électriques, les nombreux usages qu'on fait de l'électricité dans les chemins de fer, l'éclairage des villes, des ports, des ateliers, etc., etc.

Espérons que la science et le progrès auront à enregistrer de nombreux et intéressants documents dans les comptes rendus des séances où tant d'habiles ingénieurs, dégagés de toute entrave officielle, seront certainement à même d'apprécier la puissance de l'électricité et l'importance des services qu'elle est appelée à rendre à leur art et à leurs travaux.

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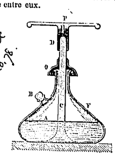
Un nouveau support isolateur

M. Mascart, professeur au Collége de France, vient d'inventer un nouveau support isolant dont l'emploi donne les résultats les plus satisfaisants pour toutes les expériences d'électricité statique.

Il se compose d'un flacon F, à goulot étroit, dans lequel passe la continuation tubulaire du fond C, d'un diamètre moindre de quelques millimètres que celui du goulot, de manière à réserver une certaine distance entre eux.

L'Electricité July 20. 78.



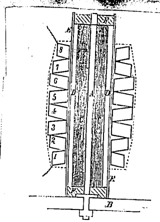
Le haut de ce bâton de verre creux est résistant, afin qu'on puisse cimenter sur lui un tube de cuivre dans lequel on pourra visser quelque appareil, tel que le disque de la figure ci-jointe, une sphère, une traverse dans un anneau, etc. Sur le côté, en haut de la bouteille, est un autre goulot B, fermé avec un bouchon de verre usé à l'émeri, par lequel on peut verser d'abord de l'acide sulfurique que l'on renouvellera de temps en temps. Comme l'espace entre le bâton creux et le goulot de la bouteille est très-petit, l'air dans la bouteille ne change

(20396.)—**Strength of Induction Currents.**—In order to solve the difficulty of A. B. C. and D. I must premise that the strength of any current, whether of electricity or water, is directly proportional to the whole quantity of stuff transmitted, and inversely proportional to the time in which it is transmitted: so that we can write C equal $\frac{Q}{t}$. Now Messon and Breguet have proved that precisely the same quantity of electricity is set going in the secondary coil when the primary circuit is made, as when it is broken. This is also roughly indicated by the experiments of A. with a galvanometer. Further, the time during which the current lasts depends on the rapidity of variation of the primary current. If this were slowly increased, or slowly diminished, the same quantity of electricity would be set in motion in the secondary wire as if it varied quickly; but the strength of its current (which varies inversely with the time) would be very much weaker. Now in a coil the primary current does increase somewhat slowly on making contact, by reason of the opposing extra current it sets up, and which has full liberty to circulate so long as the circuit is closed. But when the circuit is broken, the direct extra current meets with a break in its circuit, and though it manages to leap over a little (producing a bright spark), yet it is considerably checked; moreover, the express function of the condenser is to prevent even its passage as much as possible. It must now be apparent that the induced currents produced by make and break respectively, are of very different strengths. In fact, while one is not competent to break down any but the smallest air-resistance, the other can leap an inch or two. But if a well-conducting circuit is afforded through a galvanometer or voltameter, for instance, both currents will pass; and, as their quantities are equal, they will produce the same effect, whether of deflection or decomposition. Indeed, the current which lasts the longest time will have a better chance over the galvanometer needle; it will, moreover, be less liable to leak away in a long circuit. The fact that the current passes principally in only one direction through vacuum tubes, is indicated by the different appearances of the two ends, which appearances are reversed on the reversal of the current.—Sigma.

NOVEMBER 27, 1875.]

A NEW INDUCTION COIL.

Mr. C. F. Brush, M. E., communicates to the *Engineering and Mining Journal* a description of a novel induction coil designed by him, an engraving of which, in section, we give herewith. The three eighths inch iron rod, A, is secured by a collar and nut in the base, B, and serves as a support for the core, C, which is composed of about 1,200 iron wires (No. 20 gage) made perfectly straight and carefully annealed. This core is covered by four layers of paper saturated with paraffin, then one layer of the primary wire, D, which is of copper one eleventh inch in diameter and 90 feet in length, then six layers of paper, and, finally, the second layer of wire. The latter is not covered but is wound with a narrow strip of paper between the consecutive turns, the object of this being to economize space. A hard rubber tube, E, incloses the primary wire, and is 12 inches long, 2¼ inches in internal diameter, and ¼ inch thick. It is held by the pieces of wood, F, which also support the core. The secondary wire is 30,000 feet in length, is wound in eight sections, 1, 2, 3, 4, etc., and covers 8 inches of the tube, as shown. Sections 1 and 8 contain 35 layers of wire each; sections 7 and 2, 55 layers each, and sections 3, 4, 5, and 6, 67 layers each. This arrangement places most wire around the middle portion of the core, where its inductive force is greatest. The consecutive layers of wire in each section are insulated from each other by ten thicknesses of unsized paper saturated with melted wax; and the consecutive turns of wire in each layer are insulated from each other by being wound with a space of one two-hundredths of an inch between them. The wedge-shaped space between the sections is filled with paraffin, which insulates them, and the exterior of the sections is also covered with the same material, until the shape of the apparatus becomes as shown. The secondary wire begins with section 1, and forms the outside layer first; thence it passes from layer to layer until the innermost one is reached, there it crosses over to section 2, where sections 1 and 2 touch each other, and forms the innermost layer of section 2, thence from layer to layer until the outside one is reached; thence it passes to section 3, forming the outside layer first, and thus it proceeds until it ends in the outside layer of section 8.



The advantages of this arrangement, as regards economy of space, is obvious. No insulating material being required between the sections, where the wire passes from one to the other, none is used. But as the quantity of wire, and consequently the tension of the induced electricity, increases directly as the distance from this point toward the opposite edges of any two contiguous sections, so the thickness of paraffin increases until finally it is thickest of all where insulation is most needed. A space of one eighth of an inch between the innermost layer of the sections and the tube, D, is filled with melted paraffin, which, together with the rubber tube itself, forms the insulation between the primary and secondary wires.

The object in using the secondary wire bare is economy of space. It is a matter of the greatest importance that the whole of the secondary wire be placed as near as possible to the magnetic core, E, as the inductive force of the latter varies inversely as the square of the distance from its axis. The same amount of silk covered wire would occupy at least double the space, and would, consequently, average a much greater distance from the core.

The condenser used with this coil consists of two hundred and forty sheets of tinfoil, five by ten inches, arranged in the usual manner, and separated by single sheets of varnished paper. The break piece is Foucault's automatic, in which the rupture of the current occurs at the surface of mercury covered by a layer of absolute alcohol. It is operated by a separate electro-magnet, which, however, is in connection with the primary wire of the coil. The instrument is provided with a communicator by which the primary current is started, stopped, or reversed at pleasure.

The performance of this coil is quite extraordinary for an instrument of such small size. When operated with two cells of Bunsen's battery, it gives sparks three and a half inches in length; and with one large cell of the Grenet battery, three inch sparks are obtained. The sparks are very dense, and are attended with numerous and brilliant ramifications.

20

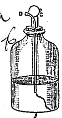
E. M. Sept 75

[23020.]—Solo of Electrophorus (U.Q.).—When the cake of resin is flapped with catskin its upper surface becomes charged with negative electricity, which does not pass to the cover when in contact, owing to the non-conduction of the resin, but acts inductively on the neutral electricity of the cover, decomposing it, attracting the positive to the under, and repelling the negative to the upper surface. The negative electricity of the upper surface of the resin acts by induction on the neutral electricity of the under, attracting the positive and repelling the negative, which passes into the earth. The positive electricity on the under binds the negative on the upper surface. The reaction between the electricities on the under and upper surfaces causes more electricity to be excited by the action of the form or metallic surface on which the resin rests. By insulating the form the charge is diminished. If the upper surface of cover is touched while in contact with cake of resin, the free negative electricity passes off, and the cover becomes charged with positive electricity.—Hugh Clements.

IMPROVED FORM OF LEYDEN JAR.

[11807.]—The following improved form of Leyden jar may, perhaps, interest some of your readers:—In addition to the ordinary form of Leyden jar there is attached a hollow brass cup, C, cemented into a glass tube. This tube passes through the wooden disc which forms the cover of the jar. A communication is formed between C and the internal coating by a brass wire, terminating in the knob D. This wire does not extend quite to the bottom of the jar, but the lower part of tube is coated with tinfoil, which is in contact with the wire, and extends to the inner coating of the jar. At the bottom of the jar a hook is provided by which a

E. M. Nov 76



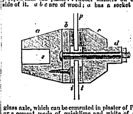
chain may be suspended so as to form a communication between the external coating and other bodies. When a jar of this kind is once charged, the wire may be removed, or allowed to fall out by inverting the jar, in which case the jar will remain charged, since no communication exists between its internal and external coating, and, as the internal coating is protected from the contact of the external air, the absorption of humidity is prevented. It will be seen that by the above arrangement an electric charge may be transferred from place to place, and kept for a considerable time.

Charles Winkelmann.

Auckland, New Zealand.

[28723.]—Winter's Electrical Machine.—The axle is better when made of glass, with wooden cheeks in centre to carry plate. Two short pieces of brass tube may be cemented on to glass axle. Just where it works in the wooden uprights you might make some journals of arbor vitæ to carry tubes.—W. J. Lancaster.

[28723.]—Winter's Electrical Machine.—I think, as far as regards results, it makes little or no difference which of the two ways mentioned you mount the plate. Mine is fitted up on the plan last named, and it works very well. I send a sectional sketch of the mode of mounting I adopted, in which *p* represents the plate, *i i* rubber washers on each side of it. *a b c* are of wood; *a* has a socket for



glass axle, which can be cemented in plaster of Paris or a cement made of quicklime and white of egg. This done, and the glass rod fitted with a wood gudgeon at the other end, the piece, *b*, is screwed on without the bolt and turned up true on the face. If *a* and *b* are made in one piece it is extremely difficult to fix the glass axle at right-angles to the face at *b*. The bolt is afterwards put in, the whole put together, screwed up, and placed in a pair of temporary bearings, in which it can be rotated, and the plate set to run true. It can afterwards be ground smooth on the edge on a grindstone. The gudgeon, *d*, runs in a wooden bearing, which incloses the end of the bolt and nut, so that there be no tendency to form convection currents in the air from the sharp angles on them. The sketch is to a scale of one-fourth for a 24in. plate.—J. B., Belfast.

[28723.]—Winter's Electrical Machine.—To insure more perfect insulation "Mir" had better have the axle entirely of glass, while the support nearest the handle should be of strong wood, screwed firmly into base of machine; the other support should be of glass, carrying on the top a piece of wood, in the side of which a hole must be bored to receive the

end of axle; the plate must be fixed nearest to the glass support, while a good space is left between the plate and the wooden support.—Courtenay B. Gray.

[28087.]—Winter's Electrical Machine.—1. One end of the wire should be connected. 2. Yes; well polished. 3. Same diameter as plate works well. You can make it larger if you like, but I prefer plate and ring to have equal diameters.—W. J. Lancaster.

77

New Dielectric Constant.—M. Neyreneuf.—On continuing the comparison of different isolating substances employed as the dielectric plates of a condenser, the author has established that for glasses of the same nature the ratio $\frac{e}{n}$ of the thickness to the number of sparks corresponding to a given quantity of electricity was constant. He has almost determined the value of this ratio for the varieties of glass met with in commerce. For substances much more isolating—such as ebonite, caoutchouc, and paraffine—the above ratio, which may be called the condensing constant, goes on increasing in a marked manner with the thickness. Consequently only results obtained with plates differing respectively little in thickness are comparable.

77

NEW HOLTZ ELECTRICAL MACHINE.

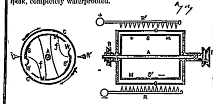
By Professor Elihu Thomson.

The many advantages possessed by induction electric machines, over those producing electricity by friction, have caused the latter to be almost entirely discarded as a source of static electricity. Of these induction machines, the "Holtz" is, perhaps, the best known, and many modifications of this machine have been designed to render it self-charging, and constant in action. When, however, the plate form is adopted, the limit to the size of the revolving plates, with the ordinary materials and space that can be allotted, is soon reached. With glass plates the speed of running is limited by the fragile nature of the glass itself.

The form of Holtz machine presently to be described, it is believed, obviates these and other disadvantages, and affords at once a cheap, compact, and portable piece of electrical apparatus, capable of being run at a very high speed, and greatly increasing the electrical power of the machine.

The materials used in the construction are chiefly paraffined wood, and paper or cardboard, also paraffined. When wood or paper is thoroughly dried or baked, and, while still hot, immersed in melted paraffin at above 100° C. until soaked, it becomes, after cooling, one of the best non-conductors of electricity known. The wood so treated is very strong, and will not subsequently warp or change its form. It is, so to speak, completely waterproofed.

7-7



In the figure, C C is a hollow revolving cylinder of paraffined paper or cardboard, the ends being made of the same material, or of wood similarly prepared. This cylinder is revolved about a *fixed* axis, A, by the pulley P. The axis A is fixed to the frame of the machine at B, and is made of paraffined wood or other insulating material. It serves as a support for the stationary inner cylinder, M M, also of paraffined cardboard. The cylinder M M carries on its inner surface one or more pairs of what are commonly known as sectors or inductors, S S', consisting of strips of partially conducting material, placed opposite the outside rows of collecting points R R', and provided with the usual pointed projections turned toward the inner surface of the revolving cylinder C C. Parts of the inner cylinder M M, adjacent to the sectors S S', are cut away in a direction from S S' opposite to the direction of rotation of the outer cylinder. These open spaces are seen at W W. The open spaces or windows, W W, are not necessary, if the contour of the inner cylinder be that shown by dotted lines, *f f*. The supports for the various parts, as above described, are all thoroughly paraffined to insure complete insulation. The metallic collecting points or combs, R R', constitute the conductors or poles of the machine, + and — respectively, or the reverse, the polarity depending on the original charge given to the machine. The charging is accomplished by holding an electrified body, as a rubbed piece of caoutchouc or vulcanite, opposite one of the spaces or windows W, as shown at E, at the same time that the cylinder C C is in motion, in the direction shown by the arrow.

The machine may be made self-charging by providing a small accessory cylinder, revolving opposite the points E, on an axis parallel to that of C C. The accessory cylinder is made of hard rubber, shellac, sulphur, or the like, and is constantly rubbed by an amalgamated cushion, as in the common frictional machine.

A machine constructed as above, with the cylinder about 7 inches diameter and 12 inches long, and run at a moderate speed, gives enough electricity to charge three 1 gallon Leyden jars to a tension of 1 inch in less than four seconds, and may be employed for every purpose where an abundance of static electricity is required.—*Franklin Journal*.

VOLPICELLI'S NEW THEORY OF ELECTRO-STATIC INDUCTION.

June 77

An insulated conductor charged with either kind of electricity acts on bodies in a natural state placed near it in a manner analogous to that of the action of a magnet on soft iron, that is, it decomposes the neutral fluid, attracting the opposite and repelling the like kind of electricity. The action thus exerted is said to take place by influence or induction. The usual apparatus for demonstrating this hypothesis is a brass cylinder placed on an insulated support and provided at its extremities, or at various points along its length, with pith balls suspended by linen threads. If this arrangement be placed near an insulated conductor charged with either kind of electricity, the natural fluid of the cylinder is supposed to be decomposed, and free electricity is developed at each end, when both pith balls there located will diverge. The electricity of opposite character to that of the conductor goes to the end of the cylinder nearest that conductor, while electricity of the same kind as the conductor seeks the further extremity. There is a point on the cylinder where no divergence of the pith balls occurs, and this is termed the neutral point.

This hypothesis was, some thirty years ago, attacked by Melloni, who asserted that the imaginary electric fluid was not separated into its positive and negative components, but that both of the latter existed all over the cylinder, although, in point of quantity, there was more negative fluid on the end nearest the positive conductor and more positive fluid on the opposite extremity. The difference between Melloni's theory and that first noted will be clear from the annexed engravings. If the inducing source, *c*, Fig. 1, is positively electri-

Fig. 1.

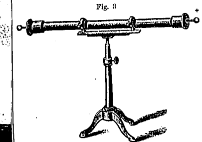
fied, all the negative fluid of the cylinder, A B, according to the old hypothesis, goes to *a m b*, and all the positive fluid to *a n b*, *a b* being the neutral point. Melloni's idea is exemplified in Fig. 2, where both kinds of electricity exist in some degree over the entire cylinder. Melloni had scarcely more than reached a definite conclusion on this subject when

Fig. 2.

he died; but his work was taken up by M. Volpicelli, who for some twenty years has pursued the necessary investigations, and has recently announced conclusions confirming those of their original enunciator.

M. Volpicelli's apparatus consists of a large glass tube, 70 inches long, terminated by metallic armatures, and contain-

Fig. 3



ing a dry pile composed of 24,000 disks closely packed together and covered with a layer of copper on one face and of peroxide of manganese on the other (Fig. 3). This battery works uniformly for several months, and is a constant source of electricity. The body on which the induced electricity is developed is an ordinary glass cylinder, perfectly isolated by threads of raw silk, by which it is suspended in the crotches of a support (Fig. 4). The electricity rendered free by induction is taken on the cylinder by means of a little proof plane, which merits a special description; for the success of the experiments is largely dependent upon the excellence of the instruments used and the care with which all possible causes of error are avoided. The plane is composed of two small disks of copper, 0·85 inch in diameter, separated by a thin layer of insulating varnish. One of these disks is in communication with the soil by means of a metallic rod which is held in the hand. The other disk is fixed to a metallic rod terminating in an ivory ball, which slides freely in an opening situated in the middle of the first disk and in an eyelet carried by an annexed arm. In order to use the device, the two disks are brought into contact, and the movable disk is placed on the cylinder. The free electricity on the surface of the latter condenses on the disk, and may be transported to a distance, as, for example, upon the exterior armature of an electroscope, situated far enough away from the dry pile not to be influenced by it. M. Volpicelli also uses a proof plane consisting simply of a pin head. A portion of the end of the pin is cut off, and the rest inserted in a knob of sealing wax at the end of a metal handle. A Böhnenberger electroscope, containing improvements devised by M. Volpicelli, is also used. The two plates, towards which the gold leaves, D, are attracted when the exterior armature, A, is electrified, are supported by two glass columns containing dry piles analagous to those of the large inducing cylinder (Fig. 5). This electroscope has

Fig. 4.

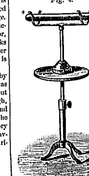
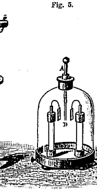


Fig. 5.



great sensibility. It might be termed a kind of electrical microscope.

In order to make the experiments, the insulated cylinder is properly placed in view by the electric source. It becomes electrified by induction. The free electricity on the cylinder is collected by the proof plane; and with the charge plane the electroscope is touched. The following phenomena then appear:

1. The free electricity found on the portion of the cylinder nearest the electric source is of the same character as that of the latter. This is diametrically opposite, of course, to the assertion of the old theory. The experiment may be repeated five or six times successively.

2. If the cylinder be placed in communication with the soil, so that the free electricity is allowed to escape, and the experiment with the proof plane be again tried, no sign of electricity is manifest.

3. If the cylinder be moved away from the electric source, so that the influence of the latter is diminished, and the proof plane be applied, the electroscope to which the latter is touched indicates an electricity of opposite character to that of the inducing body.

M. Volpicelli sums up the result of his investigations as follows: "Upon an insulated conductor submitted to the influence of an electrified body, electricity of opposite name possesses no potential. It is found in greatest quantity at the end of the conductor nearest the electrified body, and diminishes towards the opposite end. Electricity of the same name as that of the electrified body is found at all points on the insulated conductor, the end nearest the electrified source not excepted. It increases as it approaches the other extremity, and is always free." We extract our engravings from *La Nature*.

2122

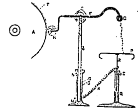
Zigzag Sparks. 77

With a view to finding the cause of the peculiar zigzag form taken commonly by electric sparks, especially those of the Holtz machine, in air, Professor Tait, of Edinburgh, has recently had a number of photographs of such sparks prepared. These sparks were produced partly in ordinary air, partly in the free air one or two feet above the flame of a strong Bunsen burner, partly in a wide glass tube, into which air was passed through a long iron tube, heated to a dark red glow. The general result of the examination is that the zigzag form depends on something which heat is capable of removing from the air. This is, therefore, not water vapor, nor is it very small drops of water, for even falling water drops were inactive, except that they produced simply an interruption in the photographed sparks. It is probably, the author thinks, organic substances which, as Schiller and Pasteur have shown, would be kept away from the apparatus by a cotton stopper as well as by direct combustion.

An improved form of electric machine, similar to that of Holtz, but much more powerful, has been devised by the Russian physicist, M. Teploff. The paper armatures occupy a space of 105 to 120 degrees, and are cut in a complicated way. Besides the two usual combs there are four others, two of which are placed opposite the posterior extremities of the armatures, and the other two towards their anterior extremities, a little above the collecting combs. Conductors covered with guttapercha connect the posterior comb of the first armature with the anterior of the second, and reciprocally. Two or more Leyden jars of average size replace the collecting tubes of Holtz. The power of the machine seems to depend on the extent of surface of the Leyden jars and the form of the armatures. The author varies the letter in each example of the machine till the maximum action is obtained. He has succeeded in producing sparks of all colours by retarding, more or less, the discharge, by introduction between the exterior armatures of the two jars, or between their inner armatures and the collecting combs, of medium conductor such as bands of coloured paper, wet cords, leaves of various plants, &c.: each matter produces a special modification of spark. One may also use jars, the armature of which are formed of paper or even of water. The red and yellow sparks easily inflame tow, carbonised wood, and lycopodium, but the blue sparks do not. aug 77.

LEYDEN JAR DISCHARGE 10 INCHES OR MORE IN LENGTH.

[13160.]—Having seen from time to time in the English Mechanic questions relative to the length of spark it is possible to obtain from a charged Leyden jar, and having devoted a considerable share of attention to the matter, with a fair amount of success, I beg to submit to the notice of the readers of the English Mechanic a method by which I succeeded in producing a vivid steel-blue spark, or flash, 10in. or more in length, and of the apparent thickness of an ordinary slate pencil. The discharge is attended with a sharp explosion very different from, and much louder than, that obtained ordinarily from a Winter's machine, and is as much like a flash



of lightning as can well be imagined. Ordinary electrical sparks of very great length (20in.) have been obtained from frictional machines before; but, as far as I can ascertain, no condensed discharge of the length of 10in. has been before noted. I believe that by taking some precautions which have since occurred to me, and by a slight alteration in the arrangement of the apparatus, the usually considered limit (the distance between the rubber and the collecting points) will not prevent me from getting sparks from a Leyden jar 20 to 30in. in length. My experiments have, however, been stopped rather abruptly for the present by the fog and rainy weather; but as soon as the dry frosty weather makes its appearance, I shall immediately resume them, and, if successful, will most likely communicate the results to our readers—with the Editor's permission. I will now describe the apparatus employed, which, as will be seen by the diagram, is nothing more than a long, narrow Leyden jar, slightly modified to suit this particular purpose. The ordinary prime conductor is altogether removed, and in its place I put a glass tube, B, 33in. long, ⅛in. thick, and 1½ internal diameter, hermetically sealed at one end. This is silvered throughout its whole length internally by the patent silvering process, and this film of silver forms the internal coating. It is supported in the upright position by the wooden stand, C, which is ¼in. thick, and into which it slides easily to the distance of a foot, and on the outside of the upright part of this wooden stand, between the lines N′ N″, is slipped a piece of thin brass tubing, D. This forms the outer coating, and is in metallic communication with the rod of the spark-drawer, P, by means of the wire, x.

E is a hollow ball of alder wood, 3in. diam., saturated with paraffin wax, and made to fit tightly on the glass tube, at its upper and open end. F is a thick brass wire passing through the ball, as shown, and terminating at one end in the 2in. brass ball, G, and at the other end in the usual collecting comb, which is protected by a wooden shield, H, saturated with paraffin, and which terminates at each end in a 3in. wooden ball, also paraffined and set back, as shown by the dotted line, K. The wire, F, is placed in metallic connection with the internal coating by pushing into the tube a tuft of very fine hard-drawn brass wire, M, and allowing the upper end to press against F, as shown at L. The brass spark-drawer, P, is 8in. diam., and highly polished, and slides easily into the wooden stand, Q; while its distance is regulated by the screw, s. I may mention that to prevent, as far as possible, any loss of electricity, the wire is covered throughout its length with caoutchouc tubing, and the external surface of glass tube is varnished with solution of shellac.

A is the cylinder of machine, and T the silk flap. It will be seen by the above description that it is almost impossible for the electricity to be drawn off by the surrounding bodies, as happens in all cases where the ordinary form of prime conductor is used, and the tendency to burst through the glass tube is overcome by the wooden coating, C, which, being an imperfect conductor, acts, as it were, like a spring, or buffer. This apparatus can be employed in all cases in which the usual form of P. C. is used, and by its means vacuum tubes can be as brilliantly illuminated as with a 14 or 15in. spark induction coil, as I have proved by trial. The cylinder of my machine is 15in. long, and 12in. diam. For smaller cylinders, I should recommend a glass tube of same length as above, but of ⅜in. diam.

J. Reynolds, L.R.C.P., &c., &c.
Cold Harbour-lane, East Brixton,
Oct. 24. 77

A Condenser of Variable Capacity.—This condenser, as described at the meeting of the Physical Society, November 14, was stated to have been designed for use in connection with the Holtz electrical machine, to show the effect of condensation on the length of the spark. It consists of a test-tube coated externally with tinfoil to form the inner armature, and a glass tube enclosing the test-tube, and having its outer surface covered with tinfoil for the outer armature. The inner tube can be slid out or in along the length of the external tube, and the capacity thereby varied. Professor Guthrie showed that a spark from the Holtz machine could by its means be gradually reduced. ~~Nov 78~~ Dec 78

Effects of Planté's Rheostatic Machine.—The effects produced by the rheostatic machine which we described a short time ago in the Telegraphic Journal, are, says M. Planté in a note to the French Academy of Sciences, similar to those from electric machines and induction coils, but present certain points of dissimilarity worthy of mention. M. Planté studied them by means of machines composed of 10, 30, 40 and 50 mica plates charged with a secondary battery of 800 couples. With a ten plate machine making 15 turns per second, a series of brilliant sparks from 13 to 14 millimetres long were obtained, succeeding each other at the rate of 30 per second, accompanied with a crackling sound. On turning the machine slowly, so that few sparks passed, they became very sinuous, and when the machines with 30 and 40 plates were employed, these sinuosities raised and lowered themselves above and below the straight line jointing the discharge points. But on quickening the speed of the machine the track of the spark became more constant for each position of the points. When the points were inclined to each other at an obtuse angle, the spark issued in a track of fire straight from the positive point, raised itself above the negative point, and curved towards in a hook which displayed numerous sinuosities. The brushes formed by the discharge, when the distance between the points are increased by 1 or 2 millimetres, take the same course. The length of the sparks appear to increase in simple proportion to the number of condenser plates. Owing to the greater

A Wandering Electric Spark.—G. Planté.—The condensers of mica which enter into the construction of the rheostatic machine are sometimes perforated when too slender under the action of a current of 800 secondary couples, just as is the glass of an overcharged Leyden jar. This accident enabled the author to observe a very curious fact, which consists in a slow and progressive movement of the spark, which the author shows in an illustration.

23

dessus toute la Méditerranée grâce à la visibilité possible de temps en temps d'une côte à l'autre. L'autre vérification se fera par le réseau italien qui, grâce à diverses îles bien placées se rattache directement aux triangles tunisiens. C'est ainsi que la prévision si hardie de Biot et d'Arago sera réalisée et que l'Afrique sera réunie sans interruption au système anglo-français et franco-espagnol.

Expériences sur les fers nickelés ou météoritiques. — Nous sommes admis à l'honneur de lire un mémoire relatif à la reproduction artificielle des alliages météoritiques de fer et de nickel. Notre méthode consistant à réduire à la chaleur rouge par l'hydrogène par le mélange des chlorures des deux métaux. Elle nous a fourni à l'état de pureté le *tænite*, le *kamacite*, etc. Nous avons pu aussi obtenir divers alliages associés en un ensemble qui, traité après polissage par un acide, donne les figures de Widmanstætten. D'autres essais ont eu pour résultat de recouvrir des fragments rocheux de ces mêmes fers nickelés et même d'empater dans ces métaux des grains de péridot ou des morceaux de dunite. Le produit avait alors tous les caractères des météorites remarquables dont le fer de Pallas est le type le plus connu et il résulte de ces faits que ces masses cosmiques représentent sans hésitation possible de vraies brèches de filons concrétionnés. L'analogie qu'on peut établir entre elles à ce point de vue et les filons terrestres ajoute un nouveau terme à la série des arguments qui conduisent à reconnaitre une grandiose unité dans les phénomènes géologiques dont les diverses parties du système solaire sont le théâtre.

Élection. — La séance est terminée par la nomination d'un membre dans la section de médecine et de chirurgie en remplacement de Claude Bernard. La liste de présentation discutée lundi dernier en comité secret portait : En 1re ligne : M. Gubler, en 2e, M. Charcot, en 3e, M. Marey, en 4e M. Paul Bert et en 5e M. Moreau. Les votants étant au nombre de 59, M. Marey est élu par 40 suffrages. M. Paul Bert est désigné par 15 bulletins, M. Charcot par 3 et M. Gubler par 1.

Stanislas Meunier.

Dec 78

ÉTINCELLE ÉLECTRIQUE AMBULANTE

Les condensateurs à lame de mica qui entrent dans la construction de la machine rhéostatique[1] se percent quelquefois, quand les lames de mica sont trop minces, sous l'action du courant de 800 couples secondaires, de même que le verre d'une bouteille de Leyde trop fortement chargée par une machine électrique. Cet accident m'a donné l'occasion d'observer un fait très-curieux, qui consiste dans une marche lente et progressive de l'étincelle électrique, et permet d'assister au développement successif de ses capricieuses sinuosités.

L'un de ces condensateurs étant posé sur un plateau métallique isolé, en relation avec un des pôles de la batterie secondaire, si l'on touche l'armature supérieure avec l'autre pôle, une étincelle éclate sur un des points du condensateur où le mica est trop

[1] *Comptes rendus*, t. LXXXV, p. 794, et t. LXXXVI, p. 761. *La Nature*, 6e année, 1878, 1er semestre, page 15.

2 24

The "Singing Condenser" has recently re-appeared at Paris, where it is generally introduced as an invention of Mr. C. Varley instead of Dr. Wright. In a description of Reiss' receiving telephone, given in 1867 in Ferguson's *Electricity*, the following passage occurs:—"Suppose a person to sing a note at the mouthpiece which produces 300 vibrations a second, the circuit is broken at the bladder 300 times, and the iron wire ticking at this rate gives out a note of the same pitch. The note is weak, and in quality resembles the sound of a toy trumpet. Dr. Wright uses a receiving apparatus of the following kind:—The line current is made to pass through the primary coil of a small induction coil. In the secondary circuit he places two sheets of paper, silvered on one side, back to back, so as to act as a condenser. Each current that comes from the sending apparatus produces a current in the secondary circuit, which changes and discharges the condenser, each discharge being accompanied by a sound like the sharp tap of a small hammer. The musical notes are rendered by these electric discharges, and are loud enough to be heard in a large hall."

This was the last word on telephony in 1867. Nine years later the speaking telephone was invented, and we hear a great deal on the subject to-day; but yet they had done something then which should not be overlooked.

Expériences faites au Laboratoire de la Société libre d'Emulation du Commerce et de l'Industrie de la Seine-Inférieure sur le Condensateur chantant.

1re Expérience :

Influence de la forme du condensateur sur la puissance des sons rendus.

J'ai essayé de renforcer les sons émis en donnant au condensateur une forme tubulaire et en faisant passer un courant d'air dans l'intérieur; ce résultat a trompé mon attente, une étude plus approfondie m'a montré qu'il ne pouvait pas en être autrement; en effet, les deux parties du condensateur, situées aux extrémités d'un même diamètre du cylindre ainsi constitué, sont tellement disposées, que leurs actions se détruisent réciproquement. Or, comme le fait est vrai pour un diamètre quelconque, il en résulte que le faible chant qui se produit n'est que la différence qui existe entre deux actions de sens contraires qui, en pratique, ne pou-

vent être rigoureusement égales. La démonstration théorique complète est très-facile, elle serait néanmoins trop longue pour prendre place ici, la démonstration expérimentale sera plus concluante.

Voici comment on peut la réaliser devant un nombreux auditoire :

Je découpe des rubans de papier d'étain de 0m 10 cent. de large sur un mètre environ de longueur.

Je prépare des lames isolantes de 0m 14 cent. de largeur sur 1m 10 de longueur environ.

J'emploie, comme lames isolantes, du papier à calquer, passé dans de l'essence de térébenthine; j'en ai toujours obtenu de bons résultats et sa préparation ne présente aucune difficulté.

Je superpose les lames isolantes et les lames conductrices et je les fais communiquer à la manière ordinaire (voir le no 13, 5 octobre); j'obtiens ainsi un condensateur étroit et très-long, six feuilles métalliques suffisent.

Si je le fais fonctionner dans ces conditions, j'obtiens un chant d'une certaine force.

Relevant alors les deux extrémités du condensateur, je donne à tout le système la forme d'un U; le chant est reproduit avec une intensité d'autant moindre que les deux branches verticales sont plus rapprochées.

Comme contre-épreuve, je replace le condensateur dans sa forme primitive, le chant retrouve aussitôt son intensité première.

Il vaut mieux, dans cette expérience, remplacer la voix humaine par un diapason électrique, la régularité y gagne beaucoup.

L'explication est simple; il est facile de voir que dans les deux branches verticales du condensateur en U, les lames sont disposées en sens inverse, et que l'induction doit les ramener à l'état neutre; la seule partie active est la base, sensiblement circulaire qui n'est point compensée.

Enfin, si j'enroule le condensateur de façon à en former un tube de 0m 14 cent. de hauteur environ et de 0m 20 cent. de diamètre, je rentre dans le cas considéré en premier et l'explication précédente peut encore s'y appliquer. Nous pouvons, en effet, prendre aux extrémités d'un même diamètre deux surfaces assez petites pour pouvoir les considérer comme plantes; dans ces deux surfaces, la disposition des feuilles sera inverse et l'effet nul ou à peu près.

2me Expérience :

Etant donné un condensateur mis en activité par un diapason électrique et émettant une note constante, ce condensateur donnera en plus du son fondamental invariable toutes les notes de la gamme, si on approche de lui une lame de substance quelconque métallique ou non dont on fera varier convenablement la distance.

Je réalise l'expérience de la manière suivante :

Un condensateur peu serré de trente-deux feuilles 21 / 12, actionné par une bobine de 0 07 centimètres, est animé par un diapason électrique, il rend un certain son que j'appellerai son fondamental.

Le condensateur est mis à plat sur une table; si j'approche de lui une feuille de verre ou une plaque métallique de surface légèrement plus grande que celle du condensateur, je ferai naître immédiatement, en plus du son fondamental, un son plus faible qui, si je rapproche de plus en plus la plaque du condensateur, passera par toutes les notes d'une gamme chromatique de deux octaves environ.

Le son est d'autant plus aigu que la lame inductrice est plus voisine du condensateur.

Toute la gamme s'obtient par un déplacement de 0m 10 à 0m 15 cent.

Ce chant, que j'appellerai secondaire, paraît suivre la loi des vibrations des cordes, car l'octave aiguë d'une note s'obtient en réduisant de moitié la distance qui sépare la plaque du condensateur et la quinte des deux tiers. Avec un peu d'étude, je suis parvenu à exécuter des airs très-simples et populaires qui ont été immédiatement reconnus.

Le phénomène qui donne naissance à ce chant secondaire doit être très-complexe, car si, au lieu d'une plaque, nous en prenons deux et laissant la plus voisine du condensateur immobile, nous éloignons ou rapprochons la plus distante, nous obtiendrons encore une modification du son. Si enfin, plaçant le condensateur verticalement, nous disposons deux plaques parallèlement à chacune de ses faces, nous obtiendrons deux notes dans un rapport quelconque, harmonique ou non, plus le son fondamental.

Il y a là, certainement, un phénomène nouveau au point de vue électrique et même au point de vue acoustique; car,

25

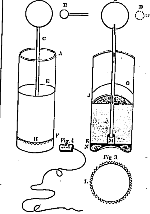
THE ELECTRICAL CONDENSER.

The condenser has of late years assumed so great a degree of importance as an essential auxiliary in practical telegraphy, especially in the working of submarine cables, and of duplex, quadruplex and automatic apparatus upon land lines, that the following communication, which was published as far back as 1841 in the first volume of the *Practical Mechanic and Engineer's Magazine* of Glasgow, Scotland, will be found of considerable historical interest. It illustrates an important step in the transition of the device from the well-known Leyden Jar which was the earliest form of the condenser, having been discovered by Muschenbroek in 1746, to the modern construction of interleaved plates so arranged as to expose a very large inductive surface. The author of the communication, Mr. Thomas Taylor, is at present connected with the Department of Agriculture at Washington, D. C., and has kindly favored us with a copy of the original publication :

To the Editor of the Practical Mechanic and Engineer's Magazine :

Sir.—I send you, for publication, a drawing and description of an improvement on the construction of the Leyden jar; and which, from experience, I find adds very materially to the power of that instrument. The principle upon which the increase of electric power which I find my jar contains, depends upon increasing the internal surface, and facilitating the escape of the fluid from the outside. The following description, with the annexed diagram, will, I hope, make the construction sufficiently apparent :

Fig. 1 is a perspective view of the jar, and fig 2 its section A, fig. 1, is a glass jar, twelve inches high and five wide, coated with tin-foil, inside and outside, in the usual manner, up to E. H is a collar, or hoop of common tinned iron, two inches broad, half an inch of which is bent over, so as to form a horizontal flange, nicked all round like the teeth of a saw, forming points for the escape of the electric fluid from the outside surface of the jar. This collar or hoop is fitted tightly on the jar, at the bottom, as represented at H F. L, fig. 3, is a ground view of this tin hoop, the nicked flange only being visible. C, fig 1, is a wooden pillar, about an inch thick, and twenty-two inches long, supporting a wooden ball, about 4½ inches diameter, hollow, to render it lighter, and both covered with tin-foil. This ball receives the electricity from the prime conductor of the machine E, and conducts it to the interior of the jar, which is filled with a series of metallic plates. In the jar which I have constructed there are 100 of these metallic discs, which may be formed of tinned iron, black sheet-iron, tin-foil, or the thin sheets of lead with which tea-chests are lined, which last is preferable, as being cheap and easily cut. Having cut the discs or plates to the size of the jar, with a hole in the centre, sufficiently large to admit the passage of the wooden pillar, they are laid one upon the top of the other, but kept from touching by a disc of cotton net, cut the same size and shape, and placed between them. The 100 plates in my jar, made in this way, and bound together by strong paper pasted round the outside, are about 2¼ inches in thickness, when in the jar; but I think that by increasing the number of plates, the capacity of the jar will likewise be increased. To prepare the jar, plaster of Paris must be poured in to make the bottom level, as represented by the light lines at the bottom of fig. 2. A small iron tube M, to receive the pillar, is soldered upon an iron plate, K, which plate is tacked on to a piece of wood, N, and being imbedded in the plaster of Paris, fits and is fixed in the bottom of the jar. The metallic discs, represented by the lines above K, are then placed in the jar, and the pillar being fitted in the tube M, the apparatus is



complete. The line J O, Fig. 2, is the top of the tin-foil coating. The electric fluid coming from the prime conductor D, descends the pillar, as shown by the direction of the arrows, and is diffused over the plates. Fig. 4 is a small piece of wood covered with tin-foil, to which a chain is attached. This being placed in contact with the hoop H, when giving any person a shock, all danger of pulling over the jar is avoided.

It will be perceived that by this arrangement there is a vast increase of surface in the jar; and so great is the increase of power, that the jar in my possession, constructed in the manner described, gives a shock equal to a battery formed of nine jars the same size, and coated in the usual manner.

Any further results worth notice which I may discover, I shall be most happy to communicate.

I am, sir, yours,

Thomas Taylor.

14, *Oxford Street, Laurieston, Glasgow*, 1841.

26

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THE DISRUPTIVE DISCHARGE.

After describing, in *La Nature*, the large induction coil constructed for Mr. W. Spottiswoode, President of the Royal Society, by Mr. Apps, M. Alfred Niaudet makes the following remarks:—

"We ask permission to conclude with an observation resulting from our own personal experience, and which we think may be novel. It is a well known fact that longer sparks are obtained between a point and a plate than between two points. It seems to us easy to explain why the former arrangement should be the best. Everybody knows that the sparks by no means pass in a straight line, especially if the distance they traverse is considerable. They follow a sinuous and capricious path, no two sparks taking the same path, or completely resembling each other.

"The path taken by the spark must be that of least resistance, and, in consequence of the motion of the air or small changes of the surface of the electrodes, this line of least resistance is constantly changing. If now we offer to the spark a somewhat extended metallic surface, such as that of a plate, the spark will not always follow the normal which is geometrically the shortest line. It often takes an oblique direction in which, by reason of almost unappreciable variations, the resistance of the air may be reduced. In popular parlance we might say that the plate offers to the spark a greater number of paths than would be offered in the case of two points, and amongst these paths that of least resistance is never the shortest.

"The peculiarity in the resistance of air is also met with in other bad conductors, and notably in glass. If we examine a plate of this material which has been pierced by the spark, we may see that the path is never a straight line, and sometimes branches may be observed which end in the substance of the glass, and which the electricity would seem to have abandoned after having essayed a passage in their direction."

Electrician Feb. 21 1880

FOUR LECTURES ON ELECTROSTATIC INDUCTION.

l JAN. 16, 23, 30, AND FEB. 6. 77

BY J. E. H. GORDON, B.A.

(Assistant Secretary of the British Association).*

LECTURE I., JAN. 16.

"Amongst the actions of different kinds into which electricity has conventionally been subdivided, there is, I think, none which excels, or even equals, in importance that called *Induction*. It is of the most general influence in electrical phenomena, appearing to be concerned in every one of them, and has in reality the character of a first, essential, and fundamental principle. Its comprehension is so important that I think we cannot proceed much further in the investigation of the laws of electricity without a more thorough understanding of its nature. How otherwise can we hope to comprehend the harmony and even unity of action which doubtless governs electrical excitement by friction, by chemical means, by heat, by magnetic influence, by evaporation, and even by the living being?"

So, forty-two years ago, wrote the Master whose memory is honoured wherever the study of natural laws is loved, and whom in this place we should more especially remember, as the Royal Institution was his home and workshop during all the best years of his life. Need I add that the passage I have just read is from the "Experimental Researches of Faraday?"

The subject of our study to-day and in the other lectures of this course will be such of the laws of induction as are now clearly known. I shall first endeavour to show you what the term induction means, and what is the problem about it which for fifty years students of nature have been trying to solve. The problem is partly solved now, but much remains to be done. It will, I think, be pleasant to follow the stages of discovery up to to-day, and perhaps to look a little forward and try to see what the discoveries which may some day be made may lead to.

First, we have the simple phenomena of induction and electrification, some of which I shall shortly show to you.

The unsolved question, "What is electricity?" we shall not attempt to touch upon. It is sufficient for our purpose to know that when a body exhibits certain properties it is said to be electrified, or to be in a state of electrification. We also know how to produce this state at will, but we know next to nothing of its nature. We do not know whether the properties of an electrified body are caused by one or two electric fluids entering it or leaving it, as water into a sponge; or by a motion of its molecules, as when a body is heated; or by a strain or twist of its structure, as when steel is magnetised.

We have no conception of electricity apart from the electrified body; we have no experience of its independent existence. Let us now begin the study of certain phenomena of electrification which it is necessary for us to understand before commencing the study of induction.

If we rub a piece of sealing-wax or glass with a silk handkerchief we find that it has the power of attracting light bodies, as you see. The glass or sealing-wax, after being rubbed, is found to be in the state called "electrification."

When I hold the electrified body near these light paper shavings, the action takes place from the sealing-wax *across the intermediate air*. What is the nature of the action? We do not fully know yet, but it is called *Induction*.

This is only one form of induction, but I shall hope to show you others. Meanwhile, note the following definition to begin with.

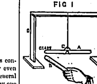
Every electrified body from which no electrification is allowed to escape has a particular action on all neighbouring bodies, and this action is called induction.

Before we go any further in the study of induction we must inquire, Is there any difference between the electrification produced by rubbing sealing-wax and that produced by rubbing glass? We may answer at once that there is, and the difference is a very curious one, namely, that the properties of the two kinds of electrification are exactly opposite to one another. By opposite I mean this: if by any means equal quantities of the two electrifications be added together, they will exactly neutralise each other, or, in other words, adding a quantity of one kind of electricity is the same as taking away an equal quantity of the other. There are a great many ways of producing electrification, but all electrification is of one or the other kind, either that of glass or that of sealing-wax. For convenience, glass electricity is called + sealing-wax electricity —. Here I have an electric machine, which is simply a convenient method of rubbing glass and silk together.

* Delivered at the Royal Institution 1879.

I have shown you one form of induction, namely, the attraction of light bodies by an electrified body. Let us now examine the effect of electrified bodies on each other. Here I have some pieces of sealing-wax and glass, and a means of suspending any one of them. We find that sealing-wax repels sealing-wax, glass repels glass, glass and sealing-wax attract each other, or, generally, like electricities repel, unlike attract. Hence you see that there is always a force acting between electrified bodies, and that, when the electrifications are alike, it is a repulsive force, when different, it is attractive.

FIG 1

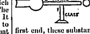


This force acts through the air or *other substance* between the electrified bodies, as you see when I put this plate of paraffin between the suspended rod and the one in the hand. It is, therefore, a form of induction. What is the machinery that conveys this force across the air or paraffin? This is a question to which we shall attempt to give a partial answer later on.

Conductors and Insulators.—In certain substances, such as metals, electrification is able to move freely; that is, if one end of a metal rod receives electrification, the electrification is at once *conducted* to every part of it, as you may here see.

The proof plane being applied to the end furthest from the machine, it is found to be electrified. These substances are called conductors. In other substances electricity is not able to move freely, and if one end is electrified, the other remains in an unelectrified state, as may be seen by substituting a glass rod for the metal one in the preceding experiment. The electricity being *insulated* at the first end, these substances are called Insulators. It is possible to insulate a conductor by placing it on a glass stand, and we can then study the movements of the electricity in it without the latter being able to escape.

FIG 2



We are now in a position to study the effect of the induction of an electrified body upon a conductor near it. Here is our conductor L, and we will place it near the charged knob K of the electric machine. The jumping up of these paper slips shows that the metal is electrified, but no electricity has passed to it, and it is electrified by induction. Thus we learn that by induction an electrified body electrifies bodies in its neighbourhood. This metal rod is electrified, although no electricity has been transferred to it. Let us now examine what difference there is between the electrification produced in this rod by *conduction*, or direct transfer of electricity, and by *induction*. First let us electrify the rod by conduction, and let us, after stopping the machine, test both ends with the proof plane. We see that both ends are *positively* electrified. We have stopped and discharged the machine, but still the electricity remains in the cylinder and will remain there until some *conducting* path is opened for it, as by touching it with the finger. The actions are just as if a portion of an electric fluid had been forced from the machine to the cylinder, had distributed itself all over the latter, as water finds its own level, and had now been drawn off through my body as water through a pipe. Let us now return and examine the parallel induction phenomena. We see by the attraction of the papers that the cylinder is electrified at both ends. Let us now examine what kind of electricity there is at each end. We find, first, that the end nearest to the machine is —, the far end +. We now see why electrified bodies attract light objects; they first induce on the side nearest to them an electrification opposite to their own and then attract it. Let us now stop the machine. All signs of electrification disappear. Thus we see, when electrification is produced by induction, there is nothing analogous to the transfer of fluid from the machine to the cylinder. It is more as if, to use a bold simile, by some straining force the cylinder was distorted into an electrified state, and, just as when we distort a plastic substance, any increase of length is accompanied by a corresponding decrease of thickness, so that the volume remains the same. So, when we electrically distort the cylinder by induction, every increase of electrification at one part of it, that is, any appearance of + electricity, is accompanied by a decrease of electrification at another part, that is, an appear

FIG.3.

FIG 4

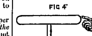


FIG 5

of — electricity. The most rigorous and accurate experiments have shown that these two quantities, viz., the increase and decrease of electrification in a body, when acted on inductively, are exactly equal. I can show you a rough experiment to illustrate this point. I have here two gold leaf electroscopes, which are exceedingly delicate machines, for detecting small quantities of electricity. We now again electrify the cylinder by induction, and by means of the proof plane transfer a little electricity from each end to the electroscopes respectively. We now stop the machine and remove the cylinder. Each electroscope remains charged, one + and one —, and each with a charge whose strength is proportional to the induced charges on the two ends of the cylinders respectively. If these charges are equal, they should neutralise each other when I connect the electroscopes, and you see they do so. The reason why it is so important that we should see clearly that equal quantities of both kinds of electrification are always produced by induction is that this experimental fact shows us that the action of induction is to produce something analogous to a distortion of the electrified body, and that, if this were not the case, but a greater quantity of one kind of electricity than another was induced, it would show that something had been added to or taken from the induced body, and the action would be more analogous to a change of bulk than to a distortion of molecular shape. The problem, then, that we have before us is: "Given the known experimental facts which we have just been considering; given that there is an action, which we call induction, across air and other insulators from an electrified body to other bodies in the neighbourhood; that the induction causes these attractions, and repulsions, and "inducings" of electrifications which we have spoken of, what is the machinery by means of which this induction acts? What is the nature of the lever, the rope, or the pushing pole, which strains, and pulls, and pushes across the air, or glass, or other non-conductor which we place between the induced and inducing bodies?" We must attempt to answer these questions bit by bit, and our first attempt shall be based on the difference between Induction and Conduction.

FIG. 6

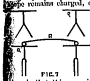
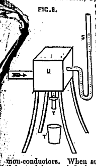


FIG. 7

We have seen that when a piece of glass or other insulator is placed in contact with the conductor of an electric machine it is thrown into a state of strain and distortion, but that the electricity does not escape through it. When, however, a metal or other conductor takes the place of the glass, there is no appearance of such a state of strain at all. What is the explanation of this? It is this. Equally in conductors and insulators a state of strain occurs, but in conductors this state of strain is continually giving way, while in insulators it does not do so. To keep up the state of strain in a conductor would be as difficult as to keep up a pressure of steam in a boiler with a large hole in it.

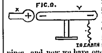
Let me show you a mechanical experiment in illustration—only in illustration, remember, not in explanation, of what I mean. Here is a vessel, U, connected to the water pipes at one end and to a pressure gauge, S, at the other. There is no escape for the water, it cannot flow or move, and the gauge shows a considerable pressure. I now turn the tap, and allow a stream of water to escape. The pressure and strain is relieved and the gauge falls; that is, as soon as the state of constraint gives way and the current flows, it is seen that the strain no longer exists. In the analogous electrical case, bodies in which the state of constraint easily gives way do not show the phenomena of strain or induction, but allow the electricity to flow freely, and these are called conductors; while, on the other hand, bodies which have a great power of resistance to the straining force can be greatly strained without allowing a current of electricity to flow. These are called insulators or non-conductors. When such a body is subjected to a powerful straining or inducing electric force it exhibits the phenomena of strain or induction very strongly. Let me now show you an experiment illustrating what I have just stated.

FIG. 8



You remember that when we placed the insulated cylinder near the machine the induction which took place charged the near end — and the far end +. In this experiment we are only concerned with the near end, and we will lengthen our cylinder so as to get the far end out of our way. How are we to do this? This is a large room, and no doubt we might, at some considerable trouble and expense, so lengthen the cylinder that we could remove its other end to a distance of some 20 or 30 feet. But we can do better than that. We will make the whole world part of our conductor. The earth, owing to the water in it, is a good conductor. We will connect this wire from the cylinder to the water pipes, and now we have one end of our conductor on the table and the other safely out of our way somewhere in Australia. Now you see there is air in the space between the machine and the cylinder, and the state of strain will commence as soon as I begin to work the machine, as you see by the divergence of the gold leaves of the electroscope when I take the proof plane from the cylinder to it; in other words, electricity is induced on our end of the conductor.

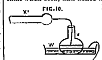
FIG. 9.



This induced electricity will remain here during the action of the machine as long as the air or other insulator is between the plates; that is, as long as the substance between the plates resists the straining force, so long will the state of strain be kept up. If, however, I connect the plates by some substance which offers an exceedingly small resistance to the straining force, as this metal bar, the state of strain at once gives way, and all induction ceases, and no divergence of the electroscope can be obtained. The electricity at the same time flows away, and distributes itself in the earth. This experiment is somewhat analogous to the mechanical one I showed you, where the strain was relieved by opening a tap and allowing the water to flow away.

The particles of glass move more freely over each other when hot than when cold, and hence we should expect that hot glass would yield more easily to a straining force than cold glass would. The following experiment shows that this is the case. Here is a glass flask containing mercury, and set in a dish of mercury. The mercury inside is connected to the electric machine, and that outside to the earth. On working the machine it is found, first, that no electricity can escape through the flask; secondly, that there is a strong induced charge on the mercury outside. Now let the mercury be made hot. It heats the glass, the particles move more freely over each other, the glass yields to the straining force, electricity escapes through it, and at the same time all induction ceases.

FIG. 10.



We have, in this lecture, by various means produced electricity, and we have produced sometimes one kind, and sometimes the other. It is important to examine whether we can actually produce one kind alone. If this were possible, we might actually increase the quantity of electricity in the world. Experiment shows us that we cannot do this. For every bit of + electricity that we produce we produce an exactly equal quantity of —. We cannot make or destroy electricity; we can only strain bodies so that their two ends shall show opposite electrical properties. When we rubbed glass we produced + electricity on its surface. Was not that a creation of electricity? No, for an exactly equal quantity of — electricity was produced on the rubber, as I can show you. (The rubber, on being laid on the electroscope, caused a strong divergence of the leaves.) To show that this — is equal to the +, a very simple experiment will suffice. I rub this sealing-wax till, by the cracking, you can hear that it is highly electrified, but do not remove the rubber from it. You see there is no effect on the electroscope. The reason is that the action of the — on the rubber exactly balances that of the + on the sealing-wax.

In the electric machine itself equal quantities are produced, only the rubbers are connected to the earth, so the — escapes, and only the + is kept. Here is the machine placed on an insulating stand, and a wire from the rubber brings the — as well as the + to the conductor. I work the machine, and you see even the gold leaf electroscope shows no sign of electrification. This shows that equal quantities are always produced. But when we rub sealing-wax and silk, and put down the silk on the table, the — electricity escapes to the earth, and is neutralised and lost, and we have to all appearance + alone in the wax. No; for the instant the balancing — is removed, the +, by induction, produces a fresh — on all surrounding bodies. It does so then, and not till then, as we may see by making one of those neighbouring bodies the electroscope, while the rubber, if it is not discharged, but removed, induces + on bodies near it. No electrification of one kind only can be produced any-

where. If we charge a balloon +, and send it up as high as possible, it will still induce an equal opposite charge on whatever is nearest to it, be it earth, clouds, or clear air. We have no means of knowing how much or in what way the earth itself, with its atmosphere, is charged; but this we know, that, whatever its charge may be, it will induce an exactly equal opposite one on the moon, the sun, and even the most distant stars.

Étude des phénomènes d'induction. — M. Gaiffe dépose sous forme de pli cacheté une note concernant quelques expériences d'induction; il signale avec quelle facilité on peut étudier chaque phénomène d'induction à l'aide du galvanomètre de Thomson. Cet instrument lui a permis de constater qu'après la fermeture du circuit, il se produit deux courants successifs dans le fil induit : le premier, relativement fort et de courte durée, dirigé dans un sens; le second faible et de longue durée, dirigé en sens inverse.

La Science pour tous July 17, 1880

Mining & Scientific Press
May 1881

Ignored Facts in Electricity.

At a meeting of the New York Academy of Sciences, Prof. C. A. Seeley, in a paper entitled "Ignored Facts in Electricity and Magnetism"—fully illustrated by experiments—showed that scientists and the text books misrepresented the phenomena of static induction. It is commonly asserted that if a soft-iron bar be brought near a magnetic pole, the bar becomes a magnet with two active poles, and a point of neutrality between them located at the middle of the bar. It is stated that if an insulated conductor be brought near a prime conductor it becomes electrified, so that the minus electricity occupies the half of the conductor contiguous to the prime conductor, and the plus electricity the remote end, with neutrality between the two halves. But on testing the statements by experiment, it will be found that the induced magnet has only one kind of active magnetism, which is of the same name as that of the inducing pole, and, moreover, that it is pretty evenly distributed over the mass of the bar; it is practically a magnet with a single pole. Similarly, the free electricity of the insulated conductor is plus and pretty evenly distributed. The actual facts are susceptible of simple and equivocal demonstration. A compass-needle, when carried along the bar, or put in any position with reference to it, turns constantly to the bar with the same pole; iron-filings are attracted all over its surface, etc. The condition of the electrical conductor may be shown by pith balls or other simple electroscopes. The facts as here stated concerning electricity might have been inferred from the ordinary theory. One kind of electricity attracts its opposite, but in the act or condition of attraction the electricities are of necessity bound in such a way that they cannot have any external influence; the external influence of the bound electricity implies a releasement which is inconsistent with its existence as induced electricity. The case of the induced magnet is of peculiar interest, because it makes it manifest that there is here a form of magnetism hitherto unrecognized, namely, magnetism—which moves and comports itself like a fluid. This induced magnetism, as to the *rationale* of its production, its distribution, and its disappearance, is so remarkably like induced static electricity as to suggest the probability that they will be found to be phases of the same thing. The facts here brought to light are related to the fundamental notions of electricity and magnetism, and it cannot be doubted that they will be of importance to science and the useful arts.

FOUR LECTURES ON ELECTROSTATIC INDUCTION.

JAN. 16, 23, 30, AND FEB. 6.

BY J. E. H. GORDON, B.A.

(Assistant Secretary of the British Association).*

LECTURE III. (CONCLUDED FROM PAGE 190.)—JAN. 30.

SPECIFIC INDUCTIVE CAPACITY.

We now turn from the mathematical diagram to the actual instrument. Here you see we are hampered by many troublesome conditions; we have not only to say, "Let *a b c d e* be plates in such a position," but to support them in that position without the supports interfering with their action, not only to say, "Let them be insulated," but to make sure that no electricity escapes, and again we have not only to say, "Let the dielectric be removed and replaced," but to provide means for removing it. You see we must not put our fingers in between the plates when the apparatus is in action.

Well, here is the apparatus (Fig. 23), as it grew up in the course of three or four months' labour. Four of the plates, viz., *b c d e*, are supported from brass stages, carried on brass pillars. Each plate hangs by a thin steel rod, which is rigid enough to move the plate a little out of the vertical, if required for adjustment. The upper end of each steel rod passes through a hole in the stage, and is attached to the centre of a little ebonite triangle, *e*, which rests on the stage by three levelling screws at its angles. By means of these screws the plates can be adjusted to be exactly parallel with each other. When the plates are adjusted, they are clamped by screws, which come down upon the triangles from the stage above. The wires connected to the steel rods lead from each triangle to the binding screws *f f*, by which wires from other instruments can be attached to them.

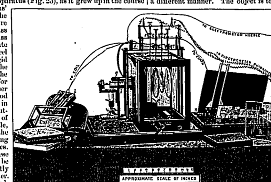


FIG. 23.

The remaining plate, *a*, is supported differently. An ebonite block is fixed at the back of it, and this is fixed to a brass rod, *b*, about an inch thick of the shape ▽ and about six inches long. This slides in two V shaped grooves in two brass pillars *b*, and is pressed down into them by springs. It is moved by a very delicate screw, with a specially contrived spring collar, to avoid "back lash," as it is called, that is to ensure that the motion of the plate reverses at the same instant as the motion of the screw head is reversed. A scale is engraved on the sliding rod, and a vernier on one of the supports. This scale is read to 1-1000th inch by a telescope fixed on the case of the instrument behind *g* (it cannot be seen in the engraving). The scale is illuminated by a candle.

The dielectrics *k k* are made seven inches square, and their thickness varies from ¼ inch to 1 inch.

The slide for inserting and withdrawing the dielectrics is shown, *c d*, in the picture. It moves in guides, and can be pulled in and out by the square handle without opening the case, or disturbing the experiment in any way. The three other handles are for adjusting the position of the dielectric, one moves it parallel to itself by means of a rack, one turns it round a vertical axis by a tangent screw, and the third round a vertical axis by screwing in or withdrawing a wedge under one side.

The callipers *m* shown in the same figure are for measuring the thickness of the dielectrics, and for adjusting the plates parallel to each other. For this latter purpose they are laid on the hinged bracket *n* which can be fixed to a socket at the back of the apparatus.

In work all the upper stage which contains the connections of the plates receiving the induction is enclosed in a metal box connected to earth, the wires leading to the electrometer are enclosed in a metal tube, and the electrometer itself is in a metal case. The reason of this is to protect these parts of the apparatus from accidental induction from the connecting wires, &c. If from any accidental cause the earth connection is interrupted the effect is at once seen in the uncertain and irregular behaviour of the instrument. The metal cover first used for the upper stage is shown. It was made of card and tinfoil. A brass one is, however, now used instead of it.

Before going any further I must express my obligations to Mr. Kieser, of the firm of Elliott Brothers, for the admirable way in which he has constructed the instrument from my drawings. The electrometer is of the ordinary Elliott pattern quadrant described by me in the last lecture in the account of Hopkinson's experiment.

The source of electricity is a large induction coil by Apps, having twenty-two miles of secondary wire (Fig. 24), which, with a suitable battery and break, is capable of giving a seventeen-inch spark in air. In these experiments it is, however, used in a different manner. The object is to obtain a moderate electrification, very rapidly reversed, and to ensure that the positive and negative electrifications should have equal strengths.

When a coil is worked in the ordinary way, although the same quantities of electricity are produced both on making and breaking the primary, yet the arrangement of the currents is such that the current produced in one direction on breaking will produce a much stronger external effect than that produced in the other direction on making. To obtain equal electrifications in the two directions it is necessary to use a very large coil, a very small battery, and a very rapid break. In these experiments the current in the coil primary is only that of ten small Leclanché cells. The rapid break is shown in Fig. 24, and also on a larger scale in Fig. 25. It consists of a little electro-magnetic engine. The scale of inches in Fig. 25 shows the size. One electro-magnet is fixed, and another revolves. A commutator is so arranged that the force between approaching poles is always attractive, and that between poles which are moving apart repulsive. When worked by four quart-sized Grove cells the flywheel of this engine revolves just 100 times per second. You see the whole engine is not more than eight inches long and four high and broad, but when I set it in motion the hum and vibration are felt all over the building. In the rim of the flywheel, which is about two inches diameter, are 60 slits cut, into each of which is let a piece of ebonite. A light spring presses on it, and the primary current on its way from the Leclanché battery to the coil has to pass from the spring to the wheel. It is thus broken 60 times and closed 60 times in each revolution of the wheel. At each break a current is induced in one direction in the secondary, and at each make one is induced in the other direction. Thus there are 120 alternating currents induced every revolution of the engine, or, as the engine turns 100 times per second, 12,000 each second.

The engine does great credit to its maker, Mr. Apps.

To test the equality of the currents in the two directions, the secondary poles were connected to a small vacuum tube. No effect whatever was produced on the light by reversing the primary by means of a commutator between the engine and the Leclanché battery.

One of the secondary poles of the coil is connected to plate c of the induction balance and the other to the plates a and e, and of course the electrifications of every part of the balance and electrometer are reversed with those of the coil poles. The strength of the electrification is such that a spark could be obtained between the coil poles of from 1-25th to 1-50th of an inch; that is, it is about equal to the direct charge of 2,000 silver cells.

In case, however, the sum of the make and break electricities should not be exactly equal, the machine, Fig. 26, was introduced

* Delivered at the Royal Institution 1879.

ON THE MINUTE MEASUREMENTS OF MODERN SCIENCE.

By ALFRED M. MAYER.

ARTICLE XVII.

On the Application of Rotating Mirrors to the Measurements of Minute Lengths, Angles, and Times.

ON WHEATSTONE'S EXPERIMENTS TO MEASURE THE VELOCITY OF ELECTRICITY AND THE DURATION OF THE ELECTRIC DISCHARGE.

IN our first article we stated that this series would end with two remarkable *applications*, in which the various methods and instruments described in this series would be

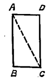


Fig. 51

combined and brought to bear on problems whose solution, at first sight, appears beyond human power. The two problems which we have selected from the extensive array found in the annals of science are: The Measurement of the Velocity of Electricity and the Duration of the Electric Discharge, and the Measurements of the Wave-Lengths of Light. In giving accounts of these problems I will show how men of science have discovered, minutely examined, and measured actions of physical forces which take place in a space less than the 1-10,000th of an inch and endure but a few billionths of a second. Such actions are the flash of the electric discharge and the undulation of a wave of ether in a beam of light.

In 1834 Charles Wheatstone, of London, read a paper before the Royal Society which marks an era in the history of experimental physics. He then first described the application of the rotating mirror to the examination of the nature and duration of phenomena which last but a few thousandths or millionths of a second. This paper of Wheatstone had more effect on the progress of science, from the publication of the method of observing and measuring with the rotating mirror, than by reason of the new facts in the nature of electricity which it gave to the world, though the latter were at that time of the first importance.

The first new application of the revolving mirror was proposed by Arago in 1838. With it he proposed to measure the relative velocities of light in air and in water, and thus to decide whether light in its nature is the rapid translation through space of very minute particles of matter, or whether it is of the nature of undulations or pulses, rapidly transmitted through a rare and highly elastic medium, which must be supposed to exist throughout the universe. If light be of the nature first described it must move more rapidly through water than through air; if of the nature of undulations of an elastic medium, it must move less rapidly in water than in air.

We cannot do better than here let Arago speak for himself on this subject. The following is what he said before the Academy of Sciences of Paris, at the meeting in which he proposed this experiment:

"I propose to show how it is possible to decide, unequivocally, whether light be composed of little particles *emanating* from radiant bodies, as Newton supposes, and as the greater part of modern geometers admit, or whether it is simply the result of the undulations of a very rare and very elastic medium, which physicists have agreed to call *ether*. The system of experiments which I am about to describe will no longer permit, it seems to me, to hesitate between these two rival theories. It will decide, *mathematically* (I use designedly this expression)—it will decide, mathematically, one of the grandest and most debated questions of natural philosophy.

"Besides, my communication is the fulfilling a sort of engagement to the Academy I accepted at one of its last secret sittings.

"I discussed the admirable method, by the aid of which Mr. Wheatstone attempted the solution of the problem of the velocity of electricity over metallic conductors. I had hardly enumerated the important results obtained by that ingenious physicist, when several of our members, whose

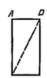


Fig. 52

names are authority in such matters, stated that my report was far too approbative. 'In supposing it well determined, the inferior limit assigned by Mr. Wheatstone to the velocity of electricity will not have,' said one, 'any marked influences on the progress of the sciences; besides, limits of the same order, and even more extensive, can be deduced indirectly from various electric and magnetic phenomena. As to the method of the revolving mirrors, it does not seem to be susceptible of application, but to the simple questions already studied by the inventor.' I tried to refute this last opinion. I believed myself that the new instrument, suitably modified, would lead to results that Mr. Wheatstone was not aware of. I already foresaw that, even in supposing it inclosed in the narrow limits of a small room, it could serve to measure the comparative velocities of light moving through air and through a liquid. I was not slow in learning, and without having hardly the right to be astonished or to complain, that my assertion had been received with incredulity. Nevertheless, I intend to vindicate it to-day in all its parts."

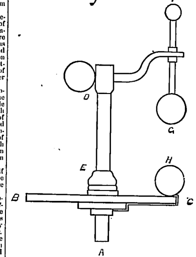
Arago then enters into the most minute details of all the parts of the experiment. The velocity of rotation that can be given to the mirror, the visibility of the image formed by light after having traversed the necessary length of liquid, the possibility of reducing that length of liquid, or the velocity of rotation of the mirror by employing simultaneously several rotating mirrors from which the light would be successively reflected, and also in substituting for water bisulphide of carbon, which acts more powerfully on the velocity of light, are, on his part, the objects of a thorough examination. After the publication of this remarkable communication no one could doubt the success of the experiment which it so carefully and so minutely described.

Failing sight and the infirmities of age prevented Arago from ever putting his proposed experiment to actual test, but, presenting his method to his younger scientific brethren to work out, it was reserved for the talented and lamented Foucault to have the honor of solving the experimental problem with an apparatus similar in principle to that proposed by Arago, but simpler in construction and more precise in its measures. With apparatus Foucault first proved that light moves *slower* in water than in air, and thereby gave to the undulatory theory of light one of its main supports.

The following is the letter, in which Foucault gave the first news of the success of this noble and ever-memorable experiment:

"To the Editor of the *Journal des Débats*—Sir: I will not wait for the expiration of the fortnight to give you an account of what most occupied the Academy of Sciences during their meeting of yesterday. All knew that M. Arago was to continue the account of his beautiful researches in polarization and photometry. The attendance was large, and the Academy recorded at its session a foreign associate and two corresponding members—Sir David Brewster, Lord Brougham, and M. De la Rive, of Geneva. But

Fig. 53



WHEATSTONE'S WHIRLING APPARATUS.

what was not expected was, that M. Arago recalled attention to one of the most beautiful projected experiments that the genius of a savant has ever produced, and he declared that, after having conceived it, he had left to the young generation the care and the honor of performing it. The experiment has more than once occupied the attention of the Academy; it proposes to decide, by means of a revolving mirror, whether light moves faster in air than in water, and to seek, in the probable result of this experiment, the confirmation of the theory at present adopted to explain all optical phenomena. You may judge, Sir, of the emotion with which I heard this generous declaration—I, who for several days had in my hands the experimental solution of this great problem! Nevertheless I thought it proper to postpone to the next meeting the reading of the paper in which I have recorded my results. In the meantime permit me, sir, to announce, in a few words, the results which I have observed.

"Light employs more time to run over the same path in water than in air, and the time which it takes to traverse these two different media is shown by the deviation of a ray which is reflected at a given moment from a mirror revolving with a great velocity. All things remaining equal, the deviations were found to be proportional to the indices of refraction of air and water. It is not possible to entertain the least doubt as to the reality of these results; they have been obtained by two different methods. The two deviations were first observed successively, and were found unequal for the same velocity of the mirror. They were then observed simultaneously, which rendered the observation still more certain.

LÉON FOUCAULT."

In 1862 Foucault added various improvements to his apparatus, and brought its measurements to such precision that he measured the velocity of light with accuracy.

"This is an admirable experiment in physics, in which, by the power of intellect and manual skill, he succeeded in not only rendering sensible, but even measurable, the time employed by light to run over a path of 20 meters, although this time barely equals the 1-15,000,000th of a second. . . .

"We would be unjust if we did not mention that the success of the experiment of Foucault was greatly indebted to Froment, the able constructor of the various parts of the apparatus. The clockwork which gave to the toothed disk a uniform motion of one revolution per second, and the revolving mirror put in motion by the little air-turbine or siren, ought to take rank among the numerous mechanical wonders which have proceeded from his hands. The most ingenious conceptions remain unrealized if they do not find an artist capable of executing them. Thus history has taken care to treasure the memory of eminent mechanicians, to whom are due the delicate constructions which have given important progress to science. The name of the illus-

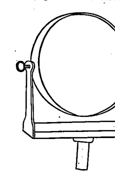


Fig. 54.

trious English clockmaker, Graham, remains forever associated with the discovery of aberration and nutation, made by Bradley with an instrument constructed by that artist; in the same manner the name of Froment will remain inseparable from the beautiful and refined experiment of which we have just spoken, and for which he constructed the important and ingenious improvements added by Foucault to the original apparatus devised by Arago."*

In like manner the name of Joseph Saxton should ever remain associated with Wheatstone's celebrated experiments with the revolving mirror, for to the skill of this eminent American mechanician Wheatstone was indebted for the construction of his apparatus and for valuable assistance given him during his experiments with it. Also, it is not improbable that the fact of Saxton's having previously used the revolving mirror in the examination of phenomena of momentary duration may have suggested to Wheatstone the application of the revolving mirror to the investigation on the velocity of electricity and the duration of the electric discharge. This investigation we will now proceed to describe.

It will render easier the understanding of Wheatstone's experiments by prefacing our description of his work with a fact or two in physiological optics which lie at the foundation of his method of experimenting.

Imagine a minute bright spark, or *dot* of light, which appears but for an instant—say that it lasts only the 1-100,000th of second. The eye, of course, can receive light from this spark only during that minute interval of time, yet the *sensation* produced by the light from the spark lasts much longer; so that after the spark has really ceased to exist the eye perceives the spark as existing. The duration of this *apparent existence* of the spark depends on the intensity of its light, and may last from 1-10th of a second to over a whole second of time. It is therefore evident that the unassisted eye can never determine the actual duration of flashes of light which have minute periods of existence; for in a series of sparks, all of the same intensity of light, and whose durations extend from 1-100,000th of a second to one-half of a second, the eye will see each spark, lasting the half of a second, if this is the duration of the sensation of light of the intensity of the sparks.

The eye, therefore, has to call in instrumental aid. This is afforded by some contrivance which will move either the spark *or its image*, and if the spark has a duration at all comparable to the time during which it has been moved, it will be drawn out into a line which has its length in the direction in which the spark or its image has been moved. Thus, for example, suppose that the spark is a mere *dot* of light—not a line—and has lasted 1-100th of a second, and that during this 1-100th of a second the spark was moved from

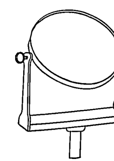


Fig. 55

right to left through one inch. Then, on account of the persistence of the sensation of light on the eye, the spark will appear as a horizontal line of one inch in length. If the velocity of the motion of translation remains the same and the spark lasts only a fraction of 1-100th of a

* See "Essay on the Velocity of Light," by Delaunay. Translated by the writer and published in Smithsonian Report, 1864.

Wheatstone is shown in Fig. 55. The reflecting surface of this mirror is inclined to the axis of rotation and nearly perpendicular to it. If a luminous point be placed anywhere in the prolongation of the axis of rotation it will be reflected, so that by the rotation of the mirror and the persistence of visual impressions, it will appear in a smoky room as a luminous cone, and the base of this cone will appear on the ceiling as a luminous ring, forming a circumference of a circle, whose center is on the axis of the mirror prolonged. In this form of experiment the angular velocity of the image is equal to that of the mirror, and both move in the same direction.

Wheatstone thus describes his experiments with this mirror: "The flame of a candle presented to it appears as a broad luminous ring; the image of the sun is converted into a magnificent fiery belt, etc. A series of minute sparks made to pass between two points, or between a point and the prime conductor of a machine, presents to the eye, from the rapidity of their succession, the appearance of a permanent star of light. When this star is placed in the prolongation of the axis of the revolving mirror, the successive sparks of which it consists are reflected to the eye, each from a different part of the surface, and they are exhibited arranged at regular distances in a circle. When the intermissions are rapid, the appearance is extremely beautiful.

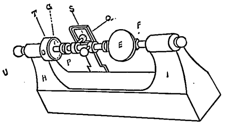


FIG. 59.

"The brush of light which appears on a point when presented at some distance from the conductor, is also by this means shown to be an intermittent action, notwithstanding its permanent appearance; its reflected images present, however, this remarkable peculiarity, they are elongated in the direction of the motion, proving that the brush is not so transient as a spark, and that the emissions which constitute it last during one interval of time measurable by the motion of the mirror.

"But this instrument is not confined to observe merely the intermittences of electric light; whenever a rapid succession of alternations occurs in an object which does not change its place, they may be separately examined by this means. Vibrating bodies afford many instances for investigation; one among them is perhaps worthy to be mentioned. A flame of hydrogen gas burning in the open air presents a continuous circle in the mirror; but while producing a sound within a glass tube, regular intermissions of intensity are observed, which present a chain-like appearance, and indicate alternate contractions and dilatations of the flame corresponding with the sonorous vibrations of the column of air."

To increase the chances of observation of sparks, etc., when their appearance cannot be commanded at the instant when the mirror is in the position to reflect them to the eye, Wheatstone proposes the use of a mirror formed of a hexagonal prism with polished faces, as shown in Fig. 60, where A B is the axis of rotation, and C, D, E, three of the reflecting facets. With this mirror the observer will have six chances of seeing the reflected image instead of only one, as he has when using a rotating mirror with one polished surface.

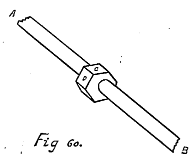


Fig 60.

On the Determination of the Velocity of Electricity through Conducting Bodies.—In the trials made to find out the velocity of electricity previous to Wheatstone's experiment, they used a long conductor, whose two ends were brought near each other so as to form a nearly closed circuit. One of these ends was placed at a short distance from a wire which went to earth, the other end was placed near a conductor leading to an electrical machine, or battery of jars. The experimenters had hoped to have seen an appreciable interval between the passage of the spark to one end of the conductor, and its appearance at the other end on its way across the space to the wire which led to the earth. In one experiment made near London in 1747, they used four miles of conductor, and the discharges at the two ends of the circuit appeared to be simultaneous to the experimenters; and naturally so, for if they had been separated by the 1-10th of a second the discharges would have appeared simultaneous by reason of the persistence of the sensation of light; and though they might have detected by the ear an interval of 1-10th of a second separating the sounds of the discharges, yet they would not have been able to detect an interval of silence between discharges separated by 1-100th of a second. It follows that in a circuit of four miles the detection of a velocity of only a few miles a second would be the limit to such methods of observation, even allowing that the method under any circumstances would give a result indicating an actual transfer of electricity from one end of the conductor to the other.

Wheatstone, after speaking of these trials, says, "I determined, therefore, to repeat a similar experiment, substituting for the imperfect judgment of the eye a revolving mirror, but more rapid in its motion and accurate in its indications than any I had previously employed. The instrument I am about to describe will, unless there be some error in the estimate, which I have not been able to perceive, measure beyond the millionths of a second; and this degree of minuteness may be yet far surpassed by more costly instruments and more careful observations."

It is often stated in text-books that Wheatstone's experiment on the velocity of electricity favors the hypothesis of two electric fluids. That this opinion should be so generally diffused is not a little remarkable, and when the reader has perused the following paragraph he will see that Wheatstone says distinctly that the expected result of his experiment is as readily explained by the hypothesis of one fluid as by that of two fluids. "But," speaking of the experiment of 1747, "as it is only on the hypothesis of an actual transfer of a fluid from one end of the wire to the other that a difference of time between the two sparks at its opposite extremities might be expected to be observed, in order to render the proposed experiment independent of this theoretical view, I took the necessary precaution of bringing a third spark, formed by disconnecting the middle of the wire near to and in a line with the extreme sparks. For on the supposition of the transfer of two fluids in opposite directions, the extreme sparks would be simultaneous, but the middle spark later in its occurrence; the same appearances would also accord with the theory of one electricity, if we admit that a disturbance of electric equilibrium is simultaneously propagated from each end, arising in the one case from successive additions to, and in the other from successive subtractions from, the neutral quantity in the conducting wire."

The experiment of Wheatstone's was made in the Adelaide Gallery of Practical Science, London, where our countryman, Saxton—who aided Wheatstone in these experiments—was then exhibiting his magneto-electric machine and other ingenious inventions. The total length of wire used was half a mile. This was stretched between the balustrades (A B and C D of Fig. 57) of the gallery in 20 parallel lengths, each 120 feet long. The ends of the wire marked 2, 3, 4, 5, of Fig. 57, were connected to the similarly numbered wires of the *spark board*, shown in Fig. 58. This spark board was fixed against the wall, so that the six balls (shown as circles in the figure) should be in a horizontal direction and parallel to the axis of the rotating mirror. The distance shot over by the sparks was 1-10th of an inch. The conducting wire was of copper and 1-15th inch in diameter.

Fig. 58 gives a general view of the apparatus to rotate the mirror and its electrical connections with the Leyden jar, M, and the conducting wire and spark board through the wires marked 1 and 2. Fig. 59 is an enlarged view of the mirror and the attachments thereto which Wheatstone used to obtain the spark at the right instant for observation, and to determine the number of revolutions made in a second by the axis of the rotating mirror. Similar parts in the two figures bear the same letters. The mirror, E, is of polished steel, one inch in diameter, and mounted on the shaft, F G, so that the plane of reflection of the mirror is in line with the axis of rotation of the shaft. The mirror was rotated by a cord going over the wheel, K L, and a groove in the axis, F G. This wheel, K L, was so large that, if the cord is supposed not to slip, the axis, F G, will make 1,800 revolutions to one of the wheel. M is a small Leyden jar, which is kept constantly charged with positive or negative electricity by means of the chain, N, connected with an electrical machine. From the inner coating of the jar leads a bent wire to the two insulated rods, O and P. The ball on the end of P is quite close to the knob, Q, on the axle, F G, when this knob comes opposite the ball on O in the rotation of this axle. In order to confine to narrow limits the spark which passes over this interval, Wheatstone placed between the knob, Q, and the ball on O a piece of mica, S, with a narrow horizontal slit in it. When the plane of the mirror is stationary and at 45° with the horizon he saw, on looking down vertically into it, the image of the balls on the spark board. Charging the jar, M, and rotating the mirror, the observer saw three sparks pass on the spark board and another pass from the knob, Q, through the slit in the mica to the ball on O. The path of the electricity may be supposed, for simplicity of explanation, to go from the outside surface of jar by the wire 1 to the wire 1 on the spark board; thence, with a spark to wire 2, and through half of the stretched parallel wires to 3; thence with a spark to wire 4; thence through the remaining half of the stretched wire to 5; thence with a spark to 6, and back to wire 6, attached to the standard of rotating apparatus and to the inner coating of the jar.

Without a knowledge of the exact number of revolutions made by the mirror in a second one cannot compute the value of deflections of the sparks in case they should be appreciable, and Wheatstone spent much time in the endeavor to get the exact velocity of the mirror. At first he used a siren, shown in Fig. 59, at T, attached to the axle, F G. With 800 revolutions to the axle, and leading air to the siren even through a few holes, the sound produced was so acute that it was either inaudible or its pitch was so high that the ears could not determine the note, and when the number of holes were reduced so as to lower the pitch the sound was too feeble to be distinctly heard. He then simply placed a small piece of paper so that the arm, P (which acts as a counterpoise to the arm and knob, Q), would strike it once at each revolution of the shaft of the mirror. When the mirror was now revolved with the maximum velocity the knob striking against the paper caused the sound G—⁴, which showed that the mirror was making 800 revolutions in one second of time. In subsequent experiments Wheatstone used a counter attached to the shaft of the mirror, and when thus retarded by this additional work put on it, the shaft made 600 revolutions per second.

Of the extraordinary powers of this apparatus as an instrument of research, and of the results of his experiments with it, Wheatstone speaks as follows: "Let us now consider what is the shortest duration of the electric light, and the greatest velocity of transmission through the wire, that can be detected by means of the instrument I have described. The mirror revolves 800 times in a second; and during this time the image of a stationary point would describe 1,600 circles: the elongation of a spark through half a degree, a quantity obviously visible, and equal to one inch seen at the distance of ten feet, would therefore indicate that it exists the 1-1,152,000th part of a second. The deviation of half a degree between the two extreme sparks, the wire being, as above stated, half a mile in length, would indicate a velocity of 576,000 miles in a second. This estimated velocity is on the supposition that the electricity passes from one end of the wire to the other; if, however, the two fluids in one theory, or the disturbances of equilibrium in the other, travel simultaneously from the two ends of the wire, the two external sparks (on the spark board) will keep their relative positions, the middle one will be alone deflected, and the velocity measured will be only one half that in the former case, viz., 288,000 miles in a second.

Repeated experiments gave the following results. In all cases, when the velocity of the *mirror exceeded a certain* limit, the three sparks were elongated into three parallel lines, and the lengths became greater as the velocity of the motion was increased. The greatest elongation observed was about 24°, indicating a duration of about the 1-24,000th of a second. The lines did not always commence at the same places; sometimes they appeared immediately below the eye, sometimes to the right, at other times to the left, and occasionally they were out of view altogether. This indetermination is owing to the arm, 2, of Fig. 59, not always taking the spark at the same distance from the discharger: several discharges are therefore required to be made before the eye can distinctly observe the appearances. When the velocity was low the terminating points (*i.e.*, the ends of the luminous lines of the elongated spark images) appeared in the same horizontal line; but when the velocity was considerable, and the upper edge of the mirror was revolving from the observer, the lines assumed this appearance ; when the top border of the mirror revolved toward the observer the lines appeared thus . In no case did I see them thus , or thus , as required in the actual transfer of a single fluid. The spark board in all these experiments was placed at the distance of ten feet from the mirror.

The interpretation of these appearances observed by Wheatstone in his mirror is as follows: First, the mirror in its revolution had time to turn 12°, while the spark lasted between the balls on the spark board, and as the mirror produces in the image double the angular deflection of its own motion, the spark appeared elongated over an arc of a circle equal to 24°. Since the mirror, by one revolution, spreads a reflected image out into two complete circles, or 2×360°=720°, it follows that 800 turns per second of the mirror spreads out a reflected image into 800×720°, or 576,000°; and $\frac{576,000}{24} = 24,000$. Which gives 1-24,000th second for the duration of the spark on the spark board in Wheatstone's experiment.

The observer sees another peculiarity of these elongated sparks; they are parallel, but they do not have their origin on the same horizontal line. When the mirror in its motion is deflecting the spark image downwards, they present this appearance , which shows that the sparks at the beginning and the end of the wire, or circuit, took place at the same instant, and that a small interval elapsed before the spark made its appearance at the broken place in the middle of the wire, and that during this small interval which elapsed the mirror had time to get a slightly greater tilt then that which it had when the side sparks appeared, so the middle spark line appears as pushed *downward* between the two side spark lines. When the mirror revolves so that the images of the sparks are drawn out in an upward direction, then the middle spark line appears slid *upward*, between the two side lines, by the same quantity that it was slid downward by the same velocity and opposite direction of rotation of the mirror.

Wheatstone states that the amount of downward or upward displacement of the middle spark line amounted to not more than one half of a degree. Now, as an elongation of 24° in the spark line gave 1-24,000th of a second for their duration on the spark board, it follows that the displacement of half of a degree gives us 1-48 of 1-24,000th of a second, or 1-1,152,000th of a second, for the time it took the electricity to go over ¼th of a mile, or half of the entire length of the copper wire; hence in one second, electricity, according to Wheatstone's experiment, will travel over $\frac{1,152,000}{4}$, or 288,000 miles of copper wire.

The very large elongation of 24° in the sparks produced in the peculiar and unusual conditions of these experiments led Wheatstone to hope to be able to elongate sparks as they are ordinarily produced by the discharges of electrical machines or Leyden jars through short conductors of very slight resistance; but he observed no elongation in the sparks even when the mirror was urged to the greatest velocity of rotation. This shows that electric discharges taking place under the above conditions cannot have an existence as long as the 1-1,152,000th of a second; for if they had had a duration of that length then Wheatstone would have caused an appreciable elongation in them. Frequently we meet with the statement that Wheatstone showed that the discharge of a Leyden jar lasts the 1-24,000th of a second. We see that Wheatstone distinctly

Alarm Produced on the Discovery of the Leyden Jar.

In describing the effect produced on himself by taking the shock from a thin glass bowl, Muschenbrock stated in a letter to Reaumer, that "he felt himself struck in his arms, shoulders, and breast, so that he lost his breath, and was two days before he recovered from the effect of the blow, and the terror," adding, "he would not take a second shock for the kingdom of France." M. Allamond, on taking a shock, declared "that he lost the use of his breath for some minutes, and then felt so intense a pain along his right arm, that he feared permanent injury from it." Winkler stated that the first time he underwent the experiment, "he suffered great convulsions through his body; that it put his blood into agitation; that he feared an ardent fever, and was obliged to have recourse to cooling medicines." The lady of this professor took the shock twice, and was rendered so weak by it that she could hardly walk. The third time it gave her bleeding at the nose.

STATIC ELECTRICITY.

May 7/

[15631.]—In reply to "Jay Aitch," 15595, p. 171, I do not think that I went at all too far in saying that as a matter of fact an isolated body is incapable of receiving an electric charge. It is quite true that this statement will not be recognised as a matter of fact by all electricians, but that is simply because perhaps the majority of electricians have so habituated themselves to looking at facts through the medium of old theories (set up before knowledge was sufficiently advanced) that they are unable to see what is really fact. Most of the electrical science of the day is due to mathematical analysis; and given any foundation of fact whatever, this analysis can be set up and a scheme devised to fit the supposed facts. Now the earliest observations in static electricity were directed to surfaces or bodies connected to the prime conductor of machines and themselves carefully insulated. Theories of electricity were based upon these observations, and the mathematical developments spring from them. Among other supposed analogies we have a number of problems about isolated bodies in infinite space, the charge upon them, and the work to be done in bringing other bodies near them; and of this class of ideas that of Prof. Ayrton as to the magnetism of the earth resulting from such a static charge upon the rotating earth is the latest.

But by degrees it became evident that the facts were only half facts, that the positive charge on the isolated body was always accompanied by a negative charge of equal quantity on surrounding bodies. To fit these new facts into the old theory (a work very like that of repairing old garments with new cloth) the theory of induction was created, that is to say, this negative charge was supposed to be a consequence of and produced by the positive charge, and to be itself subject to all the old laws of distribution.

Further progress showed us that so far from this being the case, the positive and negative charges are essentially one, indissolubly connected, so that the positive charge is incapable of existing at all except in presence of an equal negative charge connected to it by lines of force. As a consequence, inevitable but not yet recognised fully, charge is not seated upon or connected with the surfaces at all. These only make its presence manifest, serving the same purpose as the two plates of the decomposition cell. The charge itself (which, as I have lately shown, is simply energy rendered latent or potential), is located in the intermediate space, the dielectric; that is to say, all those actions which are classed as charge are simply instances of condensation; the isolated charged surface has no existence; it is simply a change of medium in a closed circuit. Therefore, before we can talk about the effect of a static charge on the surface of the earth, we must ascertain where the surrounding negative charge is. I have an intense dislike to propositions in which we are invited to assume conditions wholly out of range of experiment; we can by no possibility experiment upon a body isolated in space; but as we know that in no case can we put a charge upon an isolated body in earth, that as the more and more we approach those conditions, that is to say, the further we place our charged body from surrounding bodies, the more and more difficult it becomes to charge it, it seems to me mere absurdity to base any arguments upon that state of things existing beyond our means of experiment, which our experiments give us no reason to expect, but the occurrence of which they negative.

"Jay Aitch" will see therefore that the consequences he anticipates from the nebular hypothesis will not follow. Electricity is an essentially dual force. I do not mean any two-fluid stuff. I mean that it depends absolutely upon closed circuits of polarised molecules of matter in which energy can be transferred; the positive and negative are everywhere equally in that circuit; they are simply the opposite faces in every part of the chain or circuit. Open such a circuit anywhere, which means introduce a dielectric (as the air) into it, and you have the opposite static tensions. Electricity is known under no other conditions; deny it the circuit, and the energy which might appear as electricity becomes simply heat.

Sigma.

[36976.]—**Winter's Condensing Ring.**—Mahogany is generally used, but I have made one of pine. For a ring 18in. diameter, get two straight-grained pieces, 4ft. 6in. × 1½in. × ¾in., plane true, put a groove down middle of flat side of each for the wire to lie in, steam them, and bend them to a circle. When dry and stiff put in the wire and peg them together, gluing the joint. Allow to dry thoroughly, round off, fix the ends on a wooden knob with pin to fit in top of conductor, smooth the whole well with glasspaper, and varnish with shellac. The wire should be brought out for connection with the prime conductor. There should be a collector for each surface of the plate. In Winter's machine these are of smooth varnished wood, ring shaped, having, in the side next the glass, a groove lined with tinfoil, in which the points are set.—J. Brown, Belfast. March 7/1

[From the *Journal of the Society of Telegraph Engineers.*

EXPERIMENTAL RESEARCHES INTO MEANS OF PREVENTING INDUCTION UPON LATERAL WIRES.

Journal of Telegraph

BY PROF. D. E. HUGHES. Aug 16 1879

The induction upon lateral wires has of late years been a serious question upon telegraph lines—the constantly increasing number of wires upon the same poles, added to the adoption of high speed and consequent sensitive apparatus, renders the study of these effects of the first importance.

The disturbing effects have become each year more and more remarked; and in 1868, by the desire of the French Telegraph Administration, I undertook a series of practical experiments, with a view of finding a remedy. I at once perceived that we had to deal with a question of a more complicated nature than was at first supposed. We found then that we had to deal with the static charge of its own line, and the dynamic induction of the lateral wires, that the effects of each were very different; and whilst it was easy to deal with the comparative feeble static charge, the more powerful and rapid effects of dynamic induction could hardly be suppressed. By introducing extra resistance coils we could reduce the induced current, but, at the same time, we should reduce the current with which the line was working. The remedy was in most cases (particularly during faulty insulation) worse than the disease. Condensers and polarization batteries would allow the momentary induced currents to act, whilst it prevented the more prolonged currents of the distant station. Ordinary induction coils would allow of compensation if we had only two wires to compensate for; but as we had to consider ten or more wires they were useless for that purpose. The only remedy we then found was by the introduction of an electro-magnet, with an armature fixed upon its poles—thus being a closed magnetic condenser. This practically absorbed or destroyed all the short momentary currents; but then if on this line the apparatus was working at high speed, with consequent short currents, we practically cut off the best part of the current needed.

In this case, whilst the remedy was practically perfect for an apparatus at low speed with comparative long currents, it was useless for those working at high speed requiring shorter currents, and consequently more sensitive organs of reception.

Other duties prevented me at that date from following up this line of research. The disturbances on the lines from this cause have been on a constant increase from the adoption of more rapid, and consequently more sensitive, organs; and in the telephone we have at last arrived at an organ of rapidity and sensitiveness which not only reveals the constant induction, but which is the main reason why the telephone has not been more largely adopted upon telegraph lines.

In a late paper upon induction* I brought to notice the powerful organs of research in this field that we possess in the telephone and microphone; and we thought that by the aid of these we might investigate, theoretically, the cause and remedy for lateral voltaic induction.

The following experiments are a *résumé* of the results obtained:—

We made use of three separate and distinct means of research. The first consisted of two or more parallel wires, 20 feet long; the one being used as a primary, was connected to battery and microphone, with clock as source of sound (both ends of wire being to earth). The secondary wire, upon which the induced current was observed, was connected to telephone—both ends of this line also being to earth.

The second arrangement was made, in order to study the effects upon a much shorter length, and with more accuracy than could easily be obtained on the longer line.

Two parallel—1 millimetre, copper wires were strung upon a board, 15 × 15 inches; these wires were placed 10 inches apart, and both united at one end with 1 Daniell element placed near. The free ends of these wires could be put alternately in connection with battery; and thus, if we surrounded one of these wires with tin-foil, or other means of protecting wires, we could observe the degree of protection obtained, by comparing it with the unprotected wire. A difficulty was at once felt in obtaining sufficient induction upon a parallel wire of such a short length. We obviated this, however, by the construction of a flat rectangular coil of 100 turns, having 4 inches side exterior. Now, by placing either of the sides of this coil near the primary wire, we had 100 parallel insulated wires, of a few inches—the influence, therefore, was multiplied greatly; we had also in this coil, on the opposite side, 100 parallel layers running in a contrary direction, so the resultant strength of current was simply that due to the different distances; and it was in order to diminish this, as far as practicable, that we made the coil square. The sound obtained by this means was amply sufficient for all the researches needed.

The third means was that usually employed, namely, the use of coils either superposed or wound together in the same helix; by this means powerful effects could be easily obtained: and as the results were identical, and verified by the three systems, we will at once relate the experiments with coils.

I If we construct two flat coils of 100 yards of No. 30 copper wire each, and join one as primary to battery and microphone, the second coil as secondary, joined to telephone alone, we find that by placing one of these coils near, or within a few inches distance from the other, we hear distinctly the sounds of the clock on the microphone. Our object now being to screen the secondary coil, so as to reduce the induced current, and consequently sound obtained on telephone, we joined both coils to the same earth plate, without effect. We then took a sheet of copper, 1 millimetre thick, 12 inches square, and placed it between the coils, without effect; joined both coils to this plate, as if it were an earth plate between the coils, but no perceptible reduction of the induced current was thus obtained. We then put 10 thin 1-32 inch iron plates, 18 inches square, between the coils, again joining them as earth, but still no perceptible reduction.

II. The two coils were surrounded with several layers of tin-foil, thus enclosing each separately in a continuous metallic sheath. This, however, had no effect, and sounds were quite as loud, even when the sheaths were joined to earth. Placing both these metallic-covered coils in a vase of salt water, and all to earth, had not the slightest effect, even when the copper plate was also interposed between the coils. Theoretically, these two coils here represented a submarine cable; and as we shall see by some following experiments, neither the sea-water, nor even a metallic sheath or tube around each wire would entirely prevent dynamic induction; and this has been proved in practice, as, upon a trial of the telephone between Dover and Calais, a Morse message was clearly read by Mr. Bordeaux, simply by the induced current from another wire in the same cable.

III. A single coil was made, having four separate insulated wires all wound together in the same direction. We could thus join these coils at their free

* "Comptes rendus de l'Academie des Sciences," Paris, Dec. 30th, 1878, and 20th Jan., 1879.

ends, making several combinations, each giving very different results. We will call these separate coils Nos. 1, 2, 3, and 4—the microphone remaining on the primary, and telephone on the secondary. No. 1 joined to microphone, No. 4 to telephone—induction strong, and consequently sounds loud and clear. Nos. 1, 2, 3, to microphone, all same direction, No. 4 to telephone—no perceptible increase of sound by the increased quantity of surface; similar results when 1, 2 to microphone, and 3, 4 to telephone.

Thus by no combination of parallel wires can we hope to diminish induction; but if we join Nos. 1 and 2 to microphone, so that the current from 1 returns by 2, then we have a complete screen—no sound whatever being now heard on the secondary coil No. 4. The same effect takes place if we join 1, alone, to microphone, and 3 returning by 4 to telephone. Consequently, if a telegraph line or a telephone line had a return wire upon the same poles, and absolutely equidistant from the inducing wire, we should have perfect protection, from the fact that the primary would then induce parallel currents in both wires in the same direction, but, contrary to itself and these parallel currents would, being of equal force, neutralize each other. The remedy here is complete, although it is true that it would introduce a double resistance, and the cost of a double wire cable would probably prevent its use. Leaving, however, the practical objections to its use aside, we shall see by some following experiments that the remedy as regards prevention is absolute.

IV. Taking this same 4-wire coil, and joining 1, 2, and 3 to microphone, so that current goes through 1, returns by 2, and back again by 3, we then hear on No. 4 only one half the induction that would be caused by either wire alone.

V. Using still the same 4-wire coil, and sending by 1 and returning by 2, no sounds are heard, as we have already shown, but if we short-circuit either 1 or 2 we at once hear strongly the sounds induced by the coil that is not short circuited, in this case without interrupting the flow of the current or breaking the communications. We have produced or annulled an induced current merely by cutting off its protecting contrary direction coil, and if the microphone instead of being placed in the direct primary circuit is placed between the junction of 1 and 2, and either coil, we hear the sounds not by any variation in the primary circuit, but simply by the more or less protective influence of the return wire.

VI. If instead of a return wire of the same length in this 4-wire coil we use a shorter wire in the same coil, it does not protect it, except for the same length as the protective wire; and if as return we use an exterior coil at some distance apart but of same length as the primary, it does not protect it at all; this is evident, as from theoretical considerations we know that the return wire must be equidistant, and should be of equal length and diameter.

VII. Knowing that a metallic envelope diminishes in a slight degree the induction—first, by the work done in inducing parallel currents in this wire, itself when on a closed circuit, and, secondly, by the consequent diminution of force after such work—we tried how the many similar closed coils, introduced between the primary and secondary, would reduce the amount of induction to one-quarter of its original amount. The primary and secondary being placed 6 inches apart, the introduction of one or two similar coils between them gave no perceptible reduction of force, and it required twelve such coils to reduce the induction to one-quarter of the original amount, and this reduction only took place if the interposed coils had closed circuits; the instant the circuits were opened there was no perceptible difference with or without the twelve interposed coils. From this we draw the conclusion that the only reduction takes place when work is done in interposed coils by being on a closed circuit, and that it would require a tube of metal to surround a conductor at least twelve times the amount of primary wire, in order to reduce its inductive effects to the one-quarter as above stated.

VIII. The results obtained with coils were now applied to two lateral wires in a straight line 20 feet long—the primary being insulated by gutta-percha, and covered externally with tin-foil several times. Here we had the exact conditions which have been more than once proposed as a remedy or prevention of induction for the use of telephone lines. This covering, however, was found to be no protection at all, the induction was equally as strong with exterior coating to earth or open—theoretically there should have been a slight, and, as we have already seen, *very* slight reduction, but the difference was not perceptible. The induction through this protective covering gave loud sounds on the telephone, but if we used the outer tin-foil covering instead of a return wire for primary, then no sounds at all were heard; in fact, it formed a perfect protection, as we have already seen, in the 4-wire coil.

IX. The short local wire of 15 inches, already spoken of as the "second arrangement," was now used. The primary wire was led through a glass tube 12 inches long, which had 10 coverings of tin-foil, all joined to earth. This arrangement proved, as above stated, of no avail; the current, however, being returned by the tin-foil covering proved a perfect protection. In addition to the 10 tin-foil coatings we added 20 coatings or cylinders of thin charcoal iron—making an exterior diameter of four inches, and a total thickness of metallic sheath of ½-inch between primary and secondary wire. As but little reduction was perceptible, we placed a magnetic needle, suspended by a silk thread, at a distance of 4 inches from the primary, and measured the deflection by current. Without any protective coating it gave 3 degrees deflection, with glass tube and 10 tin-foils to earth 3 degrees, with the additional 20 iron cylinders about 2½ degrees, thus the magnetic lines of the voltaic current pass easily through non-magnetic and magnetic bodies, and as the dynamo induction is due to the *change* in this field of force, it is easy to see why the numerous metallic sheaths failed to arrest the inductive force.

(To be Concluded in next number.)

Expériences sur la machine de Holtz

Electro Dec 1879

Nous avons eu plusieurs fois déjà l'occasion de faire allusion à la théorie nouvelle imaginée récemment à Tokio par MM. Ayrton et Perry pour expliquer l'origine du magnétsme terrestre.

Il n'est pas sans intérêt de résumer sommairement les observations, fort curieuses du reste, qui ont donné à ces deux habiles ménechmes de la physique l'idée d'émettre une hypothèse dont plusieurs savants éminents se sont préoccupés.

Ces messieurs, ayant eu dans leur laboratoire de Tokio une machine de Holtz, ont répété les expériences de M. Rowland qui montre qu'une charge d'électricité mise en mouvement produit la déviation d'une aiguille aimantée tout comme le ferait un simple courant voltaïque.

L'appareil mis en rotation était un disque d'ébonite à axe vertical tournant avec une vitesse de 61 tours par seconde, au-dessous d'une aiguille astatique d'une sensibilité parfaite.

Le disque d'ébonite était doré sur ses deux faces et il tournait entre deux plaques de verre horizontales dorées et mises en communication avec la terre.

L'aiguille était parfaitement immobile quand le disque d'ébonite n'était point mis en rotation, quoiqu'il fût électrisé; mais il suffisait de lui imprimer un mouvement circulaire pour produire une action sur l'aiguille aimantée. Cette action n'était autre que celle du magnétisme de rotation d'Arago.

M. Rowland s'en est parfaitement rendu compte, et il prétend être arrivé à distinguer nettement cet effet de celui qui est produit par la rotation du disque électrisé.

Les expériences furent suivies pendant des mois au laboratoire de physique de Berlin, mais l'action n'atteignait jamais une intensité assez notable pour être mise au-dessus de toute contestation possible. M. Helmhotz ne trouva ou ne chercha pas le moyen de la rendre plus grande.

Nous nous bornerons pour le moment à renvoyer le lecteur à ce que nous disons plus haut dans notre article sur l'astronomie électrique. On y verra que nous nous servons de l'expérience de M. Rowland pour expliquer l'action que les astres dont l'état électrique est évident, peuvent exercer non pas sur leur propre magnétisme, mais sur celui des corps célestes qui gravitent autour du soleil et sur celui du soleil lui-même.

Ce nouveau genre d'induction serait différent des effets électro-dynamiques provenant de leur mouvement et viendrait le compliquer dans certaines mesures qu'il resterait à définir.

MM. Ayrton et Perry, qui croient avoir été beaucoup plus timides, ont été en réalité beaucoup plus hardis, car ils se servent de cette expérience pour expliquer une action véritablement imaginaire de la terre sur elle-même, sous prétexte que le mouvement des molécules intérieures n'est pas le même que celui des molécules superficielles. Cette manière de raisonner est éminemment anti-philosophique.

P. DESMARETS.

Nature, September 22nd 1881.

THE ELECTRIC DISCHARGE THROUGH COLZA OIL.*

By A. MACFARLANE, D. Sc., F. R. S. E.

The electrical properties of colza oil which I have examined are its dielectric strength and some phenomena which accompany the passage of the spark. By the dielectric strength of a substance I mean the ratio of the difference of potential required to pass a spark through air under the same conditions. The electrodes used were two parallel brass plates each four inches in diameter. When comparing the gases the standard distance of the plate chosen was 5 mm. In the case of liquids it is convenient to observe for a shorter distance, and reduce the result by the law which previous experiments of mine have established, namely, that in the case of the discharge between parallel plates through a liquid dielectric, the difference of potential required is proportional to the distance between the plates. (*Trans.* R. S. E., vol. xxix. p. 563). One set of observations gave the ratio for colza oil to be 2.7, another gave 2.5. Hence 2.6 may be taken. I have now obtained the following table of dielectric strengths for liquids (1 being unity).

Substance.	Dielectric Strength.
Paraffine oil	3.7
Oil of turpentine	4.0
Paraffine liquefied	2.4
Olive oil	3.5
Colza oil	2.6

The specific gravity of the colza oil is .91. The passage of the spark was accompanied by the formation of gas bubbles, but there was no deposition of solid particles. As the 4-inch plates were placed horizontally in the oil a bubble produced by the discharge was prevented from escaping by the upper plate. When the upper plate is again electrified such a bubble behaves in the following manner. If it is large enough it will extend itself somewhat like an hour-glass between the plates, but if it is smaller it takes the form of an acorn with a flat base, the base resting on one or other of the plates. When the upper plate is charged positively the bubble is repelled so as to place its base on the lower plate; when the electricity is changed to negative the bubble remains with its base on the upper plate. A reversal of the order of charging did not change the effect. After a few electrifications a sufficient number of solid particles collect to form a chain, and thus interfere with the phenomenon, the bubbles then being lengthened out in a remarkable manner, but never repelled to the lower plate. When the upper plate was charged negatively, gas bubbles appeared to me to rise from the lower plate, as if they had been formed there. To test this point further I took some sparks between two smaller disks placed vertically in the oil. The gas-bubbles were observed to rise up at the negative surface as if they had been formed at the positive surface, and had been repelled or carried straight across, and then rose up at the negative surface. When the spark was taken between two points bent at right angles to two rods dipping into the oil, the bubbles were observed to shoot out in the direction from the positively charged point, and to circulate round the earth-rod some time before rising to the surface. These phenomena indicate that the bubble is positively electrified.

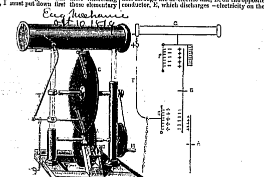
* British Association, 1881.

series of projecting points, directed against the top of the revolving di-electric disc, but not actually touching the latter. A rectangular piece of vulcanite, shown better in Fig. 2, is attached to the same, but placed opposite the points on the other side of the disc. The metal rod, E, with points similar to the one described above, is fixed against the lower part of the disc, and a movable rod, F, is in connection with E. The conductor, F, can be joined to "Earth" by means of a brass chain. In order to be able to give a clear explanation of the working of this most interesting machine, I must put down first those elementary

fective aperture of the large mirror or object-glass that? Taking your correspondent's telescope, ith his typical eyepiece, he would find by the of a dynamometer that this spot would mea-

It is more difficult to give a clear explanation of the action of the second part of this apparatus. To facilitate a thorough understanding of the process, I give the annexed diagram. A represents the glass disc of the friction machine, whose upper portion, before passing the points is charged with + electricity; it acts through the di-electric disc, B, on the opposite conductor, E, which discharges −electricity on the

Eng Mechanic Oct 10 1879



F I G. 1. F I G. 2.

scientific principles or laws upon which its action is based, and to which we shall have to refer.

After that I shall describe, separately, first the friction engine, and secondly, the induction apparatus.

1. Any substance which is not electrically excited is said to be of a neutral condition, and supposed to be charged with positive and negative electricity in the same degree; the two charges neutralising or destroying each other.
2. A body can be charged with positive electricity by having its negative charge abstracted, or *vice versa*.
3. If a dry rod or plate of glass is rubbed with silk or leather, the glass becomes charged with positive electricity, the rubber acquiring at the same time a negative charge.
4. If the rubber employed in the process is covered with powdered amalgam, the result obtained is much better.
5. A plate of insulating material, say, glass or ebonite, placed between two bodies, of which one or both may be charged with electricity, is called a di-electric.
6. Electric induction by invisible agency takes place through the di-electric.
7. If a body charged with positive electricity (A, Fig 2) is placed near a dielectric, B, and a metal conductor E on the other side of the dielectric, the conductor E deposits negative electricity on the di-electric, and (according to principle 2 above) becomes charged with positive electricity.

1. The Friction Machine.

In the ordinary plate machine, as represented in the lower portion of our illustration, Fig. 1, a disc of glass, A, is made to revolve. Pressed against its sides are two cushions, D, to which a silk cover may be attached. The action of the apparatus is greatly improved if the cushions are covered with powdered amalgam, which is put on by means of tallow. The friction caused by the pressure of the rubbers against the plates excites the electric charge, in other words, it separates the two kinds of electricity, leaving a positive charge on the glass and a negative charge on the rubber. The amalgam naturally increases the friction and its results. (See principle 4.)

In such a friction machine, every portion of the disc, after having passed between the rubbers, approaches in its revolution a conductor with a series of sparge metal points directed against the glass. The charge of positive electricity on the glass abstracts the negative charge from the neutral conductor E, Fig. 1, and leaves the latter charged with positive electricity; while that portion of the disc which has just passed the points is charged with negative electricity. (See principle 2 above.)

If a di-electric is placed between the excited disc and the conductor, as shown in Fig. 1, the same action takes place, and (see principle 6 above) the di-electric and becomes itself charged with + electricity (see principles 6 and 2 above). But the di-electric in revolving carries the part that was thus charged with −electricity to the place opposite the top conductor F; it there abstracts +electricity from H F, becomes itself charged with − electricity (until it again passes opposite E), and leaves F charged with − electricity (see principle, Fig. 2). By means of a brass chain, shown in the illustration, Fig. 1, the conductor E can be connected to "Earth." If the disc A were charged with − electricity, then the same process would occur; but in that case T would be charged with − electricity, while F and C would acquire a positive charge. The machine has two more appendages, shown in the illustrations, of which we have not spoken yet. They are—(1) a rectangular piece of vulcanite fixed opposite, but parallel to F on the other side of the di-electric; and (2) the large metal conductor C. The slab of vulcanite increases the length of spark by one-third. The large metal conductor at the top fulfils a similar task. The brass-rod T is movable at its lower extremity, so that the brass ball fixed at the top of this rod can be placed at any desired distance from C to indicate any length of spark produced.

Some such machines are made with glass discs, others have plates of ebonite; both substances are equally effective and suitable for the purpose. A machine with a disc of 20in. diameter will produce a continued series of sparks, 5in. to 7in. in length; it is powerful enough to brilliantly illuminate several feet of Geissler's tubes, pierce glass, and produce all the effects that can be obtained from the secondary current of a large induction-coil. Carré's machines are made in three sizes having pairs of discs of the following diameters respectively, 12¼in. and 17¼in., 15in. and 21¼in., 17¾in. and 23¼in.

Those of our readers who have occasion to experiment with friction machines, know that these are very sensitive to moisture in the atmosphere. The well known Holtz machine is even more sensitive than the former apparatus; but Carré's instrument is less susceptible to the evil effects of moisture in the air, and therefore recommends itself to the experimenter.

It possesses another and even greater advantage over the induction machines of Holtz and Bertsch in not requiring any initial charge from without, or necessitating any preparation. It is a self-starting machine. To set the apparatus to work, you simply turn the handle, and within *one* minute's time you hear the peculiar crackling noise which accompanies the long bluish sparks that pass between the conductors C and I. Our querist asks for "a few hints as to the best mode of keeping the apparatus in working order." 1. Keep the machine in a dry place; 2. do not allow the points of E and F to touch the disc; and 3, when needed put a little fresh amalgam on the rubbers. You will find that the instrument does not easily get

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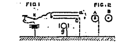
ELECTRODYNAMIC INDUCTION AND SECONDARY ELECTROSTATIC INDUCTION BETWEEN TELEGRAPH CONDUCTORS IN PROXIMITY.—In a Paper on this subject by M. de Meaux, in *Annales Télegraphiques*, the results of a series of experiments made (a) upon two gutta-percha covered wires, the external surfaces of which were insulated from earth, and (b) upon two such wires encased in lead by means of which the external surfaces of gutta-percha were connected to earth, are summed up as follows, so far as regards the electrodynamic effect:—*In a closed circuit, the intensity of the current determined by the induction of a cylindrical conductor of indefinite length upon another of the same form is not affected by surrounding one or other of these conductors, or even both of them, with a concentric metallic envelope, in communication with earth throughout its length.* In an article upon telephony, by Dr. Werner Siemens, in the same number of the *Annales*, the difference in the effects produced by the two modes of induction above mentioned is very clearly set forth. The following experiment, suggested by him, shows that the effects of secondary electrostatic induction are completely obviated by the external metallic envelope; the arc of which, it appears, was patented in England by M. Foucault under date of 2nd July, 1869. Let *a*, *b* and *c* represent three sheets of metal foil, insulated from each other by plates of mica or thin layers of gutta-percha. When the plate *b* is disconnected

FIG 1 FIG. 2



from earth, the galvanometer *g* is reflected when the key *k* is depressed, by reason of the induction upon *c* of the charge communicated to *a*; this effect being in no wise diminished by the presence of *b*. If, however, *b* is connected to earth, then no effect is produced upon the galvanometer by depressing *k*; the induction being then exerted exclusively upon *b*. The analogy of this arrangement to the case of two conductors, enclosed in an insulating material which is coated externally with a conducting material, is shown in Fig. 2. When the conducting tube of A is connected to earth, the induced *minus* charge corresponding to the *plus* charge of the wire becomes accumulated upon the inner surface of this tube; whilst the *plus* inducteous charge passes to earth. If, however, the conducting tubes of A and B were insulated from earth, they would both become polarised, and a *minus* charge would be induced in the central conductor of B; the *plus* inducteous charge flowing through this conductor to earth. In regard to electrodynamic induction, Dr. Werner Siemens arrives at the same conclusion as that stated above; a conclusion established by the following simple experiment. Two gutta-percha covered wires are wound together upon a bobbin, which is gradually immersed in water. The effects of electrostatic induction are then observed to diminish; ceasing altogether when the bobbin is completely immersed. But the currents due to electrodynamic induction, instead of being diminished by the effect of the conductive contact between the external surfaces of the insulating coverings, which is established by the water, become by this cause intensified.

Electrician May 10 1878

Qu. Aug 7 1880

ON SOME POINTS CONNECTED WITH TERRESTRIAL MAGNETISM.

I HAVE on more than one previous occasion brought forward some of the various points which are here grouped together. These points are three in number.

(*a*) Regarding the sustaining power of the earth's magnetism.
(*b*) Regarding the diurnal and other changes of the same.
(*c*) Regarding earth currents and auroras.

I may state at once that this only professes to be a working hypothesis.

(*a*) *Regarding the Sustaining Power of the Earth's Magnetism.*—I do not here intend to discuss the cause of the earth's magnetism, but I would ask in the first place if it is not possible that this cause may be something small and one which (assuming it to continue at the present moment) we may not readily perceive. If we assume this cause or magnetic nucleus to be small is it not possible to imagine that there is a machinery which acts upon this nucleus (just as we have in certain magneto-electric engines) so as to swell up the magnetism of the earth ultimately to saturation.*

May not this machinery be the great convection currents, the anti-trades, that go from the equator to the poles in the upper regions of the earth's atmosphere, and which may be looked on as conductors moving across lines of magnetic force?

It would appear to me that the tendency of such currents will be to swell up and sustain the magnetism of the earth.

(*b*) *Regarding the Diurnal and other Changes of Terrestrial Magnetism.*—It will, of course, be natural, entertaining the views now enunciated, to regard the diurnal changes of the convection currents of the earth's atmosphere, as these are manifested in the upper regions, to be the cause of the diurnal changes of terrestrial magnetism.

If this view be taken it might be argued that wind changes in these upper regions should also produce magnetic variations. The reply is, that apparently they do. In conjunction with Mr. Morisabro Hiraoka I have compared together the simultaneous records of magnetic declination ranges at Kew and at Trevandrum, and I find evidence of a progress of things from west to east, so that on the whole a particular magnetic-range phenomenon occurs at Kew 9·7 days before it occurs at Trevandrum. Again, I have attempted to show, in conjunction with Mr. Dodgson, that a particular magnetic phenomenon occurs at Kew one day before it occurs at Prague.

It would thus appear that there is a progress of magnetic phenomena from west to east, just as we know there is a progress of meteorological phenomena. As, however, the meteorological phenomena which we can examine occur in the *lower* atmospheric regions, while the magnetic phenomena are, according to this hypothesis, associated with currents in the *higher* regions, it does not follow that magnetic and meteorological phenomena should travel from west to east at the same rate. I may also mention that we have reason to believe that magnetic changes lag behind corresponding solar changes just as meteorological changes would do.

It is manifest that it will be comparatively easy to settle the fact of a progress from west to east of magnetic weather, and that if such exists it will most readily ally itself with the hypothesis above mentioned.

In the next place, if we regard those changes in the convection currents of the earth which depend on the year, we have reason to imagine that such are most pronounced at the equinoxes. It is also well known that magnetic disturbances are most frequent at these times.

Let us next proceed to regard the secular change of the earth's magnetism. To account for this magneticians have felt the need of something movable, and the hypothesis of a "little earth," a solid nucleus moving within the recesses of our planet, has found much support. But is it not more likely that the result may be caused by a secular variation in the distribution of the convection-currents of the earth? If the question be asked, What reason have we for imagining the existence of such a variation, the answer will be, A much better reason than we have for entertaining the conception of a "little earth." For there is some reason, at any rate, for imagining the power of the sun to be subject to a complicated series of periodicities. Now a secular variation in the power of the sun would produce a secular change not only in the intensity, but in the direction of the convection-currents of the earth, and, according to the above hypothesis, these in their turn would produce a secular magnetic change.

(*c*) *Regarding Earth Currents and Auroras.*—I have for some considerable time looked on the earth as a Ruhmkorff's coil with a magnetic nucleus. Above this nucleus we may suppose that we have the primary rocks, which are non-conductors, while above these we have the moist or comparatively moist surface of the earth, which is a conductor.

above this, again, we have the lower strata of the atmosphere, which are non-conductors, while above this we have the upper strata, which are conductors.

Now suppose that a small but abrupt change of the earth's magnetism takes place, no matter how. We need not enter into the causes of such.

We have thus two secondary coils, if I may use the expression: (1) the moist surface of the earth ... regions of the atmosph...

* If I am not mistaken ... as a magneto-electric eng...

La Nature 31 Jan 1880

DESCRIPTION DE LA PLUS GRANDE BOBINE D'INDUCTION

CONSTRUITE JUSQU'À CE JOUR

M. William Spottiswoode, Président de la Société Royale de Londres, a fait construire par M. Apps, fabricant d'instruments de physique à Londres, une bobine d'induction qui dépasse par ses dimensions et ses effets, tout ce qu'on avait réalisé antérieurement.

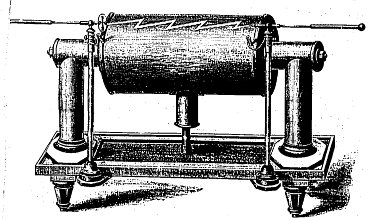
Nous en donnons la description d'après le *Philosophical Magazine*, sans presque rien changer au texte anglais de M. Spottiswoode.

L'aspect général de l'instrument est représenté par la figure ci-jointe. On voit que la bobine elle-même est portée par deux piliers massifs de bois, recouverts de gutta-percha et paraffinés à leurs deux extrémités. Outre ces deux supports, on en voit un troisième au milieu et dont la hauteur peut être réglée au moyen d'une vis, pour résister à la flexion de la pièce principale.

L'appareil entier est monté sur une base d'acajou portée par des pieds.

La bobine peut fonctionner avec deux circuits inducteurs qu'on utilise à tour de rôle. Deux personnes peuvent enlever l'un et lui substituer l'autre, en quelques minutes.

Le premier, qui sert aux longues étincelles et en réalité à la plupart des expériences, a un noyau



La plus grande bobine d'induction construite jusqu'à ce jour.

composé d'un faisceau de fils de fer de 8/10 de millimètre chacun, et formant ensemble un cylindre de 1m,10 de long et de 9 centimètres de diamètre. Il a un poids de plus de 30 kilog.

Le fil de cuivre qui constitue l'inducteur a une longueur de 600 mètres, un diamètre de 24 millimètres, une conductibilité de 95 centièmes, une résistance totale de 2,3 ohms., et un poids de 25 kilog. à peu près. Il est enroulé sur le faisceau de fils de fer, en 1344 spires disposées en 6 couches et se présente enfin sous la forme d'un cylindre de 1 mètre 6 centimètres, et d'un diamètre extérieur de 12 centimètres.

L'autre système inducteur, qui est destiné à fonctionner avec des piles de plus grande surface et à donner des étincelles courtes et nourries, pour des expériences de spectroscopie, a un noyau de fils de fer de 8/10 de millimètre comme les précédents, réunis ensemble et formant un cylindre de 1m,11 de long et de 97mm de diamètre. Le poids de ce noyau est de 41 kilog. Le fil de cuivre est le même que dans le premier circuit inducteur, mais le conducteur qui a 459 mètres de long est composé de 2 fils parallèles. Il est divisé en trois sections de chacune deux couches; leurs résistances sont respectivement 0,181, 0,211 et 0,231 ohms. La longueur du cylindre ainsi composé est de 1m,01 et son diamètre 14 centimètres. Le poids de ce fil est de 38 kilog.

Grâce à une disposition nouvelle, on peut disposer ces trois sections en une seule série, ce qui donne un conducteur de 4mm,87 de diamètres, ou en dérivation ce qui donne l'équivalent d'un conducteur unique de 14mm,65 de diamètre.

Ce fil inducteur a été employé pour fournir des étincelles de 86 centimètres de longueur (dans l'air

Nature. July 14. 1881.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, June 16.—"On Stratified Discharges. VI. Shadows of Striæ," by William Spottiswoode, P.R.S., and J. Fletcher Moulton, F.R.S.

One of the most interesting questions connected with the subject of stratified discharges is this: What is the physical, as distinguished from the electrical, nature of the striæ themselves? Are they, in fact, to be regarded as aggregations of matter possessing greater density than the gas present in the dark spaces, or are they to be considered as indicating merely special local electrical conditions? The fact of their having a definite configuration, especially on the side which is turned towards the negative terminal of the tube, that of their temperature being higher than that of the dark spaces, the manner in which they are affected by solid bodies, and other considerations, all tend to give support to the view that the striæ are loci of greater density than the dark spaces. Still it can hardly be said that as yet any experimental proof of this has been given sufficiently decisive to decide the question conclusively. And it is in the hope of contributing something towards the solution of this question that the following experiments are submitted to the notice of the Royal Society.

The two terminals of a Holtz machine were connected in the usual way with the two terminals of the tube, so as to produce a stratified discharge. A narrow strip of tin-foil, or a wire, was stretched along the tube opposite the column of striæ. The positive terminal of a second Holtz machine (in practice we used for this purpose a Töppler machine) was connected with the tin-foil, and the negative terminal with one (either) terminal of the tube. An air-spark, or interval across which sparks could pass, was interposed in the part of the circuit between the machine and the tin-foil. The effect of this arrangement was this: In the interval between two sparks the tin-foil and tube became charged like a Leyden jar; the tin-foil being the outer coating, charged positively, and the gas inside serving as the inner coating, charged negatively. When the spark passed across the interval mentioned above, the jar (*i.e.* the tube) became discharged, and the electricity previously held bound on the two coatings was set free.

When the first (say the "internal") machine was not working, or when it was disconnected, *i.e.*, when no regular discharge was passing through the tube, then, whenever a spark passed at the second (or "external") machine, a negative discharge with its accompanying Crookes' radiation took place from the inside of the tube next the tin-foil, and the opposite side of the tube became covered with a sheet of green phosphorescence (the tube being of German glass).

When, however, other things remaining as before, a discharge from the internal machine was sent through the tube, and a good stratified column was produced, it was found that the green phosphorescence was entirely cut off from the parts of the tube opposite to the striæ, while on the parts opposite to the dark spaces it remained, in the form of phosphorescent rings, as brilliant as before. The experiment was repeated with various tubes with various degrees of strength of current, and with various densities of gas (produced by heating a chamber of potash in connection with the tube). It may be added that when, as is sometimes the case, through greater exhaustion, the striæ became feebler in illumination and less compact in appearance, the shadows cast by them lost proportionally in sharpness of definition and in completeness of extinction of the phosphorescent light.

The brilliancy and definition of the phosphorescent rings may be increased by inserting a small Leyden jar in the circuit, care being taken that the jar shall discharge itself completely each time. If this is not the case the main discharge is followed by subsidiary discharges, which tend to blur the effect. The angle of dispersion may be increased, or rather supplemented, by placing more than one strip on the tube, distant from one another by an angle of 90° or 120°. By this means the rings may be made to comprise the entire circumference of the tube.

It thus appears that the striæ are competent to cast shadows in the radiant showers issuing from the inside of the tube adjacent to the tin-foil, which part acts as a negative terminal. Many experiments have contributed to show that these radiant showers, although accompaniments of the discharge, are not carriers of the discharge; and that, having once issued from their source, they continue their own course irrespective of that of the discharge proper. They are in fact material showers, and, although not improbably charged with electricity, yet their ulterior course does not appear to depend on their electrical condition. Under these circumstances the simplest explanation appears to be that they have been arrested by a material obstacle, and consequently the phenomena above described may be considered as furnishing an experimental proof that the striæ represent local aggregations of matter, and not merely special electrical conditions of the gas.

June 16.—"On Stratified Discharges. VII. Multiple Radiations from the Negative Terminal." By William Spottiswoode, P.R.S., and J. Fletcher Moulton, F.R.S.

On examining the image of a negative terminal as traced out in tubes of great exhaustion, by the phosphorescence due to Crookes' radiations, we have often noticed that the image was not a simple figure, but that more than one outline of the contour of the terminal might be traced. From the fact of the double contour having been first remarked when the terminal was of a conical form, it was at first supposed that the second image might be due to internal reflection, or to some property appertaining to the edge of the cone. But this supposition led to no satisfactory explanation of the phenomenon.

It was however thought that, inasmuch as the two images implied different systems of radiation, a magnet suitably disposed might affect them in different degrees, and thereby throw some light on their origin. For this purpose we used a large electro-magnet with its coils so coupled up as to give the two poles similar polarity. By bringing the two poles together, inclined at a moderate angle, a single pole and a field of great magnetic strength was produced.

The tube was then placed in the plane containing the axis of the two poles, and in the direction of a line bisecting their directions. The tubes first used were of great exhaustion, and were placed sometimes with the positive, sometimes with the negative terminal towards the magnet. When the tube was placed in a comparatively weak part of the field the two images of the cone were seen in their usual positions relatively to each other, except that they were slightly more separated. But as the tube was brought gradually into a stronger part of the field the two images became further separated, and by degrees a third, a fourth, and even more images were brought out on the side of the tube. In one tube of very high exhaustion, for which we are indebted to Mr. Crookes, as many as eight images became visible.

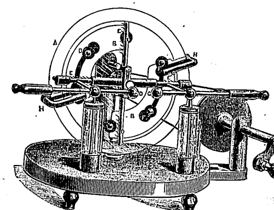
We have then, as an experimental fact, a series of images, each formed by a system of rays issuing from the surface of the negative terminal. The images being distinct, the system of rays must be distinct also. Now, as it seems hardly possible to imagine that, from every point of a surface, there can issue at one and the same instant of time a variety of systems of radiations, each system ranging over a finite angular distance, and each differently directed in space, we are driven to the conclusion that these radiations must have issued successively and not simultaneously from the terminal. In other words, the various images are formed in succession. Now, the entire series of images are present whenever a discharge passes through the tube; and when a "continuous" discharge (such as that from a Holtz machine) is passing, they are all as steady and as persistent as are any other features of the discharge. From this it follows that the radiations are not a continuous phenomenon, but that they are composed of a recurrent series of discharges, each having its own angular range, and its own direction in space; and as the electricity, which is the motive power, and the metallic terminal, which is the directing machinery, are the same in kind for each image, we are led to the conclusion that the positions of the images are determined by the force with which the radiations are projected. In fact, we understand that the various images are due to a succession of discrete discharges of successively diminishing strength.

The phenomenon of multiple images of the negative terminal as explained above has an important bearing on the nature of electrical discharges in vacuum tubes. For, if the phosphorising radiation consists of a recurring series of discrete discharges, the radiation in each series, and *à fortiori* the radiation as a whole, is discontinuous; and consequently the electrical discharge, to which it is due, must itself be discontinuous or "disruptive." We appear, therefore, in these phenomena to have an experimental proof, independent of and in addition to those adduced by Mr. De La Rue and others, of a fundamental point in the theory of these discharges, namely, their disruptive character.

42

VOSS'S INDUCTION ELECTRICAL MACHINE.

The modified Holtz machine, by Voss, possesses certain features rendering it of special value in this country, the most important of which is its independence of atmospheric conditions, as noted by the querist. The following particulars and drawing are taken from *Engineering*. The machine, in the fact that it is self-charging, requiring neither friction nor any outside initial charge to start it into action, nor is it necessary to bring the discharge terminals into contact, as in the Holtz machine, before commencing to work it, is perhaps the best in existence. On reference to the illustration it will be seen that the apparatus consists, like the Holtz machine, of two glass disks, unequal in diameter, of which the larger, A, is held in a fixed position, while the other is mounted upon a horizontal axis, and can, by means of multiplying gear, be rotated at a high velocity. To the front face of the larger plate are attached two pairs of tin foil disks, F F, F¹ F¹, each pair being connected together by a strip of tin concentric with it, is attached a metallic button of the form of a plano-convex lens, and these buttons, in the revolution of the plate, pass under and are lightly touched by the metallic brushes, F F, which are held by the bent arms, H H¹, the brushes being so adjusted as only to touch the buttons and not to come in contact with the glass of the rotating plate to which they are attached. E' and E' are two horizontal collecting combs, insulated from one another by being attached to a horizontal bar of ebonite, but connected respectively to the two discharge terminals, C and G, in the figure, and the distance between these terminals can be varied at pleasure by sliding them through the balls which are attached to the inner coatings of the two cylindrical Leyden jars by which the charge is accumulated and the discharge intensified. E¹ is a vertical bar of brass carrying at each end a comb, directed toward the rotating plate, as well as a pair of metallic brushes, similar to F and F, and



THE VOSS-HOLTZ ELECTRICAL MACHINE.

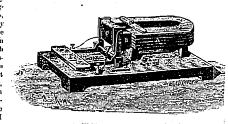
foil, and by a second strip to one of the two bent arms, H and H¹, by which they are connected to a light metallic brush directed toward the front face of the rotating plate. At the back of the fixed plate are pasted two paper coatings which correspond to what used to be called the paper "armatures" in the Holtz machine. To the face of the rotating plate are attached, at equal angular distances apart of 60°, and at a short distance from the circumference, six disks of tin foil (one of which is marked D in the figure), about an inch in diameter, corresponding in position and size with the tin foil disks upon the fixed plate, that is to say, if the disks, D, were numbered in rotation 1, 2, 3, 4, 5, and 6, those numbered 1 and 2 would, in a certain position of the rotating plate, correspond and be opposite to one connected pair of disks of the fixed plate; Nos. 4 and 5 would similarly correspond to the other pair, and Nos. 3 and 6 would have no disks on the fixed plate opposite to them. To each of the little tin foil disks, on the rotating plate and which also, in their turn, make momentary contact with the metallic buttons as they pass beneath them, and at a moment when they are not under the inductive influence of the metal disks of the fixed plate.

43

ON A NEW FORM OF MAGNETO-ELECTRIC EXPLODER.

BY MARCEL DEPREZ.

The different models of magnetic exploders that have been invented during the last thirty years present the inconvenience of being of considerable weight and size and of giving very small sparks. On seeking to arrange an apparatus of such a nature for the purpose of inflaming gaseous mixtures in gas engines, I have reached results that are much superior to those given by the models already known, both as regards weight and the intensity of the spark obtained. A few very simple theoretical considerations led me to think that if, instead of utilizing, as done up to the present time, the current directly produced on the bobbins of an electro-magnet when the latter is suddenly withdrawn from its close contact with a magnet, the current thus produced should be sent into the conducting wire of a Ruhmkorff coil—the induced wire being employed to produce the spark—the results would be better. Such a modification of the mode of operation of the apparatus carries with it certain others in its construction and in the relative sizes of the parts composing it. As the current which traverses the inducting wire of the bobbin must have a pretty great intensity, the wire wound on the electro-magnet of the exploder must be coarse; and, besides, the breaking of the inducting current produced by withdrawing the electro-magnet must take place when such current (which leaves zero to return thither in a very short space of time) passes through its maximum intensity. It was on seeking to satisfy this last-mentioned condition that I was led to invent the new interrupter for induction coils that I have described on a previous occasion. Finally, I discovered that the electro-magnets employed in the ordinary exploders contained too great a quantity of iron, and that it would be of interest to make them much smaller. These preliminaries stated, I shall now pass on to a description of the two models that I have had constructed in order to apply the principles that I have just enunciated. The first possesses a magnet weighing 1·9 kilogrammes, and the second a magnet weighing about 8 kilogrammes.



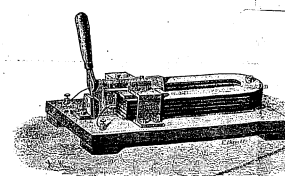
NEW MAGNETIC EXPLODER.

In the first of these models, shown in Fig. 1, the armature of soft iron, B, is connected with a rectangular frame movable around the point, D. It is formed of a piece of soft iron plate bent at its extremities at B, in such a way as to fit *very accurately* against the magnet, A, whose poles have been dressed in a polishing machine. This armature is surrounded by a coarse wire (nearly 2 millimeters in diameter) connected by electric wires to the terminals of the apparatus, which are themselves put in communication with a Ruhmkorff coil of small size.*

When it is desired to use the apparatus, a sharp blow is given to the small plate, E, and the screw of the interrupter of the induction coil is acted upon until the spark assumes a satisfactory aspect. With the small model there may be easily obtained a very hot spark of 3 millimeters in length, or a very brilliant one, destitute of an aureola, whose length may reach under favorable conditions at least 7 millimeters.

When the spring of the interrupter is given a feeble tension, two sparks may be obtained—the first at the moment of withdrawing, and the second when the armature is freely abandoned to the attraction of the pencil of magnetic rays. This latter may likewise be rendered very hot if its length be limited to about two millimeters. These two sparks develop a heat sufficiently great to set fire to a match moistened with naphtha, which is something that the sparks of the Holtz machine are incapable of doing, even when several hundred of them are directed against the moistened point.

Fig. 2 represents a more powerful model of a slightly different arrangement. The armature, A, is formed of a piece of soft iron plate 6 millimeters thick and 100 millimeters long, surrounded with a coarse wire, forming a bobbin, B. The whole is firmly joined to a brass frame movable around a horizontal axis which is in a line with the axis of the magnet, C D. The latter is provided at each extremity with two pieces of soft plate iron which are beveled off at the point at which the armature, A, rests against them. There are, then, always two of these pieces in close contact with A, and two others which are not, when the apparatus is at rest. If a smart blow be given the handle, F, so as to drive it, for example, from left to right, the magnetization of the plate, A, will not only be suddenly diminished, but even reversed, since it immediately abuts against the polar pieces of contrary name to those that it touched before the withdrawal. With this arrangement, then, more energetic effects ought to be obtained than with the preceding. Nevertheless, the apparatus that I have had constructed, although having an 8 kilogramme magnet, has not given effects that were proportionally as energetic as those afforded by the small model. I have not been able to cause it to produce sparks exceeding 10 millimeters, whatever was the size of the Ruhmkorff coil employed.—*La Lumière Electrique.*



NEW MAGNETIC EXPLODER.

A New Departure in Gunnery.

London papers state that the Superintendent of the Royal Gun Factories has adopted a new plan of increasing the initial velocity of projectiles. Having found by trial the description of slow-burning powder best adapted to his requirements, he has designed a contrivance for retaining the projectile in the chamber of the gun until the powder is sufficiently fired to set up a pressure of about two tons per square inch upon the base of the shot, which then starts at a bound, the speed of which is accelerated by the pursuit of the powder gases until it leaves the muzzle. The retention of the shot is accomplished by a ring of metal fixed around it near the base, and so regulated as to size that it will, when placed in the breech, be a trifle larger than the bore through which it has to pass. According to the resistance which it affords will be the period of retention. It has been demonstrated by experiments with fired gunpowder that in a very strong vessel the powder may be ignited and converted into gas, but yet held under subjection for an unlimited time. The retention ring is made of such strength that it will surrender at a given pressure, and the requisite conditions for the attainment of maximum velocities thus appear to have been realized. With the 10·4 inch gun a 402 pound shot has been fired at a muzzle velocity of 2,275 feet per second, the equivalent of which in energy is 16,500 foot tons, but as the powder charge was somewhat in excess of the service allowance it is fair to reduce this velocity by 100 feet. It will even then be far in advance of the speed attained under former conditions. The improvement has had a stronger illustration in a competitive trial between the two experimental 45 ton guns—that of Elswick manufacture, with the air-spaced chamber, and that of Woolwich, with the retention ring.

The former, with 350 pounds of powder (rather above its service charge), discharged a 700 pound projectile at a velocity of 1,900 feet per second; the latter, crammed with 400 pounds of powder and the same shot, recorded a speed of 2,120 feet. These figures represent in energy respectively 17,500 and 20,800 tons per foot, and the advantage in an attack upon armor plates may be assumed in the same proportion.

This improvement in gunnery, it is said, has created great satisfaction in the government departments, and great things are expected from it.

Menlo Park Scrapbook, Cat. 1055

No. 39. "Aerostatics"

This scrapbook covers the years 1880-1881 and contains clippings about aerostatics. There are 142 numbered pages.

Blank pages not filmed: 2-9, 22-142.

1055

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Eng. Mech. Sept. 3. 1880

ABSTRACTS OF REPORTS, PAPERS, &c.

39 **Finding the Heights of Clouds.**

Mr. Francis Galton read a paper upon "Determining the Heights and Distances of Clouds." He said that this might be done by their reflection in a low pool of water and in a mercurial horizon. The calm surface of a sheet of water might be made to serve the purpose of a large mirror, in a gigantic vertical range-finder, whereby a sufficiently large parallax might be made for the effective measurement of clouds. The observation of the height and thickness of the different strata of clouds, and of the rates of movement, was at the present time perhaps the most promising, as it was the least explored branch of meteorology. As there were comparatively few places in England where the two conditions were found of a pool of water, well screened from wind, and of a station situated many feet in height above it, the author hoped, by the publication of this memoir, to induce some qualified persons, who had access to favourable stations, such as existed in Wales, to interest themselves in the subject, and to make observations. The necessary angles might be obtained with a sextant and mercurial horizon; but it would be convenient to have in addition a tripod stand, with a bar of wood across the top to support the mercurial trough, with some simple instrument for the rapid and rough measurement of altitudes.

39 Aug 26 1880

NATURE Aug 26, 1880

A BALLOON ascent was made at Cherbourg, on the occasion of the *fête* given by the Municipality to M. Grévy, by MM. Perron and Capt. Gauthier. The general direction of the wind being from the land to the sea, a government steamer was sent out to secure the safety of the aëronauts if necessary. Before starting not less than thirty pilot-balloons were sent up to ascertain the superposition of the aërial currents. It was proved that at 400 metres the wind was blowing from the sea. After having travelled for more than an hour in the direction of Portsmouth, the aëronauts opened their valve and returned safely on shore. More than a hundred thousand spectators witnessed the experiment. The culminating point of the ascent was an altitude of 1,500 metres, where the travellers could see the English coast, the whole of the Isle of Wight, &c. The scenery is stated to have surpassed description. Some very curious observations were made on the colours of the sea. In the places where the water is very deep it looks quite inky, and the curves of level are so clearly manifested that they bear comparison with equidistant lines worked on ordnance maps. When travelling at so great an altitude ships can be detected with some difficulty; but smoke can be seen even when the smoke-producing steamer can hardly be perceived with the naked eye.

Engineering Aug 27 1880

12

BRAZILIAN RAILROADS.—Brazil has 1790 miles of railroad in operation, and 1087 miles in course of construction.

Engineering Aug 27 1880 39

THE BALLOON SOCIETY OF GREAT BRITAIN.—At a meeting held on Friday at the Society's rooms, 5, Robert-street, Adelphi, W. H. Le Fevre in the chair, twenty-five new members were elected, amongst others, Colonel Sandeman, Commander Cheyne, F. Bidder, Carl Voigh, F.R.G.S., F. C. Capel, J. Gracio, and Professor Kalthaler. The President opened the meeting by referring to the recent balloon voyage out to sea at Cherbourg. Mr. Simmons stated that when he some years ago made a similar trip at Hull he went 20 miles out to sea, and then got into an anticipated return current which he found a few feet above the outward current, and which safely landed him at the desired spot on *terra firma*. The President observed that this interesting fact confirmed the opinion he had entertained for many years past that the currents travel only in thin layers, and move in every direction at different altitudes. He trusted the Society would eventually be the means of accurately and scientifically determining the laws by which these currents were regulated or influenced, and thus utilising them for the purposes of travelling as well as for meteorological objects. Captain Morton stated that he travelled on the 4th of August 37 miles in 18 minutes, and the President remarked that in all his calculations for large structures he never calculated on the wind travelling more than 80 miles per hour. The discussion was continued by Mr. Spencer and Mr. Simmons, who stated that from their own experience they could confirm Captain Morton's statement. The President read a letter from a member of the Society who had made one of his ascents in a thunderstorm, and found the atmosphere at an altitude of about 200 ft., and for a height of 100 ft. to be of a dull leaden hue, but as soon as he had risen above this stratum he found the sky quite unclouded, and witnessed perfectly clearly the storm raging below in all its grandeur. After a short discussion as to the best mode and means of inflating balloons in the Arctic regions, in which Commander Cheyne and others took part, Mr. Gordon, the honorary secretary, reported the arrangements that had been made for the balloon contest on the 4th of September next, and for which the following aeronauts had entered, viz., Mr. Wright, Mr. Simmons, Mr. Youens, Captain Morton, and Messrs. Side, Orton, Barker, Spencer, Adams, and Jackson. The referee to be a member of the Council of the Aeronautical Society, the ascents to be made from the Crystal and Alexandra Palaces, Lillie Bridge, Wormwood Scrubs, Epping Forest, Hendon, Kensal Green, and Clapham Rink.

Engineering Sept 10 1880

Engineering Sept 10 1880

THE BALLOON SOCIETY OF GREAT BRITAIN.—At a meeting of the Executive Committee held at the office, 5, Robert-street, John-street, Adelphi, the President, W. H. Le Fevre, C.E., stated that the maximum distance travelled was 43¼ miles in 97 minutes, or at the rate of 26.907 miles per hour. A paper will be read before this Society by Mr. Simmonds, C.E., this evening, Friday, on "A New Form of Parakite."

39

Electrician Sept 9 1880

39 Electrician Sept 9 1880

AT the last meeting of the Balloon Society of Great Britain the recent balloon voyage out to sea at Cherbourg was referred to. Mr. Simmons stated that when he some years ago made a similar trip at Hull he went twenty miles out to sea and then got into an anticipated return current which he found a few feet above the outward current, and which safely landed him at the desired spot on *terra firma*. The president read a letter from a member of the Society who had made one of his ascents in a thunderstorm and found the atmosphere at an altitude of about 200 feet and for a height of 100 feet to be of a dull leaden hue, but as soon as he had risen above this stratum he found the sky quite unclouded, and witnessed perfectly clearly the storm raging below in all its grandeur. On Saturday afternoon a balloon contest took place from various points in the neighbourhood of London, under the auspices of the Balloon Society. Eight balloons were to have started, but only five succeeded in getting away. A silver medal was to be awarded to the balloon that traversed the greatest distance in one hour and a half. The competition seems to have had some connection with Commander Cheyne's proposed Arctic Expedition; but so far as we have ascertained no new scientific results seems to have been obtained. One balloon seems to have attained a height of 14,000 feet.

DURING the Session of the City and Guilds of London Institute, commencing October 4, Prof. Armstrong, F.R.S., and Prof. Ayrton, Inst.C.E., will continue their tutorial and laboratory courses of instruction in Chemistry and Physics as applied to the Arts and Manufactures, at the Cowper Street Schools, Finsbury, in rooms rented from the Middle Class Schools Corporation, pending the erection of the City and Guilds Technical College, Finsbury. Dr. Armstrong will deliver a course of about thirty lectures on "Organic Chemistry, with special Reference to its Industrial Applications," on Mondays, at 8.30 to 9.30 p.m., commencing October 4. He will also deliver a course of about twenty-four lectures on Tuesday and Friday afternoons at 4 to 5 o'clock, commencing October 5. Although the chief object of these lectures is to afford such preliminary training as is necessary for those who may desire later on to study particular branches of Applied Chemistry, more than usual attention will be given to matters of technical importance. There will also be daily Laboratory Classes. Prof. Ayrton will deliver a course of evening lectures on "Electrical Instrument Making," on Tuesdays at 8.30 to 9.30 o'clock, commencing October 5, the first twelve of the lectures being given before Christmas. On Friday evenings, at 8.30 to 9.30 o'clock, commencing October 8, Prof. Ayrton will also deliver a course of lectures, the first twelve being given before Christmas, on "Weighing Appliances and Motor Machinery," adapted to the wants of makers and users of machinery. He will also deliver a course of about twenty-four lectures on Monday and Wednesday afternoons, at 4 to 5 o'clock, commencing October 4, on the "Electric Light."

Oct 8 18[80]

MILITARY BALLOONING.

The Balloon Committee have been trying practical experiments as to how far it is safe for a "scouting" balloon to approach an enemy's lines, and the result of their inquiry has been most decisive upon this point. It is not so easy as it may at first sight appear to rise swiftly over the heads of friends and foes to a point of vantage whence every manœuvre may be watched with facility and safety. In the experiment which came off at Dungeness last week, one of the service balloons, such as would be employed for the ascent of one or two persons, was inflated and sent up, captive, to a height of about 800 feet, and at a distance of about 2000 yards from a battery furnished with one of the new 8-inch howitzers. The second shot was aimed and fired so deftly that it burst just in front of the balloon, a number of the fragments of the shell penetrating its envelope and lacerating it to such an extent as to bring it down in a very short time. The success of the experiment, in showing that scouts in the air cannot consider themselves safe when within the range of a field gun, was no doubt highly gratifying to the officers conducting it, but it will in no wise detract from the value of balloons for military purposes. 39

ON THE AURORA AND ZODIACAL LIGHT OF MAY 2, 1877.—Abstracted from a paper by Mr. Henry C. Lewis, at the American Association for the Advancement of Science. "A simultaneous appearance of an aurora and the zodiacal light appeared on this evening, and a comparison between them is here given. The various changes of the aurora are given in detail. A remarkable feature was the formation of a bright streamer which maintained its position relative to the earth for nearly an hour. Meanwhile, the zodiacal cone, which was bright early in the evening, had moved past the streamer and passed below the horizon. The streamer had remained, like the great pointer, fixed to the earth, and marking its motion, while the heavens revolved past it. This fact was conclusive evidence of the terrestrial character of the aurora and of the cosmical character of the zodiacal light. Another fact leading to the same conclusion was the character of their spectra. That of the zodiacal light was continuous, and that of the aurora was a line-spectrum—the former is such as would be given by sunlight reflected from matter in space; the latter would be given by an electric discharge through a gas." 39 Electrician Oct 9 1880

Electrician Oct 4 1881

ON A NEW METHOD OF AERIAL LOCOMOTION.

WITHOUT denying altogether the possibility of directing balloons, it must be admitted that all the great amount of human ingenuity applied for solving that problem has thus far given but very little practical result.

If we turn from this method of "floating" to that of "flying," by which the elevating as well as the propelling force had to be obtained by means of wings or propellers driven by manual or steam power, we will find that here too the result is hardly a positive one, as up to this day the weight of the motors applied has always been found to be too great in proportion to their motive force. Now, although it is very probable that in course of time this proportion of weight to power will greatly be altered in favor of the latter, still for the present no practical solution of that difficulty has been suggested.

But is there besides the two already mentioned methods, no third one by which we could overcome the attraction of the earth?

Our answer is, Yes; there is a third method, based on a well known principle, which, however, up to this time has not been given due attention by inventors, and we may almost say by scientific men, as in several books on natural sciences and mechanics, I hardly found any allusion to the following phenomena.

Let us suppose a hollow cylinder to contain gas under a high pressure; the moment we allow the gas to rush out one end, the cylinder will be pushed in the opposite direction by a force which will be proportional to the pressure of the gas and to the size of the opening. It is evident, however, that by the same cylinder we do not gain anything in effect by enlarging the opening, as by such a process we only augment the intensity of the force at the expense of its duration.

But if we succeeded in maintaining the inner pressure for a longer time without diminishing too much the size of the opening, we would obtain a continuously acting force which we might try as a motive power.

Now, the above condition can actually be realized for a certain length of time by filling the cylinder with a mixture of such solid bodies as, by being set fire to, will develop gases just as rapidly as these can flow out by the opening.

This is the way the motive force is obtained which drives the fire rocket with such astonishing velocity high into the air; and it is strange indeed that more attention has not yet been given to this kind of propulsive power, when the great number of failures already in the two over and over beaten tracks, ought to have forced aeronautical inventors to try in a new direction. Without entering too far into the failures that tried to frighten me out of these researches, I will relate briefly those only of the experiments that I think conclusive in this matter.

An iron tube 6 inches long by 1¾ interior diameter was fastened to a kind of suspended carriage, which by means of two wheels (one placed behind the other) could run easily on a wire stretched between two trees at the distance of 35 yards. One end of the tube was closed, the other had a thread for a screw cut over it, so that by means of a set of iron caps (having each one a different sized hole in its center) the opening could be reduced to 8, 6, 4, 3, 2, or 1 millimeter. The tube was filled with a composition as used for fire-rockets. First, no cap was screwed on, and the 150 grammes, taking about 14 seconds to burn out, had not been able to move the carriage weighing 2 kilogrammes. Next the 8 millimeter opening was employed. The result was only a total advance of about 6 yards by short, irregular jerks. The 6 millimeter cap had a far better result, as the carriage, beginning with a slow motion, traversed the entire distance in about 11 seconds, *i. e.*, before the charge was burnt out.

With the 4 millimeters the distance traversed at the end of the first second was over 1 meter, or very nearly equal to the effect produced by a well made fire rocket which burned about the same quality of powder per second; and the entire distance was run in seven seconds. With the 3 millimeter opening the carriage was, in less than five seconds, dashed with such force against the second tree that the wheels broke down. After remedying the accident, I expected from the 2 millimeter a much more brilliant success, but was entirely disappointed, as the carriage, although started with a high velocity, suddenly came to a standstill at the middle of the distance. On examining the tube I found the marks that gas had escaped between the tube and the cap, and as this escape took place in a direction contrary to that originally intended, it explained the standstill. This opinion was corroborated by lighting the 1 millimeter; as here the carriage, hardly it began to move, was hurled back again to the point of starting.

I intended (then in Paris) to continue these experiments, but previous engagements obliged me to leave for South America, where I could do nothing in this matter. Now, however, when after some years I again came to this country, where new ideas are not regarded with such distrust as in the Old World, I will try to take up again these researches, as it seems very probable that, besides the scientific interest, there can a practical result be reached, if this matter only be taken up with sufficient vigor. Now, in my former experiments the most of motive power obtained from 1 gramme composition was to impart to a mass of 75 grammes a velocity of 12 meters at the end of the first second; in other words, by burning 1 gramme of fuel per second we could overcome the weight of 75 grammes, and give that mass an additional velocity of over 2 meters at the end of the first second. But as the cylinders I was experimenting with could not have resisted more than 25 atmospheres, and as the velocity of gases issuing under 250 atmospheres must be considerably higher than the one that gave this result, it follows that the quantity of motive force obtained can be greatly augmented by employing cylinders of a greater resistance. To what limit the pressure, and consequent useful effect, can be brought advantageously, *this* must be the object of the next experiments, and this is the point which will decide whether this invention has to obtain a practical application or will only remain a scientific curiosity.

The objection that what we gained in effect by higher pressures we would have to lose by the necessarily greater weight of the more resisting cylinders: this objection only would hold good in case we imitated the construction of a fire rocket, where a cylinder capable of resisting the intended pressure holds all the fuel that is to be burnt during the entire traject.

The remedy is obvious. Far more serious objection to this kind of motors will be found in the price of the work, but I leave this question, as it would be impossible to discuss it before conclusive experiments shall not be made.

It is, however, to be supposed that even by an extremely high price it would find several applications, being able to fulfill several conditions not otherwise to be realized, among whom not the least curious is the circumstance that such a motor could do work even if placed above the atmosphere.

CHARLES SARKADY.

New York, November 1880.

13

14

FLIGHT OF BIRDS—"FIDDLER" ON VIBRATIONS—PHYSICAL HYPOTHESES.

[17903.]—In letter 17847, p. 33, F. H. Wenham, though, to my thinking, right in his views that the swiftly advancing plane will not descend so rapidly as the passive, has yet fallen into a slight error in introducing the very fascinating theory that the weight of the air passed over is effective in supporting the plane, because a flying machine at a greater height above the ground would pass over a greater quantity of air than at a lower elevation. He also appears to consider that the problem is directly in the proportion of weights, in the same way as a lever or a system of pulleys is equilibrated. Now the efficient factor is the inertia of the air. Of course inertia is proportional to mass, or weight; but what it is to be determined is, what depth of air ought to be taken into account. An illustration of the elastic inertia of a fluid occurs to me. The still surface of a sheet of water may be struck so smartly by the hand as to produce a sharp tingling, and those who practise jumping into water are aware how frequently the inexperienced receive stinging blows from the violent percussion of a flattish part of the body—the abdomen, back, or even the head—against the previously unmoving surface of the water. By the way, exception was taken by one some time back to the expression (quoted from the Duke of Argyll's "Reign of Law") "momentum of a motionless body." No doubt it is paradoxical, but not wholly meaningless. The "inertia"

fact, but as the South American contrivance does not appear to have been witnessed by "H. A." himself, he will, perhaps, not feel hurt if I say that if the floating kite in some degree resembled the account he gives of it, yet we may be sure that some important matter of fact must have been overlooked in the description. My incredulity arises from the following considerations:—

(1) The kite, so soon as liberated, being wholly immersed in the current of wind, would go to leeward as fast as the wind, and there would, therefore, be no air pressing against its sloping surface to maintain it.

(2) The streamers from the same cause would be inoperative.

"Fiddler" (17819) quotes me (17801) "Vibration is not the motive power." The words I used are, "Vibration *in the cases mentioned by 'Fiddler,'*" &c., my allusion of course being to the facts mentioned in his letter (17752); and the case to which he now applies my remark is not (in the way in which he uses it) analogous. Vibration is, undoubtedly, as its very definition implies, a form of motion, and, as such, is a motive power. As matter is indestructible, so motion is continuous. Motion does not *make* heat; heat *is* motion, and the amount of work contained in a heated body is the momentum of the moving molecules; that is to say, it is a function of their *mass* and *velocity*. Light and sound also are motion, and so, no doubt, is electricity. There is no difference of the kind "Fiddler" supposes between light and heat. One is neither more attractive nor more diffusive than the other.

The only difference is that the movements (heat) which, while they fail to excite our eyes, are yet perceived as warmth by the nerves of the skin, are slower, and generally more ponderous, than those which we perceive as light. They contain more motion, and therefore yield more to the radiometer. "Fiddler" is wrong in supposing that the electric light has no action on the vanes. The vanes are moved by the molecules of air remaining in the so-called vacuum, not by the heat itself. When the vacuum is more nearly perfect, the motion lessens and finally ceases. I cannot conceive why he calls heat "fixed vibrations," and light "free vibrations." There is no such difference whatever. The burning-glass concentrates both light and heat. Growing plants do not repulse light. The "electrical action when in the dispensing mode" is quite beyond my powers of comprehension. I try not to laugh at "Fiddler."

In the pretty experiment he describes, the sides of the tumbler move out and in at regular intervals. The intervals are small, because the tumbler is small; but nevertheless they shake, or move, the split match backwards and forwards, and that causes the mill to turn round, just in the same way as "Fiddler" might twirl a hooked stick round by a backward and forward movement of the hand. Electricity must be looked upon as motion of some kind. With it, though "Fiddler" says we can't, we can get power without fire or boiler, as in electro-motive machines.

"Mockerasheta" (17850) appeared desirous of understanding the undulatory theory. Of course, I don't pretend to the least particle of originality, and he would do best to read Herschel's "Familiar Lectures," where he will be learning from "one who knew."

If two series of ring-shaped waves are formed upon the surface of a placid pond they proceed to the edges of the pond practically unaltered in their shapes, period, and energy from what they would be if either were formed alone. And yet they interfere, the one with the other, at the points of their intersection. Where crest crosses crest a pile higher than either wave is formed. Trough crossing trough produces a pit deeper than either trough. Crest crossing trough produces level. Look at the surface of a bay or estuary during a breeze. There roll the remains of the great sea waves formed away in the ocean by the accumulations of petty waves superimposed one on another. Their line in consequence of the retarding influence of long-shore friction tends to become parallel to the general coast line, and they therefore roll in at the bay's mouth, stretching almost straight across. Now, the bay itself being a miniature ocean, has its ripples, its wavelets, and its billows. These, in their due places, starting from the sheltered side in the order named, roll superimposed upon, or crossing the others, and where they have attained a sufficient size to be easily distinguishable, and where, also, the direction of the wind sends them across the greater sea-waves they serrate their

concentrated on their point of origin in the centre of the pond. Meeting the new waves constantly radiating at the same speed, the surprising phenomenon of stationary waves will be observed. I must not, however, attempt to use any more illustrations.

"Mockerasheta" states that the "rays" (or, as he ought to have said, "waves") [of light] "never interfere." In this he is of course completely wrong. The phenomena of interference may be said to be one of the most important supports of the undulatory theory. What would "Mockerasheta's" surprise be to learn that the phenomena of diffraction must be taken to establish the fact that not only is there interference, but that every point on the surface of every advancing wave of light must form a new centre from which spherical waves are originated. For the solution of this and the other points upon which he is "mixed up," I must respectfully refer him to a treatise on optics.

To revert to water-waves. As we stand on a gradually sloping shore watching the waves roll in, we find that there are maximum waves which roll much farther than others. These are the crests of very much larger waves upon which the others are superimposed.

Wetherby, 17 Sept. Severg.

FLIGHT OF BIRDS.

[17935.]—Some years ago, in Ceylon, a brother planter and myself were out with our guns. Seeing a very large hawk, or eagle, flying over our heads, my companion fired, hit him and brought him tumbling to the ground nearly at our feet. On approaching him we found that, although severely wounded, he was far from being mortally hurt. His ugly beak, formidable claws, and menacing eyes, warned us that danger lurked in treating him with too much familiarity. The utmost we ventured to do, though he lay perfectly still, was each to take hold of the tips of his wings in order to stretch them out between us to their utmost extent, to judge of his size, and to admire their enormous spread. We, then, in mere wantonness, swung him backwards and forwards several times between us, and finally launched him forward with all our strength to see how far we could throw him. Imagine our surprise to see him sail majestically away without the slightest visible motion of his wings, unchanged from the outstretched spread which our conduct had given them, to the hills on the other side of the valley. We stood nearly at the top of a ridge of hills sloping to a deep and wide valley. The direction of his flight was downward, along a slightly-inclined plane.

R. W. I.

[17936.]—I shall confine my notice of Mr. Wenham's letter to the machines proposed by him, page 38 and 62.

First, as regards the former, I am surprised to find that I have been "egotistic, and risking my assumed authority," in supposing that the laths were placed at ¼in. distance. I did not intend to imply that a distance of that amount was required by the machine; but I really supposed that was Mr. Wenham's own idea, although, by omission, not explicitly stated. My reason for this was, that then all the air met by the machine would be opposed by some portion of aëroplane. It was not in consequence of any estimate of the forward resistance.

This resistance is stated by Mr. Wenham to be unknown to him; but then he has ascertained, I presume, the vertical resistance to be precisely 300lb. For "this angle or rise, represented as 1 in 63, it will be that required to be given to the aëroplanes to maintain the equilibrium and the level of flight, and sustain the weight of 300lb." So that the vertical resistance must be 300lb. Further, the resistance to a plane constantly kept at the same angle to line of motion, and moving horizontally with a given velocity, must be the same as if it moved vertically with the same velocity and angle. Now, when a plane descends vertically, the resistance has been supposed by Mr. Wenham to be that given by Smeaton, which would be, therefore, one would suppose, at all events, an approximate working hypothesis for the horizontal or forward resistance. But this is of comparatively little moment, only making the arrangement, to my comprehension, a shade more inscrutable. The important point is the assumption of one minute. That "actuating weights may be represented by an angle composed of the two forces" may be true, but I have not the least idea of the meaning. But that "actuating weights may be considered, irrespective of any given time," I think I agree with. I suppose it would include the assertion that when weights are in equilibrium they are in equilibrium always. But unfortunately Mr. Wenham's conclusion entirely depends upon the assumption of one minute. He says 300lb. is the 63rd part of 85 tons, which passes through the machine in one minute, and that therefore the rise is to be 1 in 63 to support 300lb. But if the time is of no consequence, take one second as an "illustration merely," then the quantity of air would be one-sixtieth part of 8·5 tons, and the rise by the same reasoning would be 1 in 3,600. Or, if we take one hour, the quantity of air would be 60 times 8·5 tons, and the rise would be 1 in 1; that is, the plane would have to be vertical, and if more than one hour, the reasoning would not apply at all. Further, if the forward resistance is unknown, how did Mr. Wenham know, except from his "inner consciousness," that the aëroplane required might not be many times too large to be included in the space of 72 square feet, being 18 inches wide.

The arrangement given, page 62, is liable to similar objections in an intensified form. There can be no question as to the theory of the rotated lamina, in which category falls the theory of wing-flapping, whether the wings be stationary or in motion, paddle-wheels, and screws in motion. But upon further reflection with regard to a descending horizontal plane with horizontal velocity, if the velocity were not supposed to vary, and if the path were not curvilinear, the resistance would be the same as if the body descended vertically with the velocity of the body in its path, and with the plane at the same angle to the line of motion, and the stream lines would be steady. The resistance being ordinary, of course, when the plane and line of motion is absolutely horizontal, the pressure above and below is exactly equal, being the hydrostatic, and the resistance is absolutely nil, even if the velocity were a million miles per hour.

There are many things in Mr. Wenham's letter, page 87, that I could take exception to; but I will confine myself to one statement, page 88, third column:

"A body weighing 21lb. and descending with a velocity (supposed terminal in air) of 1,320ft. would expend upon the air nearly 81 H.P., that is 27,000 ft.-lb. per minute. But then, as a corollary it is stated that the same H.P., or, indeed, more is required to raise the body upon a yielding support like air." No height is here mentioned, but surely an ascent of a mile requires a larger total expenditure than an ascent of an inch. At the risk of making an exhibition of "egotism," I suppose an ascent of 1320ft. per minute is intended. Now, there is no necessary connection between the energy wasted upon the air during a descent of 1320ft. and the H.P. required to lift the bird the same height. In H.P. the idea of time is involved. To lift the bird 1,320ft. by action upon the air would certainly require an expenditure of more than 27,000ft.-lb.

Let us suppose to fix the idea that 54,000ft.-lb. was required. But if one hour was occupied in the ascent the bird need not have more than 1-10th of a H.P. to accomplish the ascent.

I do not know whether the definitions of inertia given by "Severg," page 86, are familiar to any of your readers. They are new to me. One is "that inertia is proportional to the weight of the body into its velocity, and has the same value as momentum." Consequently, the inertia of a body not in motion is zero—that is, has no inertia, which shows clearly that inertia is not an essential property of matter. Again, momentum implicitly defined above as proportional to weight into velocity would be different for the same body and velocity at different distances from the earth's surface, which I was before unaware of.

I am not sure whether the idea is also intended, apparently in opposition to the previous definition, that a body at rest, but impinged upon by another body, has really inertia proportional to its own weight into the velocity of the other body. At all events, we have the information that if two bodies impinge upon one another, one being at rest and the other having velocity, the "force" is the same whichever body has the velocity. By force is, I presume, meant energy expended. That is to say, it makes no difference to me whether I fall on a mountain with a velocity of say 20ft. per second, or whether the mountain falls upon me with the same velocity. This is another novelty.

Page 86, third column, the same gentleman has made another discovery, which might perhaps be appropriately termed the atomic theory of time. It appears that "a period of time (that is, a portion of time) really consists of small portions of time." To say that a portion of time really consists of portions of time, is a very little more than saying that time consists of time, or at all events, that time may be conceived as divisible, which will scarcely be considered as information so valuable as to deserve any particular pointing out. But it is the word "small" which is the pivot which implies that no large portions are possible, otherwise, why say small? The word "large" would be quite as appropriate. This discovery may be expected to throw a flood of light upon the constitution of time, and merits special recognition.

"For the future, I will no longer stand in Mr. Wenham's way in matters connected with aërial navigation, for this will be my last utterance upon that subject.

W. C. E.

AERIAL FLIGHT.

(*Continued from page 89.*)

[17937.]—Experiments have been made to test resisting the power of conical bodies of various forms in the following manner:—A thin lath was placed horizontally, so as to move freely on a pivot set midway; at one end of the lath a circular card was attached, at the other end a sliding clip traversed, for holding paper cones, having their bases the exact size of the opposite disc. The instrument acted like a steelyard; and when held against the wind, the paper cones were adjusted at different distances from the centre, according to their forms and angles, in order to balance the resistance of the air against the opposing flat surface. The resistance was found to be diminished nearly in the ratio that the height of the cone exceeded the diameter of its base.

It might be expected that the pull of the string of a flying kite should give some indication of the force of inclined surfaces acting against a current of air; but no correct data can be obtained in this way. The incline of the kite is far greater than ever appears in the case of the advancing wing-surface of a bird. The tail is purposely made to give steadiness by a strong pull backwards from the action of the wind, which also exerts considerable force on the suspended cord, which for more than half its length hangs nearly perpendicularly. But the kite, as a means of obtaining unlimited lifting and tractive power, in certain cases where it might be usefully applied, seems to have been somewhat neglected. For its power of raising weights, the following quotation is taken from vol. xii. of the *Transactions of the Society of Arts*, relating to Captain Dansey's mode of communicating with a lee shore. The kite was made of a sheet of holland exactly 9ft. square, extended by two spars placed diagonally, and as stretched spread a surface of 55 square feet. "The kite, in a strong breeze, extended 1,800 yards of line five-eighths in circumference, and would have extended more had it been at hand. It also extended 360 yards of line, 1½in. in circumference, weighing 60lb. The holland weighed 3¼lb.; the spars, one of which was armed at the head with iron spikes, for the purpose of mooring it, 6¾lb.; and the tail was five times its length, composed of 8lb. of rope and 14 of elm plank, weighing together 22lb."

We have here the remarkable fact of 92¼lb. carried by a surface of only 55 square feet.

As all such experiments bear a very close relation to the subject of this paper, it may be suggested that a form of kite should be employed for reconnoitering and exploring purposes, in lieu of balloons held by ropes. These would be torn to pieces in the very breeze that would render a kite most serviceable and safe. In the arrangement there should be a smaller and upper kite, capable of sustaining the weight of the apparatus. The lower kite should be as nearly as practicable in the form of a circular flat plane, distended with ribs, with a car attached beneath like a parachute. Four guy-ropes leading to the car would be required for altering the angle of the plane—vertically with respect to the horizon, and laterally relative to the direction of the wind. By these means the observer could regulate his altitude so as to command a view of a country, in a radius of at least twenty miles; he could veer to a great extent from side to side, from the wind's course, or lower himself gently, with the choice of a suitable spot for descent. Should the cord break, or the wind fail, the kite would, in either case, act as a parachute, and as such might be purposely detached from the cord, which then being sustained from the upper kite, could be easily recovered. The direction of descent could be commanded by the guy-ropes, these being hauled taut in the required direction for landing.

The author has good reasons for believing that there would be less risk associated with the employment of this apparatus than the reconnoitring balloons that have now frequently been made use of in warfare. The practical application of these suggestions appears to have been anticipated some years previously. In a small work, styled the "History of Charvolant, or Kite Carriage," published by Longman and Co., appears the following remarks:—"These buoyant sails, possessing immense powers, will, as we have before remarked, serve for floating observatories. . . . . Elevated in the air, a single sentinel, with a perspective, could watch and report the advance of the most powerful forces, while yet at a great distance. He could mark their line of march, the composition of their force, and their general strength, long before he could be seen by the enemy." Again, at page 53, we have an account of ascents actually made, as follows:—"Nor was less progress made in the experimental department, when large weights were required to be raised or transposed. While on the subject, we must not omit to observe that the first person who soared aloft in the air by this invention was a lady, whose courage would not be denied this test its strength. An arm-chair was brought on the ground, then lowering the cordage of the kite by slackening the lower brace, the chair was firmly lashed to the main-line, and the lady took her seat. The main-brace being hauled taut, the huge buoyant sail rose aloft with its fair burden, continuing to ascend to the height of 100 yards. On descending, she expressed herself much pleased with the easy motion of the kite, and the delightful prospect she had enjoyed. Soon after this, another experiment of a similar nature took place, when the inventor's son successfully carried out a design not less safe than bold; that of scaling, by this powerful aërial machine, the brow of a cliff 200ft. in perpendicular height. Here, after safely landing, he again took his seat in a chair expressly prepared for the purpose, and, detaching the swivel-line, which kept it at its elevation, glided gently down the cordage to the hand of the director. The buoyant sail employed on this occasion was thirty feet in height, with a proportionate spread of canvas. The rise of the machine was most majestic, and nothing could surpass the steadiness with which it was manœuvred; the certainty with which it answered the action of the braces and the ease with which its power was lessened or increased. . . . . Subsequently to this, an experiment of a very bold and novel character was made upon an extensive down, where a wagon with a considerable load was drawn along, while this huge machine, at the same time, carried an observer aloft in the air, realising almost the romance of flying."

It may be remarked that the brace-lines here referred to were conveyed down the main-line and managed below; but it is evident that the same lines could be managed with equal facility by the person seated in the car above; and if the main-line were attached to a water-drag instead of a wheeled car, the adventurer could cross rivers, lakes, or bays, with considerable latitude for steering and selecting the point of landing, by hauling on the port or starboard brace-lines as required. And from the uniformity of the resistance offered by the water-drag, this experiment could not be attended with any greater amount of risk than a land flight by the same means.

The wings of all flying creatures, whether of birds, bats, butterflies, or other insects, have this one peculiarity of structure in common. The front, or leading edge, is rendered rigid by bone, cartilage, or a thickening of the membrane; and in most birds of perfect flight, even the individual feathers are formed upon the same condition. In consequence of this, when the wing is waved in air, it gives a persistent force in one direction, caused by the elastic reaction of the following portion of the edge. The fins and tails of fishes act upon the same principle. In the most rapid swimmers these organs are termed "lobated and pointed." The tail extends out very wide transversely to the body, so that a powerful impulse is obtained against a wide stratum of water, on the condition before explained. This action is imitated in Macintosh's screw-propeller, the blade of which is made of thin steel, so as to be elastic. While the vessel is stationary, the blades are in a line with the keel, but during rotation they bend on one side, more or less, according to the speed and degree of propulsion required, and are thus self-compensating; and could practical difficulties be overcome, would prove to be a form of propeller perfect in theory.

In the flying mechanism of beetles there is a difference of arrangement. When the elytra, or wing-cases, are opened, they are checked by a stop, which sets them at a fixed angle. It is probable that these serve as "aeroplanes," for carrying the weight of the insect, while the delicate membrane that folds beneath acts more as a propelling than a supporting organ. A beetle cannot fly with the elytra removed.

The wing of a bird, or bat, is both a supporting and propelling organ, and flight is performed in a rapid course, as follows:—During the down-stroke it can be easily imagined how the bird is sustained; but in the up-stroke, the weight is also equally well supported, for in raising the wing, it is slightly inclined upwards against the rapidly passing air, and as this angle is somewhat in excess of the motion due to the raising of the wing, the bird is sustained as much during the up as the down-stroke—in fact, though the wing may be rising, the bird is still pressing against the air with a force equal to the weight of its body. The faculty of turning up the wing may be easily seen when a large bird alights; for after gliding down its aërial gradient, on its approach to the ground it turns up the plane of its wing against the air; this checks its descent, and it lands gently.

F. H. Wenham.

(*To be continued.*)

14 16 39

AERIAL FLIGHT.

[17860.]—The subject of aërial flight is now attracting much attention from your correspondents, some of whom appear to be men of very considerable ability, well capable of seeing and discussing the question on theoretical grounds.

I have much to say ultimately on the subject myself, but I should have so often to quote or refer to the experiments described in the following paper that it has occurred to me that you might be willing to publish the paper itself, as it is out of print, and has never been transcribed beyond the reports of the Society, so that it would be quite new to most of your readers.

F. H. Wenham.

At the first meeting of the Aëronautical Society, held at the great room of the Society of Arts, on the 27th of June, 1866, His Grace the Duke of Argyll in the chair, The following paper was read by F. H. Wenham, Esq., C.E.:—

"On Aerial Locomotion and the Laws by which Heavy Bodies Impelled through Air are Sustained."

The resistance against a surface of a defined area, passing rapidly through yielding media, may be divided into two opposing forces. One arising from the cohesion of the separated particles; and the other from their weight and inertia, which, according to well-known laws, will require a constant power to set them in motion.

In plastic substances, the first condition, that of cohesion, will give rise to the greatest resistance. In water this has very little retarding effect, but in air, from its extreme fluidity, the cohesive force becomes inappreciable, and all resistances are caused by its weight alone; therefore, a weight, suspended from a plane surface, descending perpendicularly in air, is limited in its rate of fall by the weight of air that can be set in motion in a given time.

If a weight of 150lb. is suspended from a surface of the same number of square feet, the uniform descent will be 1,300 feet per minute, and the force given out and expended on the air, at this rate of fall, will be nearly six horse-power; and, conversely, this same speed and power must be communicated to the surface to keep the weight sustained at a fixed altitude. As the surface is increased, so does the rate of descent and its accompanying power, expended in a given time, decrease. It might, therefore, be inferred that, with a sufficient extent of surface reproduced, or worked up to a higher altitude, a man might by his exertions raise himself for a time, while the surface descends at a less speed.

A man, in raising his own body, can perform 4,250 units of work—that is, this number of pounds raised 1ft. high per minute—and can raise his own weight—say, 150lb.—22ft. per minute. But at this speed the atmospheric resistance is so small that 120,000 square feet would be required to balance his exertions, making no allowance for weight beyond his own body.

We have thus reasons for the failure of the many misdirected attempts that have, from time to time, been made to raise weights perpendicularly in the air by wings or deceding surfaces. Though the flight of a bird is maintained by a constant reaction or abutment against an enormous weight of air in comparison with the weight of its own body, yet, as will be subsequently shown, the support upon that weight is not necessarily commanded by great extent of wing-surface, but by the direction of motion.

One of the first birds in the scale of flying magnitude is the pelican. It is seen in the streams and estuaries of warm climates, fish being its only food. On the Nile, after the inundation, it arrives in flocks of many hundreds together, having migrated from long distances. A specimen shot was found to weigh twenty-one pounds, and measured ten feet across the wings, from end to end. The pelican rises with much difficulty, but, once on the wing, appears to fly with very little exertion, notwithstanding its great weight. Their mode of progress is peculiar and graceful. They fly after a leader, in one single train. As he rises or descends, so his followers do the same in succession, imitating his movements precisely. At a distance, this gives them the appearance of a long undulating ribbon, glistening under the cloudless sun of an Oriental sky. During their flight they make about seventy strokes per minute with their wings. This uncouth-looking bird is somewhat whimsical in its habits. Groups of them may be seen far above the earth, at a distance from the river-side, soaring, apparently for their own pleasure. With outstretched and motionless wings, they float serenely, high in the atmosphere, for more than an hour together, traversing the same locality in circling movements. With head thrown back, and enormous bills resting on their breasts, they almost fall asleep. A few easy strokes of their wings each minute, as their momentum or velocity diminishes, serves to keep them sustained at the same level. The effort required is obviously slight, and not confirmatory of the excessive amount of power said to be requisite for maintaining the flight of a bird of this weight and size. The pelican displays no symptom of being endowed with great strength, for when only slightly wounded it is easily captured, not having adequate power for effective resistance, but heavily flapping the huge wings, that should, as some imagine, give a stroke equal in vigour to the kick of a horse.

During a calm evening, flocks of spoonbills take their flight directly up the river's course; as if linked together in unison, and move by the same impulse, they alter not their relative positions, but at less than fifteen inches above the water's surface, they speed swiftly by with ease and grace inimitable, a living sheet of spotless white. Let one circumstance be remarked,—though they have fleeted past at a rate of near thirty miles an hour, so little do they disturb the element in which they move, that not a ripple of the placid bosom of the river, which they almost touch, has marked their track. How wonderfully does their progress contrast with that of creatures who are compelled to drag their slow and weary way against the fluid a thousandfold more dense, flowing in strong and eddying current beneath them.

Our pennant droops listlessly, the wished-for north wind cometh not. According to custom we step on shore, gun in hand. A flock of white herons, "buffalo-birds," almost within our reach, run a short distance from the pathway as we approach them. Others are seen perched in social groups upon the backs of the apathetic and mud-begrimed animals whose name they bear. Beyond the ripening dhourra crops which skirt the river-side, the land is covered with immense numbers of blue pigeons, flying to and fro in shoals, and searching for food with restless diligence. The musical whistle from the pinions of the wood-doves sounds cheerily, as they dart past with the speed of an arrow. Ever and anon are seen a covey of the brilliant, many-coloured partridges of the district, whose long and pointed wings give them a strength and duration of flight that seems interminable, alighting at distances beyond the possibility of marking them down, as we are accustomed to do with their plumper brethren at home. But still more remarkable is the spectacle which the sky presents. As far as the eye can reach it is dotted with birds of prey of every size and description. Eagles, vultures, kites and hawks, of manifold species, down to the small, swallow-like, insectivorous hawk common in the Delta, which skims the surface of the ground in pursuit of its insect prey. None seem bent on going forward, but all are soaring leisurely round over the same locality, as if the invisible element which supports them were their medium of rest as well as motion. But mark that object sitting in solitary state in the midst of yon plain: what a magnificent eagle! An approach to within eighty yards arouses the king of birds from his apathy. He partly opens his enormous wings, but stirs not yet from his station. On gaining a few feet more he begins to *walk* away, with half-expanded but motionless wings. Now for the chance fire! A charge of No. 3 from 11 bore rattles audibly but ineffectively upon his densely feathered body; his walk increases to a run, he gathers speed with his slowly-waving wings, and eventually leaves the ground. Rising at a gradual inclination, he mounts aloft and sails majestically away to his place of refuge in the Lybian range, distant at least five miles from where he rose. Some fragments of feathers denote the spot where the shot had struck him. The marks of his claws are traceable in the sandy soil, as, at first with firm and decided digs, he forced his way, but as he lightened his body and increased his speed with the aid of his wings, the imprints of his talons gradually merged into long scratches. The measured distance from the point where they vanished, to the place where he had stood, proved that with all the stimulus that the shot must have given to his exertions, he had been compelled to run full twenty yards before he could raise himself from the earth.

Again the boat is under way, though the wind is but just sufficient to enable us to stem the current. An immense kite is soaring overhead, scarcely higher than the top of our lateen yard, affording a fine opportunity for contemplating his easy and unlaboured movements. The cook has now thrown overboard some offal. With a solemn swoop the bird descends and seizes it in his talons. How easily he rises again with motionless expanded wings, the mere force and momentum of his *descent* serving to raise him again to more than half-mast high. Observe him next, with lazy flapping wings, and head turned under his body; he is placidly devouring the pendant morsel from his foot, and calmly gliding onwards.

The Nile abounds with large aquatic birds of almost every variety. During a residence upon its surface for nine months out of the year, immense numbers have been seen to come and go, for the majority of them are migratory. Egypt being merely a narrow strip of territory, passing through one of the most desert parts of the earth, and rendered fertile only by the periodical rise of the waters of the river, it is probable that these birds make it their grand thoroughfare into the rich districts of Central Africa.

On nearing our own shores, steaming against a moderate head-wind, from a station abaft the wheel the movements of some half-dozen gulls are observed, following in the wake of the ship, in patient expectation of any edibles that may be thrown overboard. One that is more familiar than the rest comes so near at times that the winnowing of his wings can be heard; he has just dropped astern, and now comes on again. With the axis of his body exactly at the level of the eyesight, his every movement can be distinctly marked. He approaches to within ten yards, and utters his wild plaintive note, as he turns his head from side to side, and regards us with his jet black eye. But where is the angle or upward rise of his wings, that should compensate for his descending tendency, in a yielding medium like air? The incline cannot be detected, for, to all appearance, his wings are edgewise, or parallel to his line of motion, and he appears to skim along a solid support. No smooth-edged rails, or steel-tired wheels, with polished axles revolving in well oiled brasses, are needed here for the purpose of diminishing friction, for Nature's machinery has surpassed them all. The retarding effects of gravity in the creature under notice, are almost annulled, for he is gliding forward upon a frictionless plane. There are various reasons for concluding that the direct flight of many birds is maintained with a much less expenditure of power, for a high speed, than by any mode of progression.

The first subject for consideration is the proportion of surface to weight, and their combined effect in descending perpendicularly through the atmosphere. The datum is here based upon the consideration of safety, for it may sometimes be needful for a living being to drop passively, without muscular effort. One square foot of sustaining surface, for every pound of the total weight, will be sufficient for security.

According to Smeaton's table of atmospheric resistances, to produce a force of one pound on a square foot, the wind must move against the plane (or, which is the same thing, the plane against the wind), at the rate of twenty-two feet per second, or 1,320ft. per minute, equal to fifteen miles per hour. The resistance of the air will now balance the weight on the descending surface, and, consequently, it cannot exceed that speed. Now, twenty-two feet per second is the velocity acquired at the end of a fall of eight feet—a height from which a well-knit man or animal may leap down without much risk of injury. Therefore, if a man with parachute weigh together 143lb., spreading the same number of square feet of surface contained in a circle fourteen and a half feet in diameter, he will descend at perhaps an unpleasant velocity, but with safety to life and limb.

It is a remarkable fact how this proportion of wing-surface to weight extends throughout a great variety of the flying portion of the animal kingdom, even down to hornets, bees, and other insects. In some instances, however, as in the gallinaceous tribe, including pheasants, this area is somewhat exceeded, but they are known to be very poor flyers. Residing as they do chiefly on the ground, their wings are only required for short distances, or for raising them or easing the descent from their roosting-places in forest-trees, the shortness of their wings preventing them from taking extended flights. The wing-surface of the common swallow is rather more than in the ratio of two square feet per pound, but having also great length of pinion, it is both swift and enduring in its flight. When on a rapid course this bird is in the habit of furling its wings into a narrow compass. The greater extent of surface is probably needful for the continual variations of speed and instant stoppages requisite for obtaining its insect food.

On the other hand, there are some birds, particularly of the duck tribe, whose wing-surface but little exceeds half a square foot, or seventy-two inches per pound, yet they may be classed among the strongest and swiftest of flyers. A weight of one pound, suspended from an area of this extent, would acquire a velocity due to a fall of sixteen feet—a height sufficient for the destruction or injury of most animals. But when the plane is urged forward horizontally, in a manner analogous to the wings of a bird during flight, the sustaining power is greatly influenced by the form and arrangement of the surface.

In the case of perpendicular descent, as a parachute, the sustaining effect will be much the same, whatever the figure of the outline of the superficies may be, and a circle perhaps affords the best resistance of any. Take, for example, a circle of twenty square feet (as possessed by the pelican) loaded with as many pounds. This, as just stated, will limit the rate of perpendicular descent to 1,320ft. per minute. But, instead of a circle sixty-one inches in diameter, if the area is bounded by a parallelogram ten feet long by two feet broad, and whilst at perfect freedom to descend perpendicularly, let a force be applied exactly in a horizontal

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IRON.

ONDON, FRIDAY, OCTOBER 22, 1880.

SCIENTIFIC AËROSTATION.

LTHOUGH the art of traversing the air by means of balloons has received a large amount ireful scientific attention ever since its earliest lopment, it has made but modest progress tols attaining the position which has often been icted, and sometimes claimed for it, namely, of general practical utility. We of course from present consideration the notion of the oon, aërostat, aërial ship, or whatever other e it may be called by, forming a ready method ansport for passengers and merchandise through air in any direction at the will of man, as being racticable under existing natural laws. We ply take the balloon as it now exists, and we find be very much the machine it was when first lered practically available for ascents about one dred years ago, its sphere of usefulness having but slightly extended, and its real services in cause of science being of but very recent date. ay be objected that the development of the balitself is of but comparatively recent date, and we are therefore expecting too much from it, or east that our remarks as to its slow progress are ewhat premature. Let us then briefly glance at nistory, and we shall see whether or not these ections are altogether valid. The discovery by vendish in 1766 of the remarkable lightness of rogen gas may be taken as the germ of the ention of the balloon, whilst Professor Black of nburgh may be credited with the application of idea, inasmuch as he procured a thin animal nbrane which he proposed to inflate with this gas test its ascensional powers, although he never ipleted the experiment. In 1772 Cavallo followed the notion by inflating swines' bladders, but he ved at no practical results. The Brothers Montfier perfected the idea and really invented the loon, but the first attempt to render it of practical ity did not take place until 1794, during the Wars the Revolution. At that time an aërostatic instion was formed at Meudon, near Paris, and at battle of Fleurus, near Charleroi, a balloon in rge of a corps of "aërostiers" from Meudon dered signal service. Balloons have since been ilarly employed, and the question of military looning continues to command the attention of own and other Governments.

he first attempt to enlist the service of balloons ely in the interests of science was made on the of July, 1803, when Robertson and Lhoest made iscent at Hamburg. The results of their obserons were considered to be of such importance the French Institute arranged for further ascents, h were made in 1804 by MM. Biot and Gaysac. They, however, failed to confirm the results ined by Robertson and Lhoest, and science ived but little assistance from the balloon from t time until about seventeen years since. In the rim, however, a few scientific aërial voyages were ertaken, notably those of Humboldt, in America, Rush and Green, in England, in 1847-9, on behalf he British Association, and of Barral and Bixio, Paris, in 1850. No very important results accrued, the contributions of balloons to positive science y be set down at almost nothing until about 1863, n Mr. James Glaisher communicated to the al Institution the results of eight ascents he had le for the purposes of scientific research. His elations awakened a new interest in, and gave a h impulse to, aëronautics. He subsequently made reat number of ascents, and as a result has added ny interesting and important facts to the annals of sical science, and which he has communicated the Royal Institution. But with all this, and ough the balloon has rendered important aid to ence, its practical utility would appear to be cond within these limits, and those of military obserion, and the fulfilment of the predictions of its eral utilisation appear to be very remote notwithnding its century of existence. We do not, of rse, deny to the balloon the position of importe it occupies as an invention, and which position it will continue to occupy, even though it remains an isolated power. But at the same time we hold that it has as yet failed to fulfil the mission which has been claimed for it, of becoming a means of practical everyday usefulness. Nor do we at present see any chance of its general practical utility.

We have been led to discuss the present subject by reason of our having been charged of late with having manifested a lack of interest in the proposed Arctic balloon expedition and with undue reticence with regard to the Balloon Society of Great Britain, which has recently sprung into existence. Now we confess to being of an essentially practical turn of mind, and we do not mind owning our inability to discover anything very practical, or perhaps practicable, in either the expedition or the society. The aim and end of the expedition are now well known, and all we can say is that, if the necessary funds are forthcoming and the expedition is started, we shall heartily wish it success. With regard to the society, that is already established and working; so by its works it may be judged. But we are by no means clear as to what its precise objects are. It has, we presume, been established for the advancement of aëronautical science; but some years ago a society—the Aëronautical Society of Great Britain—was established for a similar purpose, and we believe it is still in existence and doing all the work that can fall within the province of such a society, or, if it is not, it should be. We are not aware that the Balloon Society has any higher or more practical aims than the older institution, nor can we find evidence of this from its action. It holds meetings, at which papers are read and discussed, and it has organised several aëronautical excursions. In all this, however, we fail to find, even from close inquiry, that it has thrown any additional light upon science, or has enriched its annals by the contribution of any new practical results. The most recent of its exploits is the organisation of the International Balloon Contest at the Crystal Palace, which was to have taken place on Wednesday last. As it was stated that some important scientific results were to be the outcome, we, in the interests of science, were desirous of seeing the start, ascertaining the direction of the intended researches, and in due time of recording the results. We therefore repaired to the Crystal Palace on the day stated, but cannot say that the visit afforded us unmixed satisfaction.

The two balloons which were to take part in the contest belong, one to the Balloon Society and the other to the Académie d'Aérostation Météorologique de Paris. The former has a capacity of 28,000 cubic feet, and was in charge of Mr. T. Wright, as aëronaut, and the latter a capacity of 42,000 cubic feet, M. Wilfrid de Fonveille being the French aëronaut. The Lord Mayor of London and the leading civic dignitaries of Paris and Brussels were present to witness the ascent, which was fixed to take place at three o'clock, and great was to have been the ceremonial. But the Fates were—or rather the weather was—unpropitious, and in consequence of a fall of snow and rain the ascent was postponed to the following day—yesterday, when it took place.

So far it was unfortunate, although it does not augur well for the future of ballooning from a practical point of view if ascents are to be controlled by variations of weather. Desirous of learning the precise scientific objects of the ascent, we addressed ourselves to the authorities of the Balloon Society, and ascertained in the first place that it was to be a sort of balloon race in which the machine that travelled the greatest distance was to be the victor. Beyond this, certain meteorological observations were to be made; but upon the nature of these observations, and as to whether any new points were to be investigated, or anything attempted which had not previously been tried, we failed to elicit any definite or precise information. All we could learn was that the differences in speed and temperature between air-currents at various altitudes were to be noted. The practical outcome of all this, we were told, on further inquiry, was to be the demonstration that the balloon was available as a means for providing weather forecasts a fortnight in advance. Now it need hardly be pointed out that the expense of an aërial staff would be enormous, the practicability of the scheme, to say the least, highly problematical—especially if ascents are dependent upon the seasons—and the utility of the results very questionable. We are therefore justified in maintaining that both from a scientific and a practical point of view, and judged by its works generally, the Balloon Society does not make out a remarkably strong case for support; whilst, with regard to the International Balloon Contest, we are inclined to the opinion that the most, if not the only, practical results that will accrue will be a respectable addition to the exchequer of the Crystal Palace Company. And we sincerely hope it may prove to be so.

17

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19

AERIAL FLIGHT.

(*Continued from page* 113.)

[17963.]—It has before been shown how utterly inadequate the mere perpendicular impulse of a plane is found to be in supporting a weight, when there is no horizontal motion at the time. There is no material weight of air to be acted upon, and it yields to the slightest force, however great the velocity of impulse may be. On the other hand, suppose that a large bird, in full flight, can make forty miles per hour, or 3,520ft. per minute, and perform one stroke per second. Now, during every fractional portion of that stroke, the wing is acting upon and obtaining an impulse from a fresh and undisturbed body of air; and if the vibration of the wing is limited to an arc of two feet, this by no means represents the small force of action that would be obtained when in a stationary position, for the impulse is secured upon a stratum of fifty-eight feet in length of air at each stroke. So that the conditions of weight of air for obtaining support equally well apply to weight of air, and its reaction in producing forward impulse.

So necessary is the acquirement of this horizontal speed, even in commencing flight, that most heavy birds, when possible, rise against the wind, and even run at the top of their speed to make their wings available, as in the example of the eagle, mentioned at the commencement of this paper. It is stated that the Arabs, on horseback, can approach near enough to spear these birds, when on the plain, before they are able to rise: their habit is to perch on an eminence, where possible.

The tail of a bird is not necessary for flight. A pigeon can fly perfectly with this appendage cut short off: it probably performs an important function in steering, for it is to be remarked that most birds that have either to pursue or evade pursuit are amply provided with this organ.

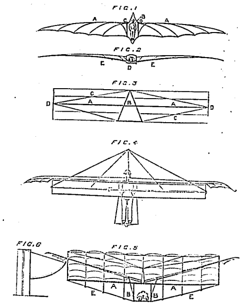
The foregoing reasoning is based upon facts, which tend to show that the flight of the largest and heaviest of all birds is really performed with but a small amount of force, and that man is endowed with sufficient muscular power to enable him also to take individual and extended flights, and that success is probably only involved in a question of suitable mechanical adaptations. But if the wings are to be modelled in imitation of natural examples, but very little consideration will serve to demonstrate its utter impracticability when applied in these forms. The annexed diagram, Fig. 1, would be about the proportions needed for a man of medium weight. The wings, *a a*, must extend out sixty feet from end to end, and measure four feet across the broadest part. The man, *b*, should be in a horizontal position, encased in a strong framework, to which the wings are hinged at *c c*. The wings must be stiffened by elastic ribs, extending back from the pinions. These must be trussed by a thin band of steel, *e e*, Fig. 2, for the purpose of diminishing the weight and thickness of the spar. At the front, where the pinions are hinged, there are two levers attached, and drawn together by a spiral spring, *d*, Fig. 2, the tension of which is sufficient to balance the weight of the body and machine, and cause the wings to be easily vibrated by the movement of the feet acting on treadles. This spring serves the purpose of the pectoral muscles in birds. But with all such arrangements the apparatus must fail—length of wing is indispensable! and a spar thirty feet long must be strong, heavy, and cumbrous; to propel this alone through the air, at a high speed, would require more power than any man could command.

In repudiating all imitations of natural wings, it does not follow that the only channel is closed in which flying mechanism may prove successful. Though birds do fly upon definite mechanical principles, and with a moderate exertion of force, yet the wing must necessarily be a vital organ and member of the living body. It must have a marvellous self-acting principle of repair, in case the feathers are broken or torn; it must also fold up in a small compass, and form a covering for the body.

These considerations bear no relation to artificial wings; so in designing a flying-machine, any deviations are admissible, provided the theoretical conditions involved in flight are borne in mind.

Having remarked how thin a stratum of air is displaced beneath the wings of a bird in rapid flight, it follows that in order to obtain the necessary *length* of plane for supporting heavy weights, the surface may be superposed, or placed in parallel rows, with an interval between them. A dozen pelicans may fly one above the other without mutual impediment, as if framed together; and it is thus shown how two hundredweight may be supported in a transverse distance of only ten feet.

In order to test this idea, six bands of stiff paper, three feet long and three inches wide, were stretched at a slight upward angle, in a light rectangular frame, with an interval of three inches between them, the arrangement resembling an open Venetian blind. When this was held against a breeze, the lifting power was very great, and even by running with it in a calm it required much force to keep it down. The success of this model led to the construction of one of a sufficient size to carry the weight of a man. Fig. 3 represents the arrangement. *a a* is a thin plank, tapered at the outer ends, and attached at the base to a triangle, *b*, made of similar plank, for the insertion of the body. The boards, *a a*, were trussed with thin bands of iron, *c c*, and at the ends were vertical rods, *d d*. Between these were stretched five bands of holland, fifteen inches broad and sixteen feet long, the total length of the web being eighty feet. This was taken out after dark into a wet piece of meadow land, one November evening, during a strong breeze, wherein it became quite unmanageable. The wind acting upon the already tightly-stretched webs, their united pull caused the central boards to bend considerably, with a twisting, vibratory motion. During a lull, the head and shoulders were inserted in the triangle, with the chest resting on the baseboard. A sudden gust caught up the experimenter, who was carried some distance from the ground, and the affair falling over sideways, broke up the right-hand set of webs.



In all new machines we gain experience by repeated failures, which frequently form the stepping-stones to ultimate success. The rude contrivance just described (which was but the work of a few hours) had taught, first, that the webs, or aëroplanes, must not be distended in a frame, as this must of necessity be strong and heavy, to withstand their combined tension; second, that the planes must be made so as either to furl or fold up, for the sake of portability.

In order to meet these conditions, the following arrangement was afterwards tried:—*a a*, Figs. 4 and 5, is the main spar, sixteen feet long, half an inch thick at the base, and tapered, both in breadth and thickness, to the end; to this spar was fastened the panels *b b*, having a base-board for the support of the body. Under this, and fastened to the end of the main spar, is a thin steel tie-band, *c c*, with struts starting from the spar. This served as the foundation of the superposed aëroplanes, and, though very light, was found to be exceedingly strong; for when the ends of the spar were placed upon supports, the middle bore the weight of the body without any strain or deflection; and further, by a separation at the base-board, the spars could be folded back, with a hinge, to half their length. Above this were arranged the aëroplanes, consisting of six webs of thin holland, fifteen inches broad; these were kept in parallel planes, by vertical divisions, two feet wide, of the same fabric, so that when distended by a current of air, each two feet of web pulled in opposition to its neighbour; and finally, at the ends (which were each sewn over laths), a pull due to only two feet had to be counteracted, instead of the strain arising from the entire length, as in the former experiment. The end-pull was sustained by vertical rods, sliding through loops on the transverse ones at the ends of the webs, the whole of which could fall flat on the spar, till raised and distended by a breeze. The top was stretched by a lath, *f*, and the system kept vertical by staycords, taken from a bowsprit carried out in front, shown in Fig. 6. All the front edges of the aëroplanes were stiffened by bands of crinoline steel. This series was for the supporting arrangement, being equivalent to a length of wing of ninety-six feet. Exterior to this, two propellers were to be attached, turning on spindles just above the back. They are kept drawn up by a light spring, and pulled down by cords or chains, running over pulleys in the panels *b b*, and fastened to the end of a swivelling cross-yoke, sliding on the base-board. By working this cross-piece with the feet, motion will be communicated to the propellers, and by giving a longer stroke with one foot than the other, a greater extent of motion will be given to the corresponding propeller, thus enabling the machine to turn, just as oars are worked in a rowing boat. The propellers act on the same principle as the wing of a bird or bat: their ends being made of fabric, stretched by elastic ribs, a simple waving motion up and down will give a strong forward impulse. In order to start, the legs are lowered beneath the base-board, and the experimenter must run against the wind.

An experiment recently made with this apparatus developed a cause of failure. The angle required for producing the requisite supporting power was found to be so small, that the crinoline steel would not keep the front edges in tension. Some of them were borne downwards, and more on one side than the other, by the operation of the wind, and this also produced a strong fluttering motion in the webs, destroying the integrity of their plane surfaces, and fatal to their proper action.

Another arrangement has since been constructed, having laths sewn in both edges of the webs, which are kept permanently distended by cross-stretchers. All these planes are hinged to a vertical central board, so as to fold back when the bottom ties are released, but the system is much heavier than the former one, and no experiments of any consequence have as yet been tried with it.

It may be remarked that although a principle is here defined, yet considerable difficulty is experienced in carrying the theory into practice. When the wind approaches to fifteen or twenty miles per hour, the lifting power of these arrangements is all that is requisite, and, by additional planes, can be increased to any extent; but the capricious nature of the ground-currents is a perpetual source of trouble.

Great weight does not appear to be of much consequence, if carried in the body; but the aëroplanes and their attachments seem as if they were required to be very light, otherwise they are awkward to carry, and impede the movements in running and making a start. In a dead calm, it is almost impracticable to get sufficient horizontal speed, by mere running alone, to raise the weight of the body. Once off the ground, the speed must be an increasing one, if continued by suitable propellers. The small amount of experience as yet gained, appears to indicate that if the aëroplanes could be raised in detail, like a superposed series of kites, they would first carry the weight of the machine itself, and next relieve that of the body.

Until the last few months no substantial attempt has been made to construct a flying-machine, in accordance with the principle involved in this paper, which was written seven years ago. The author trusts that he has contributed something towards the elucidation of a new theory, and shown that the flight of a bird in its performance does not require that enormous amount of force usually supposed, and that in fact birds do not exert more power in flying than quadrupeds in running, but considerably less; for the wing movements of a

14

20

Eng. Mech. & World Science July 1. 1881.

AËRONAUTICAL SOCIETY OF GREAT BRITAIN.

THE Annual General Meeting of this Society was held at the Society of Arts' room on Monday night. The chair was taken by Mr. James Glaisher, F.R.S., who remarked that he regretted he could not speak of more important results. Mr. Infield, who had made a large shield a year since, had constantly been at work on it ever since, but was not satisfied with its present condition, and, therefore, reserved its exhibition for another occasion. He had hoped to have told them that balloons had been used for photographing the country, especially as the plates could now be prepared weeks beforehand, need only be exposed for a few seconds, and could be kept for a lengthened period before development; but these anticipations yet remained unfulfilled.

Mr. W. H. Phillips showed a model of a new flying-machine he was making, and read a paper describing it. He said the requirements for artificial flight were (1) that the expanse of wing-surface should be sufficient to sustain the whole weight in easy descent; (2) that the wing-surface needed might be provided by two large wings, or by many smaller wings equal thereto; (3) that lightness and strength were indispensable; (4) that the down-stroke of wing must be sufficient in force to sustain and propel horizontally the whole weight; and (5) the down-stroke, if intermittent, must be rapid, as otherwise the whole apparatus descends between the intervals of stroke. Acting on these principles, he had projected an apparatus which he had made to considerable size, employing an impetus of thirteen million pounds of steam. Of it he showed a model, consisting of an elementary skeleton in rigid steel wire for one long, slightly curved, and narrow wing; the frame was clothed with a series of loose cambric "feathers," oblong in form, hung from the ridge transversely. The whole weighed 4oz., but required a weight of 4lb. to move it up or down. However, by counterpoising the wing with another it could be more easily moved, and he proposed to increase the number of these wings and to employ steam-power for levitation. A short discussion followed, in which Mr. Moy remarked that however easily the wings might be balanced, Mr. Phillips would need a good balance at his banker's to construct a working model.

The Secretary (Mr. F. W. Brearey) read a communication from Mr. S. E. Peal, of Sapakati, Sibsagur, Asam, on "The Flotation of Large Birds and Balloons." The writer stated that he had written to the ENGLISH MECHANIC on the "Flotation and Soaring of Birds"—a subject which he thought he had unusual opportunities of observing. It did not seem to be understood in England that large birds could not only float without flapping the wings for long periods without coming down, but actually rise thus to elevations of some 1,000 to 6,000 or 8,000ft. The bird, when thus soaring, seemed perfectly motionless, and could easily be followed and watched by a good telescope; in all cases the wings were fully extended rigidly. The pelican, adjutant, cyrus, and vulture all soared in this way. They invariably rose from the ground by flapping the wings vigorously; they did not soar and float, unless there was some wind; they could not soar or float in a calm, wind being needful; generally by rising they described a circular spiral track, a track which in the main seemed to tend to leewards. They had in Asam two steady winds, the N.N.E. and W.S.W. often blowing at once, one over the other alternating; birds would go some way in one and gradually return in the other. The birds were never seen to move in right lines for any distance, unless coming down. It was highly probable that the birds slept or dozed when soaring, and collision was not likely because of the loud vibration of the feather-tips. The solution of the question of soaring seemed of value, as it involved a minimum of muscular exertion, say 1-10th that of flying. The difference appeared to be that, in flying, not only the friction of passage horizontally through the air had to be overcome, but the power needed to overcome gravitation; whereas, in soaring, which generally took place at high speeds, the wing-surfaces passed through the air and over a stratum of it ere the latter could be set in motion, as if it were rigid sheet-glass, on which the wings skated, *à la* boomerang. Thus the usual effects of gravitation were not seen, and birds that soared needed long narrow wings, while those that only flew had shorter and wider wings. The wing-surface narrowing as speed increased, would seem to indicate a useful direction to work in, the same applying to any form of screw for aerial propulsion. The support was also apparently more effective at or near the tips than close to the body, due, perhaps, to passing through a less disturbed state. By the ENGLISH MECHANIC of April 15th last, p. 131, the writer found that a law which he had discovered some years ago when investigating the flight of pickets or long bullets, did not appear to be yet known as well as it should be. It was illustrated in the ENGLISH MECHANIC about three years ago. It was only possible to keep an oblong balloon end on to the wind when it was anchored by the end; when free to move, the balloon (unless going at precisely the same speed as the air), eventually and certainly placed itself at right angles to its line of progress. The law which compelled this was both simple and universal; and it could easily be seen in paper models of suitable forms suspended by a thread if held in a draught of air. In the case of a long bullet, which was a very heavy body compared to its size, it was found necessary to make it spin rapidly on its long axis, to avoid "oversetting" from pressure on the point. The amount of point necessary to prevent "overset" in such a small body as a bullet, was very great compared to its size, and in such a large body as a balloon would greatly exceed its levitating power, if wholly used for this purpose. With a knowledge of this law he asserted that experiments on a large scale were simply wasted money and time. The two principles of penetrating resisting media were typified by the arrow and the picket bullet; the former flew point on during its entire flight, whereas in the latter the axis of direction remained constant. Theoretically and practically, an oblong balloon was simply a means of increasing instead of diminishing the area of resistance; the power needed to prevent "overset," whether got from a skeleton screw at high speed, or in any other way, would be far more than the balloon could lift as machinery. The law might be stated thus: "All bodies tend naturally to place their greatest area of resistance to any resisting medium." Lately the author had written to the Secretary of the Royal Geographical Society suggesting that the peculiarly steady and regular N.N.E. and W.S.W. winds prevalent in Asam during most of the year were eminently suitable for exploring the inaccessible country by balloon, and for photographing it and mapping it out. The whole of Bengal could be surveyed by taking advantage of the same winds. The Chairman, in proposing a vote of thanks to Mr. Peal, expressed his gratification that that gentleman had conveyed the result of his observations on Oriental wind-currents and the flight of tropical birds to the public in the ENGLISH MECHANIC. Mr. Douglas Scoffern read a *résumé* of what had been done in aërial navigation, in which he advocated the more attentive study of parachutes, which led to an animated and personal discussion between Mr. Simmons, Mr. Moy, and the reader of the paper.

Herald. Sept. 8. 1881.

AERIAL NAVIGATION.

Proposed Voyage from Minnesota to the Atlantic Seaboard.

SCIENTIFIC RESULTS EXPECTED.

The United States Signal Service To Be Represented on the Trip.

[BY TELEGRAPH TO THE HERALD.]

MINNEAPOLIS, Minn., Sept. 6, 1881.

Everything is ready for the King balloon voyage from this city to the Atlantic seaboard but the weather. The wind has been blowing steadily all the morning from west to east, exactly opposite to the breeze we need. Rain is falling in torrents, and the Minnesota hills are hid in mists. The start has been postponed till Friday. It is likely, however, that the general meteorological conditions may change within the next ten hours in our favor. Upon the heels of the storm a stiff northwestern wind is looked for, and the United States Signal station at St. Paul predicts clear and cool weather for to-morrow afternoon. If this prophecy turns out to be true it is likely that the balloon expedition will prove one of the most remarkable scientific experiments of the nineteenth century.

THE AERIAL TOURISTS.

The party who are to make the trip consist of Professor Samuel A. King, the aeronaut; Mr. W. O. Nicholas, of the Chicago *Times*; Mr. Luther L. Holden, of the Boston *Journal*; Mr. Winslow Upton, of the United States Signal Service; Mr. E. R. Johnston, of the St. Paul and Minneapolis *Pioneer Press*; Mr. Charles M. Faye, of the Minneapolis *Tribune*, and your correspondent. To-day we signed an agreement to the effect that Professor King shall be absolute commander of the balloon and its occupants, and whenever it becomes necessary for one of the company to leave the car at any stage of the journey the person designated by the commander shall obey without demur. This document provided that the dropped men should be "cheerful" about it, but as some one is likely to be suddenly left in the middle of a forest, perhaps a hundred miles from the nearest settlement, the correspondents refused to sign until the objectionable word was withdrawn. Each man is provided with a complete suit of rubber clothing, a compass, automatic lamp and flask of corn juice, to guard against snake bites.

A MONSTER BALLOON.

The ascension will take place from the grounds of the Minneapolis Agricultural and Mechanical Fair. A great amphitheatre has been erected which is capable of seating 20,000 people. It is over a quarter of a mile long, and in the centre on the wet grass lies the great balloon ready for inflation, except that it will have to be turned inside out and the machinery adjusted. Alongside of it are ranged several large wooden cylindrical tanks, from which the gas is to be obtained to generate the necessary 100,000 feet of hydrogen. On 25,000 pounds of iron scraps will be poured 24,000 pounds of sulphuric acid, the former being stored in the tanks, while 12,000 pounds of lime will be used in purifying and 14,000 pounds of ice in cooling the gas. The enormous bag which is to hold the gas is of a peculiar rubber cloth, made expressly for the purpose. Two sheets of cambric received sixty coats of thin rubber varnish each and were then fused into a sort of Mackintosh cloth by iron rollers. The material is very light and will prevent the percolation of the gas. It has been tested and stood a heavy pressure before air was forced through its pores. This is an important step toward success, as the cloth in the balloon is doubled, except at the top, where it is trebled, as the upward tendency of the gas puts the greatest strain upon the upper part. There are sixty-two gores or segments, each ninety-five feet long and thirty-five inches at the lower portion. Each seam has three rows of stitching cemented with rubber.

PREPARATIONS FOR AN EMERGENCY.

The copper throttle valve is of the most improved make and will be fastened securely in the top of the balloon. The usual "rip rope," or collapsing cord, is sewed into one of the seams and the end hangs down through the neck of the balloon in the car, so that at a moment's notice the whole structure can be ripped open from top to bottom. The balloon is 186 feet in circumference and ninety-five feet in height, and the netting is spun from the finest hemp and cotton. The car is an ordinary oval wicker basket. In no other respects is the balloon remarkable, except that it has been built with greater care than any other structure of the same kind. The expedition is the most laborious one that has ever been organized in this country.

SCIENTIFIC FEATURE OF THE TRIP.

General Hazen, Chief of the United States Signal Service, has detailed Mr. Upton to accompany the party and make a report to the government at the termination of the voyage. This is the most important feature of all, as the scientific result of the trip will depend upon the accuracy of his observations. He has been assistant in the observatories at Cambridge, Cincinnati and Washington. He was the first assistant to Professor Abbe in the scientific branch of the service at Washington, and in that capacity computed an order of the recent comet. Mr. Upton has been instructed to particularly observe the direction and force of the air currents, besides the temperature and distribution of moisture. If the balloon rises above the clouds his orders are to locate its position by means of a sextant, which will be carried in the car. This is the first time that an attempt has been made to use a sextant in the air, and if it succeeds the scientific world will have gained something. The Washington signal station will be notified at the moment the balloon starts, and for eighteen hours afterward every government signal station east of Dakota and as far south as Virginia will take hourly observations in harmony with Mr. Upton. The instruments he will take with him are two barometers, a hygrometer, a Dupont apparatus, a wet bulb thermometer, three dry bulb thermometers, a solar radiation thermometer, a minimum thermometer, an air meter and a sextant. Besides these he has an apparatus invented expressly for this journey. It is a Japanese instrument so balanced that it will indicate whether the balloon is going downward or upward and show the velocity at which it is moving. Edison has sent out an electric light which will be attached to the car and used at night if the moon is obscured by clouds.

PROFESSOR KING'S THEORIES.

Professor King has two theories that will be tested, if possible, by Mr. Upton. One is that clouds cause some kind of attraction for balloons. The other is between areas of high pressure and areas of low pressure. There can be found thin plains of vapor which can neither be seen from above nor below, but which are perfectly discernible when the balloon has reached their level. This vapor shoots out in such a peculiar manner that the Professor is inclined to believe the Aurora Borealis is caused by it. Everything will be put to an actual physical test. Mr. Upton has compared his instruments with those at the St. Paul Signal Station and found them true. According to instructions he will make a similar comparison at the nearest station to the final landing. The gradual change in the air as the lakes are crossed or as the ocean is approached will be carefully noted down.

CONTINGENCIES PROVIDED FOR.

We will want to start at a pretty fair altitude, as Minneapolis is over eight hundred feet above the sea level, and the balloon will have to rise at least four thousand feet to escape the surface disturbances. The beginning of the voyage may be discouraging on account of the mountainous character of the country, but if we can clear Lake Michigan we have good prospects of reaching the seaboard. If the wind is blowing strongly toward the north we will not start, as the party would be landed in Lake Superior in a few hours. Lest we should be dipped in any of the lakes fifty hermetically sealed cans have been sewed in a bag and fastened under the seat of the car, so that it will float. The car will contain 200 pounds of rations, including 150 pounds of canned meats, chicken, turkey, and a supply of "hard tack." A large quantity of liquid comforts will also be taken, and 500 pounds of sand ballast. On account of the rain the balloon was not painted. In the language of the late William Nye, its name, "it shall be nameless." It is simply a great white globe. There will be an attempt made to influence the course of the balloon, the idea being to trace the air currents and test the theory of the eastern movement of storms. A drag rope several hundred feet long will hang beneath the car, and to it will be attached a strong anchor. At any time, should a serious danger present itself, the balloon can be secured until the wind changes or the danger disappears. Apparatus for camping out and cooking in the woods will be taken with us. In this way the journey will be accomplished, even if it is impossible to do it at one bound.

UTILIZING THE ELECTRIC LIGHT.

One of the greatest difficulties in ballooning at night will be removed by the electric light, which will illuminate the scene sufficiently to allow the principal landmarks to be seen. This will preclude the possibility of our happening into a sheet of water for an anchorage in the darkness. Our voyage will extend over many lakes and rivers that lie scattered "from the bleak shores of the sea to the land where the Father of Waters seizes the bills in his hand and drags them down to the ocean." There are faint indications which would point to the Gulf of St. Lawrence as the destination of the expedition, if the ship floats long enough. But whether we will go northeast or southeast will be settled, I think, before we will pass Chicago, as the current seems to separate at Lake Michigan.

[BY TELEGRAPH TO THE HERALD.]

MINNEAPOLIS, Minn., Sept. 7, 1881.

The weather here is cold, but clearer than yesterday. The balloon expedition will start on Friday afternoon with good prospects. The Edison electric light apparatus, which is to be taken in the balloon car, has been tested and is an entire success.

ACCIDENT TO AN AERONAUT.

BOSTON, Mass., Sept. 7, 1881.

Professor Rogers, the aeronaut, made a balloon ascension at Point of Pines, a suburban summer resort, to-day. When the balloon had reached an altitude of 1,000 feet an upper seam ripped, allowing gas to escape and causing the balloon to descend rapidly. When within 100 feet of the ground the balloon collapsed, the car tipped and Professor Rogers fell to the ground at Nahant Beach, about a mile from the starting point. He was picked up unconscious, but soon rallied, and was carried to his home in Malden. He is thought to have sustained severe internal injuries.

21

Menlo Park Scrapbook, Cat. 1056

No. 40. "Various Electrical Appliances and Torpedo Experiments"

This scrapbook covers the years 1873-1881. It contains clippings about electrical devices, applications for electricity, electricity in war, and torpedoes. There is also one clipping about Edison's phonometer. The book contains 137 numbered pages.

Blank pages not filmed: 2-9.

Various Electrical Applicances

In Torpedo experiment

1055

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Elect July 15. 75.

Electric Fall-Machines.—M. Waldner.—These are for demonstrating the laws of falling bodies. In one arrangement a brass ball is hung by a thread some height above the ground. Under it, at distance = 1, are two metallic balls connected with the poles of an electric machine; they are so far apart that a spark cannot pass between them, but, if the suspended ball drop between them a spark will pass. Further down, at distance = 4, then = 9, &c., are similar pairs of balls. The thread of the suspended ball being burnt, the latter falls between the successive pairs, giving passage at each pair, to the current, and simultaneously, the spark in another part of the circuit strikes a revolving soot-blackened drum, making a mark. The distances between successive marks are found to be equal. In a second arrangement, there are two cylindrical conductors, insulated and vertical, with a metallic ball suspended between them at the top, hardly filling the interval, and sufficient to enable a spark to pass between the cylinders, which are connected with the poles of an induction (secondary) coil. One of the cylinders has a coating of soot-blackened paper. The thread is burnt, and the ball falls; sparks are made to pass at regular intervals of time, by means of clockwork, interrupting the battery current. Each spark leaves its mark on the blackened surface; and thus are shown the spaces passed over in equal times.

Elect News Aug 19. 75

AN ELECTRIC PHOTOMETER.

Whoever (says Dr. Werner Siemens, in a paper recently read to the Verein für Gewerbfleiss) has gone thoroughly into the subject of Photometry, will have come to the conviction that it is still at a very low stage of development. It has not yet been once fixed what, exactly, we have to measure. Every solid body, we know, raised to high temperatures, emits light and heat-rays in all directions. According to the new theory it is ether waves, of all possible wave-lengths, which go out from the hot body. A portion of these waves excites in our retina, when it strikes it, the sensation of light. If short and long ether waves are in a proportion to each other, like that in which the sun or other very highly heated body emits them, we call the sensation of light we receive from them "white light." When, however, only light waves of a certain wave-length are admitted to our eye, our sensation of light is altered, and we name the light, red, yellow, blue, violet, according to the wave-length of the rays admitted. The prism, it is known, is a means by which the rays of a white bundle of light may be separated according to the wave-length. Since the impressions of the red, yellow, blue light are quite different on us, it is evidently quite impossible to compare together the intensities of such different sensations. The photometers hitherto made, however, are all on the principle of so regulating the action of the two light-sources to be compared, on an illuminated object, that the latter seems to our eye illuminated to an equal degree by the two sources. This method is best carried out by Bunsen's photometer, which is based on the fact that an oil-spot on a piece of white paper is no longer visible, when it is illuminated on both sides equally, strongly with white light. This is pretty accurate so long as both light sources send out white light, or at least light of the same colour. If the colours are different the spot does not disappear, and there is no means of comparison. There is, of course, still another criterion of light-strength, and it is properly the only correct one. We require light for the perception of objects, and that light is for us the best or brightest which enables us most distinctly to see the objects. One might hereupon construct a photometer quite independent of colour, by so regulating, in any way (*e.g.*, by diminishing the light-receiving surface of a lens), the strength of the two light sources, that the same object might be equally distinctly perceived with both. It would appear, however, that the eyes of different men are unequally receptive for differently coloured light, and are also soon fatigued, so that this otherwise rational method of light measurement, also, cannot yield constant results.

I have endeavoured to utilise electricity (that force which so often helps us when other forces fail), in measurement of light.

It is known that selenium—a substance standing on the boundary of the metals and metalloids, and possessing many remarkable physical properties—has two properties, which would seem to render it peculiarly suitable for the object in view. When selenium that has been quickly cooled—amorphous selenium—is heated to a temperature of 80° to 100°, the mass becomes crystalline, under development of heat, and a conductor of electricity, whereas in the amorphous state it is an insulator. Now, this crystalline selenium has the remarkable property—discovered and described by the English Lieut. Sale—of conducting electricity better when it is illuminated than when it is in darkness. Sale further found that the increase of the conductivity increases with the strength of the illumination, so that—in remarkable agreement with the retina of the eye—it is most strongly influenced by those parts of the spectrum which most affect the eye.

These remarkable properties I sought to turn to account in photometry. The initial difficulties—consisting partly in the small conductivity of crystalline selenium, its inconstancy, and the very weak and variable action of the light, partly in the disturbing influence of heat-rays—I succeeded in removing, inasmuch as, by long heating of amorphous selenium nearly to its melting-point, or by crystallising out from the slowly cooled molten mass, I prepared a modification of the crystallised selenium, which conducts much better, is much more influenced by light, is not essentially affected by heat-rays, and retains its properties pretty constant. It is especially notable that its conductivity *decreases* on heating, as in the case of metals, whereas in the other the conductivity *increases*, as in the case of conducting metalloids and electrolytes. By filling up the interval of two small flat spirals of wire with such coarsely crystalline selenium between two leaves of mica, I have succeeded in producing a photometric apparatus which—with a Daniell's cell or a small thermo-electric electromotor—gives sufficiently strong currents for one to be able to compare, by measurement of them, even very weak intensities of light with sufficient exactness.

The apparatus which I show you here is such an electric photometer. At the bottom of a small tube, which can be rotated, is some of the selenium preparation as described. The ends of the two spiral wires are connected with each other through a Daniell cell and the wire of a galvanometer. The needle is thus deflected. If I remove the cover of the tube, and admit the light of a gas-flame, whose strength I would measure, to the selenium disc, the conductivity of the disc increases proportionally to the strength of the light; so the deflection of the needle becomes greater. If I now turn the tube so that it is directed to a normal candle, instead of to the flame to be measured, and regulate the distance of this normal candle so that the deflection of the needle becomes and remains the same when the selenium is alternately illuminated by the flame to be measured and the normal candle, the light action is the same from both, and the light strengths are accordingly in inverse proportion to their distance from the selenium plate.

This instrument can be made with any degree of sensibility desired, and I hope that a practically serviceable apparatus may be developed from it. It will probably also become possible thus to indicate light strength graphically in a continuous matter, but many experiments are yet required in order to acquire a sufficient basis for this.

12

CONTROLLING AND CORRECTING CLOCKS BY ELECTRICITY.

A paper on this subject was read at the Society of Arts on Wednesday evening, 22nd inst., by Frederick J. Ritchie, Esq., of Messrs. J. Ritchie and Son, Edinburgh. He began by describing the system of time signals initiated by Greenwich Observatory, and sent to the principal towns of Great Britain, and noticed a few of the most successful results in the application of electricity to clocks, which might be classified under three divisions:—

1st. Those whose motive power is wholly electric, and which are wholly independent of any other force whatever.

2nd. Those depending on currents of electricity transmitted at regular intervals, and applied directly to carry forward the wheel-work and hands.

These two classes require no periodical winding-up, and may properly be termed electric clocks.

3rd. Those which, being complete clocks in themselves, and capable of performing all the duties of clocks without the external aid of electricity, show their own time, and require winding up at certain intervals, but, for the purpose of being made more useful and correct timekeepers, have currents of electricity transmitted from some standard clock, so applied as to control and correct the vibration of the pendulum or the movements of the wheel-work and hands, and so cause them to show uniformity of time with the governing clock.

Mr. Alexander Bain's electric magnetic pendulum was noticed, and high praise given to Mr. R. L. Jones's method for securing coincident time to the fraction of a second. Mr. Ritchie then described the electro sympathetic clocks introduced by his firm about five years ago, which are in use in many public offices, and have been exhibited at the South Kensington Exhibition of scientific instruments. The attention of the firm has recently been given to means of reproducing the most minute divisions of time, and the rest of the paper was devoted to their experience and success in accomplishing this end, with some indication of what has been done by others in the same field. Thus, about thirty-six years ago, the late Mr. Alexander Bain proposed a method of setting the minute hands of ordinary clocks to correct time every hour in a most simple and effective manner. Whether he ever put his system into actual operation, or to what extent, the lecturer had been unable to learn, but the plan is noticed in a pamphlet published in 1843, "On the Application of the Electric Fluid to the useful Arts," and is, fortunately, illustrated by a diagram and description with references. An electro-magnet was placed behind the dial of the clock to be corrected. The armature of the magnet carried a rod ending in a fork or V immediately above the figure XII. A pin projected back from the minute hand was so placed as to clear the arms of the V when the armature was at rest, or in its normal position, and forced to occupy the angle of the V, when, by the attraction of the magnet, the armature and rod were drawn upwards. Exactly at the last, or sixtieth second of the hour, as shown by the normal clock, contact was automatically made by it with a battery in connection with the line wire, so rendering the magnet active, and attracting the armature, and forcing the V against the pin in the hand, causing it to indicate the exact hour if within its range of action. The simplicity of this application must strike everyone, both from its direct action and fewness of mechanical parts.

To obviate defects found in Mr. Bain's method, Messrs. Ritchie substituted an I or block system, by removing one limb of the V and placing the other at a smaller angle to the pin on the hand, and giving the clock a slightly gaining rate. Instead of a momentary signal or current, one was adopted of fifteen seconds' duration, commencing at the fifty-ninth minute, forty-fifth second of each hour, and ending at the sixtieth second, or the exact hour of the normal clock. An automatic break is used where the line wire is passed by a spring, which is held out of contact with the battery terminal by means of a double lever, one end of which rests on the periphery of a disc upon the same axis as the minute hand. A notch in this disc allows the descent of the lever for a portion of a minute once an hour, during which the second lever comes into action on a disc on the scape wheel arbor. This has a step cut away for one-fourth revolution to allow the lever to fall and contact to be made by the spring on the stud, commencing at the forty-fifth and ending at the sixtieth second, during which time a current is passed to the line.

The adoption of this system at once enabled Messrs. Ritchie to reduce the battery power, and to secure the hand more firmly to the clockwork, so that larger clocks could be placed in circuit and treated with safety. Further experience led to other slight modifications, and for the system is now claimed the following advantages over any previous methods of correction:—

1st. Extreme simplicity and lightness of the mechanical parts, and anyone conversant with electricity will at once appreciate how much depends on that.

2nd. The battery power required to work it is very small. This is obtained:—

(a) From the amount of motion in the stop pin being so small that the magnetic action on the armature is very powerful.

(b) No mechanical work is demanded of the current in setting the hands of the clock.

(c) No friction appears to be overcome, except that of the axis or centres on which the lever works.

(d) The preponderance of the double lever over the armature is just sufficient to ensure its falling out of action, consequently no power is wasted in doing unnecessary work or lifting useless weight.

The friction which (although it would prove very small) would be caused by the pressure of the scape wheel upon the stop pin is got rid of entirely by taking advantage of the inclined surface, or impulse part of the pallet, to wind back the wheel by the vibration of the pendulum, and allow the lever to fall freely out of action.

3rd. The certainty of action is very great, as the forward motion of the clock is arrested at the last wheel, or the point of greatest leverage in the train, and all uncertainties of elasticity are removed.

4th. The hands may be so securely fixed as that no exposure can affect them without wholly stopping the clock.

By no other method yet suggested could correction be applied to a large steeple clock, as any interference with the hands of such would result in the destruction of the apparatus or breaking the hands.

5th. The range of action is also very great. Should the clock be accidentally set slow of correct time, it will, by its own normal gaining rate, be accelerated till the hands indicate correct time, and only then will any action be performed by the corrector. Should the clock be set fast, even to the extent of five minutes (for the disc is cut to cover that extent of error) then the corrector could, by arresting the wheel work for the whole fifteen seconds in each hour, gradually eliminate the error, and have the clock set automatically to coincident time with the normal clock, and then resume its correcting action.

6th. It is applicable to clocks of all qualities and sizes, from the commonest German or American kitchen clock to the largest clock ever constructed, or which could be made or even conceived.

7th. The smallest possible expense in furnishing and fitting of apparatus and maintainance of battery power.

Elect News Sept 16. 75

Improvements in signalling or working signals on railways and in the means or apparatus employed therein. William Robert Sykes, telegraph engineer, Nunhead, Surrey. February 23, 1875. No. 662.—This Provisional Specification describes a novel system of signalling or of working signals whereby it becomes impossible for a signalman to give the signal for a train to proceed until he has received a signal from the next station or signalling point that the previous train has passed. The system is in fact a combined lock and block system, the movement of a signal lever for a train to proceed having the effect of locking that lever until the lock is released by the movement of a lever at the next station or signalling point after the train has passed it, while the lever at the said next station cannot be moved until freed by the movement of a lever at a third station or signalling point shewing that the line between the second and third points is clear.

Elect News Sept 30. 75

165,700. *Electric Boiler-Alarms and Registers.* William C. Baker, New York, N.Y. Filed June 23, 1875.—Circuit closed by high or low pressure through magnets, controlling a dial and step-by-step escapement, thus registering how often the rules as to maximum and minimum of pressure have been violated. An intermediate magnet in same circuit closes branch circuit to self-acting magnetic bell. 1. The combination, with a low water or pressure alarm and an electric circuit-closing apparatus, of an electro-magnet, step-by-step movement, and dial, to indicate the number of times the boiler has been neglected, substantially as set forth. 2. The combination, with a boiler-alarm and electric circuits substantially as specified, of 6-branch, circuit, electro-magnet alarm-bell, and automatic circuit-breaker, operated by the hammer, substantially as and for the purposes set forth.

Elect News Aug 19. 75

Improvements in the means and apparatus for indicating the speed of ships. Henry Edward Hargreaves, Rio de Janeiro, Brazil; at present of No. 12, Fenchurch Street, London. January 30, 1875.—No. 353. This invention relates to electric logs, wherein the revolutions of the vanes of the log cause an electric current to be passed at certain intervals along a conducting wire passing from the log to a recording instrument on board ship. According to the present improvements, the revolutions of the screw vanes effect the rotation of a worm and worm-wheel, on which is a stud that at every revolution of the wheel causes a contact-spring to close an electric circuit comprising a battery and a recording instrument on board ship. The recording instrument is an ordinary Morse receiving instrument, the paper strip being marked with divisions representing hours and minutes, so that the number of divisions occurring between two marks made on the paper by the passing of two consecutive currents will indicate the time in which the vessel traversed the distance corresponding to one revolution of the worm-wheel of the log.

Elect News Aug 26. 75

Electric Apparatus presented by M. Deschiens.—Report by Count du Moncel.—Some of these instruments are divided by M. Liais, Director of the Imperial Observatory of Brazil, viz:—(1.) *An Electro-Chronometric Regulator.* Without attempting a full description we may state that the interruptions of the current are effected under a bell jar filled with hydrogen, and on a mercury surface; thus obviating oxidation of the interrupter. The mechanical action working the interrupter and the pendulum is by a free escapement, which the pendulum only touches at each double oscillation just when passing the vertical. This escapement liberates a lever, solicited by a weight; which lever gives an impulsion to the pendulum, and also, before stopping, acts on a special beam, working the interrupter; the latter then causes an electro-magnet to be excited, which replaces the impelling lever in its former position and restores the escapement. The beam of the interrupter returns of itself to its normal position; so that everything is in position again for the next movement of the pendulum in the same direction. (2.) *An Electro-Chronometric Counter* (indicating on a dial the movements of the regulative pendulum).—To avoid the failure of contacts, M. Liais uses a massive pendulum, of annealed iron, acted on by an electro-magnet, so that if the contact should fail the dial train may not be affected; since the oscillation of the pendulum continuing all the same, the escapement always acts. Further, as the electro-magnetic action is only effective at the extreme points of the oscillations, the numerous contacts sometimes produced, resulting from certain trepidations of the apparatus, have no effect on the counter; as also the irregularities of velocity of the pendulum itself, which cannot quit the extreme point of its oscillation except when the current has ceased to pass through the electro-magnet. (3.) *Electric Chronograph.*—This is an improvement on one made by M. Liais twenty years ago for the Paris Observatory. The registration is not on a paper-covered cylinder, but on a paper sheet fixed on a horizontal circular plate; and the tracings are made in two spiral lines from circumference to centre. Thus a great number of indications can be made on one sheet, and the sheets can be easily kept in a portfolio. The cord of the motor is wound round a fusee, so that the turns of the plate may differ little from each other for the same interval of time. The two tracing styles are kept constantly pointed by the very fact of friction on the paper. The rotation of the plate turns a pulley, covered with a caoutchouc ring, which rests on it; and this turns two other pulleys with which the styles are connected, so that the latter are turned also in a continuous and regular manner. To obtain greater precision, copper points are sometimes used in place of the pencils, and the paper is prepared with zinc-white. (Some other improvements in detail are mentioned.) Among M. Deschien's own instruments is a system of dial telegraph, in which the regulation of the electro-magnetic action is effected in a double manner (by the tension of an antagonistic spring, and by the distance, greater or less, of the armature from the magnetic cores), by means of a double button placed in front of the apparatus, under the dial. This button corresponds to a hollow axis which envelopes a solid axis; the former has a helical groove in which catches a mother screw fitted to the antagonistic spring of the armature; the other, terminated by a screw, and worked exteriorly by means of a key which one introduces into the centre of the button, moves the iron of the electro-magnet, and the plate-form on which it is mounted. This arrangement is very convenient in practice.

L'Electricite July 20. 78.

Application de l'électricité à la photographie

On a remarqué qu'en électrisant positivement les plaques de verre dont se servent les photographes, le collodion se détache de lui-même. Nous reviendrons sur cette application aussi inattendue qu'intéressante.

Elect News Sept 16. 75

13
3

164,661. *Electrical Billiard Registers.*—Chas. H. Russell and Julius Sax, assignors to Bernhard Ahrens, all of London, England.—Two index fingers, one for each ball, carried on same shaft, one directly, one by a sleeve, each actuated by its own electro-magnet and circuit. First one around actuates mechanism scoring one game on the smaller or game dials. 1. The combination of the armature levers C C, the intermediate gearing a_4 a_5, and the index hands, substantially as described. 2. The combination of the armature levers, the intermediate gearing, and the index hands, with the game recording mechanism consisting, essentially, of the loose pulley M with its discs and stops, the intermediate gearing, and the recording dial and index, as described. 3. The combination of the pusher lever C, and the stop d_1 for limiting its backward movement, as described. 4. The combination of the pusher lever C, and the stop d^2 for limiting its forward movement, substantially as described. 5. The combination of the pusher lever C, and the stops d^1 d^2 for limiting its forward and backward movement. 6. The combination of the index hands a^1 a^2 and the gearing a^4 a^5, having the weight E, as described. 7. The combination of the studs N, the spring stops m^1, loose pinion M, and the connecting gearing, as described.

164,723. *Electric Toys.* Wm. Decker, New York.—Electrical excitation in the glass, resulting from rubbing, causes the figures to dance and execute various gymnastic feats. The electric toy composed of the glass plate A, which is supported on legs B, and of the rubber C, combined to affect the figures D D, which are placed beneath the glass, substantially in the manner herein shown and described.

L'Electricite Nov. 8. 78.

123174 : 13 mars 1878. — *Appareil électro-magnétique*, par M. F. Dumas.

Cet appareil se compose de deux organes essentiels :

1° Le *compositeur* ou *lecteur électro-musical* commande la production des sons en leur assignant la hauteur qui constitue la note musicale ; la durée, élément du rhythme ou de la cadence ; l'intensité qui donne l'expression, etc.

2° *L'exécutant électro-magnétique* qui a pour objet de remplacer les doigts de l'artiste en frappant ou pressant sur les touches du clavier ou sur les clés de l'instrument, soit directement, soit à l'aide de leviers, suivant les indications qui lui sont transmises par le premier organe.

123193 : 14 mars 1878. — *Compteurs électro-chronométriques*, par M. Billet.

Le perfectionnement apporté à ces compteurs a pour but d'assurer la marche régulière des aiguilles, en supprimant les chocs produits par la brusquerie des mouvements des armatures et de permettre à ces compteurs de fonctionner avec des courants peu constants.

Sont supprimés : les répartiteurs, les ressorts à force antagoniste régulièrement croissante et les cliquets de retien, etc.

L'avancement des aiguilles s'effectue un peu plus lentement en une seconde, demi-seconde ou quart de seconde, mais toujours sans choc.

14

L'Electricite Oct-20.78.

MÉTÉOROLOGIE ÉLECTRIQUE

M. Palmieri nous envoie une note sur la comparaison de l'électromètre à conducteur mobile et de l'électromètre à veine liquide descendante qu'il vient de présenter à l'Académie royale des Sciences physiques et mathématiques de Naples dont il est membre.

L'auteur se plaint avec quelque amertume que dans aucun traité français on ne parle de son appareil. En effet, nous ne le trouvons mentionné ni dans l'*Électricité* de M. Gavarret, ni dans l'*Électricité de tension* de M. Moscart.

Mais, quel est le plus à plaindre de M. Palmieri ou des plagiaires qui donnent ainsi une preuve évidente du peu de soin avec lequel ils se tiennent au courant des progrès de la science à laquelle ils prétendent initier leurs lecteurs?

L'auteur s'élève en outre contre une erreur qui paraît commune en France, et qui consiste à supposer que les électromètres prennent l'électricité des couches d'air avec lesquelles ils se trouvent en contact de la même manière qu'un baromètre indique la pression de l'air qui y règne.

Nous confessons que cette hérésie singulière est partagée par nombre de personnages officiels. Mais, il est juste de faire remarquer que ces personnages ne sont, d'ordinaire, que des reflets des opinions allemandes. C'est à Berlin que se trouvent donc les personnes responsables de ces idées absurdes. C'est de l'autre côté du Rhin que M. Palmieri doit adresser ses doléances.

Il doit, jusqu'à ce que le public éclairé ait ouvert les yeux, se contenter de notre approbation sincère.

Nous demanderons la permission d'emprunter à l'excellent *Annuaire de l'Observatoire de Montsouris* pour 1878 (page 48) un passage qui montrera dans quelles conditions déplorables fonctionnent les électromètres Thompson de cet établissement modèle:

« Nous nous bornerons encore cette année à résumer dans deux tableaux les résultats tels qu'ils nous sont fournis par notre électromètre, depuis que le vase à écoulement d'eau a été placé à l'abri de l'humidité dans une des salles de l'Observatoire. Ces résultats sont faibles, parce que le filet d'eau qui se divise à un mètre quatre-vingts du sol et à un mètre du mur de l'Observatoire est dominé par le bâtiment qui, en ce point, a une assez grande hauteur et est en outre garni de deux balcons en saillie. Pour ramener ces nombres à ce qu'on eût obtenu à deux mètres du sol en plein gazon, *il faudrait les multiplier par un facteur voisin de sept en moyenne.* MAIS CE FACTEUR A ÉTÉ TROUVÉ TROP VARIABLE POUR QUE NOUS EN FASSIONS USAGE.

« Le 3 août, le potentiel moyen étant de 19,2 au niveau du filet d'eau, le potentiel de la couche d'air à deux mètres du sol, en plein gazon, a varié de 97 à 130 éléments Daniell dans le milieu du jour. Le lendemain 4, l'électromètre de l'Observatoire marquant en moyenne 15,2, nous avons obtenu, en plein gazon, des nombres variant de 72 à 151 éléments Daniell. Chaque fois que la vapeur d'une locomotive est chassée vers nous par le vent, les signes positifs font place à des signes négatifs très-accusés. *Une seule fois, le potentiel de l'air étant négatif nous l'avons vu passer, pendant quelques instants, au positif à la suite du passage d'une locomotive.* »

Nous ne croyons pas que M. Palmieri ait pu rédiger une critique plus mordante de l'appareil dont il combat si énergiquement et si savamment l'usage.

M. Palmieri craint que sa nationalité ne nuise au développement de ses doctrines. Nous nous bornerons à lui dire que la nation qui a produit Beccaria, Volta et Galvani sera toujours considérée, excepté par les Prussiens scientifiques de Paris, clique académique et universitaire dont l'influence tire à sa fin, comme étant la première des nations électriques.

L'Electricite Sept 20.78

Comptour électro-chronométrique. — Système de MM. Mildé.

Ceux qui sont venus visiter plusieurs fois l'exposition française de la classe 65 qui comprend, comme on le sait, tous les appareils télégraphiques, ont remarqué au fond de la salle un énorme cadran d'horloge qui depuis le commencement de l'Exposition a donné exactement l'heure sans se déranger, et qui n'a pourtant d'autre moteur qu'un tout petit mécanisme électro-magnétique mis en action par un simple pendule qu'on voit à l'exposition de M. Mildé. Pour ceux qui connaissent la marche capricieuse de ces sortes de compteurs, les résultats obtenus par ce système sont réellement très-intéressants, et ils feront peut-être revenir sur l'opinion si défavorable, qu'on a aujourd'hui, sur ce système de transmission de l'heure. Pourtant dans les mécanismes employés, il n'y a rien de réellement nouveau; mais la disposition de tous les organes est si bien entendue que c'est évidemment à elle qu'il faut attribuer les effets avantageux que ce système a fournis.

Nous représentons le mécanisme électro-magnétique du compteur. C'est, comme on le voit, un électro-aimant E E dont l'armature articulée oscille verticalement devant ses pôles en réagissant sur un levier articulé D qui porte le cliquet d'impulsion *E* et un butoir d'arrêt B qui empêche le passage de plusieurs dents au moment des impulsions. Le cliquet de retenue R articulée en S se termine par un bras muni d'un bec d'encliquetage qui joue au-dessus de l'extrémité supérieure de l'armature et peut l'encliqueter au moment où le bec du cliquet de retenue est soulevé pour laisser passer la dent. Or, il résulte de cette disposition que si le cliquet d'impulsion, après avoir poussé une dent, tendait à se relever avant que le cliquet de retenue n'ait fait son office, il en serait empêché par l'armature qui se trouve enclanchée jusqu'à ce que l'échappement soit

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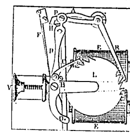

entièrement effectué. Celui-ci se trouve donc effectué indépendamment de la durée et des variations de l'action électrique et de l'action des courants d'air qui pourraient agir sur les aiguilles. Du moment où le rochet a commencé son mouvement, il faut qu'il s'accomplisse intégralement, le cliquet d'impulsion ne peut plus retourner en arrière, et comme le butoir d'arrêt empêche le rochet de faire sauter plus d'une dent en avant, celui-ci, au moment de chaque échappement, est retenu des deux côtés et est forcé de fonctionner régulièrement. D'un autre côté, comme l'armature réagit sur le levier D par l'effet de son articulation sur un point de sa longueur, qui peut être à telle distance que l'on veut du point d'articulation de D, on peut faire accomplir au rochet L la course nécessaire pour l'échappement de ses dents. Dans ce système, le ressort antagoniste de l'armature est constitué par une lame de ressort F dont on peut régler la tension au moyen d'une vis, et la distance attractive de l'armature est réglée au moyen de la vis à contre-écrou V.

La disposition de l'interrupteur appelé à faire fonctionner l'appareil précédent est aussi bien entendue. Pour ne rien changer aux conditions de l'horloge régulatrice, c'est l'ancre d'échappement lui-même qui constitue l'organe interrupteur. A cet effet, l'une des branches de cette ancre porte au-dessous de la palette de repos, et un peu en arrière, une petite palette de platine que peut rencontrer une cheville d'or placée sur la roue d'échappement, au moment où la dent correspondante à cette cheville vient appuyer sur la palette de l'ancre, il en résulte un contact par pression et par friction éminemment bon pour les effets électriques et qui n'exige pour se produire aucune force autre que celle nécessaire au fonctionnement de l'échappement lui-même, laquelle concourt par conséquent à l'entretien du mouvement du balancier au lieu de tendre à l'arrêter.

Pour assurer la bonté des contacts, M. Mildé, au lieu de faire ses liaisons électriques avec les pièces mobiles par des frotteurs, les effectue au moyen de longues lames flexibles dont l'une est fixée au guide du balancier près de son axe d'oscillation.

En somme, le système de M. Mildé, quoique ne présentant rien de nouveau comme principe, se fait remarquer par les bonnes conditions de sa disposition.

TH. DU MONCEL.

ELECTRICITY AS AN EXECUTIONER.—The revolting scenes accompanying the execution of criminals are well calculated to bring to public notice the disadvantages of hanging as a mode of capital punishment. Instead of building a gallows and providing rope, the sheriff, advised by a competent electrician, would procure a powerful Ruhmkorff coil and a heavy battery. These instruments would rarely need replacing, and would last indefinitely for other executions. The battery and coil should be of sufficient strength to deliver an eighteen inch spark. In case of there being more than one person to be executed, all of the condemned would be conducted with all due ceremony to the place of execution, the left hand of one man handcuffed to the right hand of his neighbour, and the conducting wire fastened to bracelets on the disengaged wrists of both criminals, if only two are to be hanged, or to the wrists of the outer men, if more than that number are to suffer. The culprits being seated so as to be seen by the legal witnesses, the sheriff presses a button. The current is instantly established from the coil, passes through the bodies of the men, and all is over. With a competent electrician, who might be a member of the police force, and specially charged with the duty, there would be no possibility of mistakes. The same ignominy which attaches to the gallows would be transferred to this mode of destruction, while the peculiar death by lightning, which, among the ignorant of all nations and ages, has been the subject of profound superstition, would, without doubt, through its very incomprehensibility and mystery imbue the uneducated masses with a deeper horror.—*Scientific American.*

Electric photometer.—Dr. Werner Siemens.—Crystalline [illegible] electricity better when exposed to light than in darkness, the conductivity increasing directly with the degree of illumination. This property, which was discovered by Lieut. Sale, has been utilized by Dr. Siemens in the construction of a delicate photometer, the only additional apparatus required being a one-cell Daniel battery and a galvanometer.

[illegible]

aérienne, cette tâche s'imposait comme une nécessité nationale. Aussi, le conseil municipal a-t-il donné l'impulsion que le Gouvernement et l'Assemblée nationale n'ont fait que suivre.

Le palais du bey de Tunis, épave laissée au Champ-de-Mars lors de l'Exposition universelle de 1867, sert à abriter un laboratoire où M. Marié-Davy a introduit un nombre incroyable d'intruments nouveaux et de dispositions ingénieuses, auxquelles personne n'avait songé. Il reste encore à résoudre pour la mise en activité régulière de ces opérations, une multitude de difficultés de détails et de problèmes inattendus.

Mais le zèle est si grand que l'observatoire de Montsouris sera un des objets les plus curieux de tout Paris, lorsque le Champ-de-Mars ouvrira de nouveau ses portes aux industriels et aux curieux accourus à l'envi des extrémités du monde.

Tous les services étant à créer, l'attention de M. Marié-Davy a dû se porter d'abord sur l'organisation des observations pour lesquelles les méthodes existent et les instruments ne sont point à inventer. Malgré son importance, l'électricité ne pouvait donc fixer dès les débuts l'attention du savant physicien, ses méthodes et instruments sont également à inventer.

On ignore même la portée et presque la nature des services qu'elle semble appelée à rendre. N'est-ce point à son propos que le mot d'Arago est vrai en toute rigueur, et que l'on peut écrire comme lui : « En science, l'imprévu a la part du lion. »

Cependant le rôle de l'électricité est déjà si important, que l'examen des instruments et outils électriques qui se trouvent à Montsouris offrira un grand intérêt de nouveauté. Que sera-ce quand on pourra se préoccuper de leur règlement et organisation systématique?

Nous partagerons cette étude rapide en trois parties : les paratonnerres, l'électricité ouvrière, et les instruments d'étude de l'électricité naturelle.

Depuis que M. Marié-Davy est directeur de l'observatoire, la foudre a déjà visité deux fois l'établissement. Avant que cette haute fonction ne lui fût confiée, elle avait déjà frappé le palais ; ce phénomène a été décrit par nous dans la *Liberté*.

Il était donc urgent de prendre des mesures contre de nouvelles invasions du fluide qui pouvaient être moins brusques que les précédentes, et sur lesquelles on pouvait compter, car la foudre n'ayant point de caprices, ces visites tiennent à quelque circonstance fatale.

Malheureusement la question des paratonnerres était en suspens, par suite de la création d'un comité spécial chargé de prendre des mesures pour assurer la parfaite efficacité de ces organes de protection. Il fallait donc attendre que le rapport fût déposé, et que l'adjudication ait eu lieu.

L'établissement de Montsouris sera un des premiers monuments publics pourvu de paratonnerres construits sur le système de la Commission, car M. Eugène Grenet, adjudicataire, a reçu toutes les instructions nécessaires pour procéder aux constructions et à la fabrication.

Les paratonnerres seront au nombre de trois, car chaque dôme est destiné à en recevoir un, comme on peut le voir sur la figure. Les pointes seules seront en cuivre, et les conducteurs en fer, la Commission n'ayant pu traiter l'observatoire différemment que les autres édifices municipaux. Le seul progrès saillant, réalisé dans la partie aérienne sera dans la suppression du platine, remplacé par un métal qui a le double avantage d'être moins dur et moins dispendieux. Les tiges seront, de plus, terminées par des pointes multiples recourbées, de manière à être en harmonie avec l'architecture générale du palais.

Mais, composée en grande partie de membres de l'Institut, la Commission ne croit chargée de travailler au progrès de la science électrique. Elle aura donc prochainement l'honneur d'installer le paratonnerre d'études de l'observatoire de Montsouris, car cet appareil sera indépendant, isolé de tout bâtiment, ne tenant aux autres paratonnerres que par le puits commun dans lequel se rendra son conducteur. Toutes les précautions seront prises pour que la conductibilité de cet appareil soit aussi parfaite que possible, et qu'il soutire par conséquent aux nuages des masses considérables d'électricité.

La partie souterraine pénétrera jusqu'à la nappe aquifère, et les communications seront établies de telle manière que l'action de l'humidité ne puisse jamais les détruire ou les affaiblir.

Les vérifications établies par la commission dans les autres édifices publics ont lieu deux fois par an. Il est clair que la commission ne saurait borner là son ambition, et qu'elle donnera certainement à l'observatoire de Montsouris *un tour de faveur!*

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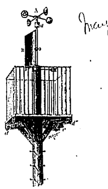


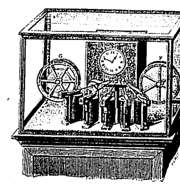
GIROUETTE DE L'ANÉMOMÈTRE ÉLECTRIQUE DE M. HERVÉ MANGON.

Si l'on suivait l'avis que nous avons exprimé dans notre brochure, sur l'*utilité d'établir le contrôle des paratonnerres*, on établirait certainement dans cette occasion le contrôle d'une façon permanente.

Nous arrivons en second lieu à l'étude de l'électricité ouvrière dont les emplois sont déjà nombreux et importants.

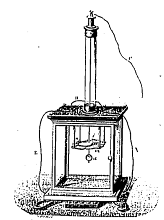
On s'en est servi dans la graduation de l'anémomètre enregistreur de M. Hervé-Mangon, dont nous donnons le dessin.

L'appareil se compose de deux parties distinctes. Au sommet d'un pilone, qui a 20 mètres d'élévation, se trouve une roue à coupe destinée à recevoir l'impulsion du vent.


ÉLECTRO-AIMANT
ENREGISTREUR DES DIRECTIONS DE VENTS.

Les tours de roue sont enregistrés, *une marque* est faite tous les cinq cents tours par un électro-aimant sur un rouleau de papier mû proportionnellement au temps par un ressort d'horlogerie.

C'est ce renseignement que certains journaux publient chaque jour.


ÉLECTROMÈTRE THOMSON, MODIFIÉ PAR M. BRAULY.

La direction du vent est donnée par un procédé beaucoup plus compliqué, mais dans lequel l'électricité ne joue pas un moindre rôle.

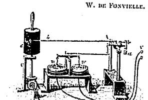
Quatre électro-aimants ont été affectés au service des quatre points cardinaux, se nommant : l'un l'électro-aimant du Nord, l'autre de l'Est, le troisième de l'Ouest et le quatrième du Sud.

Un courant est envoyé par un distributeur toutes les cinq minutes. Lorsque la girouette vient du Nord, c'est l'électro-aimant du Nord qui donne sa marque ; lorsque le vent est entre Nord et Est, le courant passe à la fois dans les électros du Nord et de l'Est. Si la girouette remonte encore vers l'Est, c'est l'électro de l'Est qui, seul, est mis en action, ainsi de suite pour tout le rhumb.

L'électricité est parfaitement docile, mais elle ne joue dans ce système qu'un rôle très-subordonné, puisqu'elle se borne à produire l'ouverture et la fermeture des courants; son action ne se bornera pas toujours évidemment, dans la solution de cette question importante, à jouer un rôle si essentiellement secondaire. Nous demandons la permission de remettre à plus tard l'exposé de nos idées.

Il en sera de même des résultats obtenus avec l'électromètre de Thompson qui a été modifié par M. Brauly, et dont nous nous bornons à donner aujourd'hui la figure. La plus grande différence consiste comme il est facile de le voir dans la forme de la partie mobile. Quant aux dispositions qui sont prises pour assurer la conductibilité, elles sont analogues à celles qui ont été adoptées par le célèbre physicien anglais.

W. DE FONVIELLE.



précieuses adhésions, et les encouragements que nous avons reçus nous font espérer qu'il réunira dans une commune pensée, dégagée de toute influence hostile ou jalouse, tous les vrais amis de la science et du progrès.

HALLEZ D'ARROS

L'ÉLECTRICITÉ

A L'EXPOSITION UNIVERSELLE DE 1878

(9e *article*)

DE L'UNIFICATION DE L'HEURE DANS LES VILLES.

L'un des progrès qui est le plus réclamé aujourd'hui par l'opinion publique est l'unification de l'heure dans les villes. Quand on réfléchit aux conséquences que peut avoir pour les affaires une différence d'heure de quelques minutes, différence qui peut vous faire manquer un train de chemin de fer, une adjudication ou un rendez-vous d'affaires, qui peut vous rendre passible de punitions ou de réprimandes quand vous arrivez en retard, on se demande comment les villes n'ont pas plus tôt profité des nombreux moyens qui leur étaient offerts pour régulariser l'heure des horloges publiques. On répond, il est vrai, que l'écart des heures n'est jamais assez grand pour entraîner des dommages regrettables, mais j'ai constaté moi-même souvent des erreurs dépassant cinq et même dix minutes.

Les moyens proposés pour l'unification de l'heure sont de diverse nature. Les uns sont fondés sur l'emploi des effets pneumatiques, les autres sur les réactions électriques. Ces derniers sont évidemment les plus simples et les moins coûteux; mais les nombreux caprices de l'électricité se sont révélés si souvent dans les expériences que l'on a faites de ces systèmes, que la confiance que l'on pouvait avoir en eux s'est trouvée très-ébranlée. Ces résultats défavorables tenaient évidemment à ce que l'on n'avait pas appliqué l'électricité dans les conditions qui étaient spécialement propres à sa nature. Il ne faut pas perdre de vue, en effet, que l'on ne peut demander à l'électricité qu'une action mécanique très-minime; mais comme elle peut se manifester instantanément à telle distance que l'on veut, on peut en obtenir des effets que nuls autres moyens ne pourraient fournir et qui, combinés avec des actions mécaniques indépendantes, peuvent en devenir, en quelque sorte, l'âme ou la partie dirigeante. D'après ces considérations, il est évident que l'emploi des compteurs électro-chronométriques dans lesquels l'électricité fait tous les frais du mouvement, ne peut être recommandé pour l'unification de l'heure dans les villes; dans de grands établissements publics et industriels où les fils de communication ne sont pas sujets à être influencés par les causes extérieures, ils peuvent, il est vrai, être utilement employés à cause de leur bon marché relatif et de la facilité qu'ils donnent de faire fonctionner des cadrans de grand diamètre; mais du moment où ces fils doivent constituer des lignes aériennes ou même souterraines, leur emploi doit être proscrit, car ils ne peuvent présenter aucune sûreté dans leur marche. Il est vrai qu'avec les systèmes à courants renversés de M. Glœsener, les effets sont meilleurs, et plusieurs villes de la Belgique, entre autres Liége, ont un service public ainsi organisé, mais il faut qu'on y apporte une grande surveillance, et on m'a assuré que, souvent, l'on était obligé de réparer à la main les irrégularités d'action des mécanismes électro-magnétiques. Or, du moment où l'on est obligé d'avoir un service de surveillance, le système électrique devient une superfétation, car, en l'appliquant aux horloges ordinaires, on se trouverait avoir l'heure aussi exactement.

Ce que nous disons des compteurs électro-chronométriques dans lesquels l'électricité fait tous les frais du mouvement peut également s'appliquer aux compteurs électro-chronométriques à mouvements d'horlogerie dans lesquels la marche des aiguilles dépend d'échappements déterminés électriquement. Sans doute, l'action électro-magnétique est alors plus sûre, mais les effets des courants accidentels ne sont pas prévenus pour cela, et il peut alors se faire que des échappements soient effectués en dehors de la transmission ou manquent tout à fait, et, comme avec ce système les erreurs s'accumulent, il peut se faire qu'au bout de plusieurs jours on ait à enregistrer des retards ou des avances sensibles. Il faut, de plus, remonter les horloges comme si l'électricité n'intervenait pas.

Ces différentes considérations ont fait penser à la commission des horloges de la Ville de Paris que l'unification de l'heure dans une ville n'aurait quelque chance de succès qu'en n'employant l'électricité que comme un moyen auxiliaire, c'est-à-dire comme un organe de sécurité et de correction dont l'intervention pourrait ne pas être indispensable à la marche des horloges, mais qui, lorsqu'il réagirait, pourrait en corriger les défectuosités à des intervalles de temps plus ou moins éloignés. D'après ce principe, il était indiqué qu'on devait toujours employer pour les horloges publiques des horloges ordinaires, mais qu'on devait leur appliquer un mécanisme correcteur qui pouvait être plus ou moins compliqué suivant la précision qu'on voulait apporter à leurs indications.

Le problème, posé de cette manière, est évidemment susceptible de plusieurs solutions. On peut, en effet, demander à ce mécanisme correcteur une action toutes les secondes, et alors le problème se trouve ramené à synchroniser électriquement les oscillations du balancier des diverses horloges à régler d'après celles du pendule d'une horloge type ou régulatrice. Ce système permet d'unifier l'heure à une très-petite fraction de seconde près; mais, en somme, une pareille précision, utile il est vrai pour les horlogers, n'est pas nécessaire pour le public qui se contenterait d'avoir l'heure à quelques secondes près; et si on réduit le problème à ces dernières conditions, sa solution devient beaucoup plus simple et plus facile, car il suffit de remettre à l'heure électriquement les horloges, soit toutes les heures, soit même une fois par jour. Il faudrait, en effet, qu'une horloge fût bien mauvaise pour varier d'un certain nombre de secondes dans l'espace d'une heure. Dans une ville peu considérable, il est évident que le problème posé de cette manière satisferait aux besoins des populations, et nous verrons que les essais qui ont été tentés peuvent donner raison à cette conclusion; mais dans une grande ville comme Paris, il n'en est plus de même. L'heure exacte peut être donnée par l'Observatoire, et il est utile pour le réglage de tous les chronomètres qui s'y construisent, que les horlogers puissent avoir l'heure exacte dans leur quartier, sans qu'ils aient à se déranger pour la prendre chaque jour à l'Observatoire.

On pouvait donc désirer que, dans les différents quartiers de Paris, il y eût des centres horaires dont les horloges pussent marcher complétement synchroniquement avec celle de l'Observatoire, et qui pussent à leur tour servir d'horloges régulatrices pour remettre à l'heure les différentes horloges de leurs quartiers respectifs par des moyens plus simples. C'est ce dernier parti qu'a adopté en principe la sous-commission des horloges de Paris, et elle en étudie actuellement les moyens d'exécution.

Sans préjuger en rien les décisions qui pourront être émises par cette commission et celles du conseil municipal de la Ville de Paris, nous pouvons donner une idée de la manière dont le double problème pourrait être le plus facilement et le plus complétement résolu.

On pourrait, par exemple, établir au centre de la Ville de Paris un double réseau télégraphique partant de l'Observatoire, pour constituer deux circuits entièrement métalliques et indépendants, comprenant chacun six centres horaires que l'on choisirait de manière à être échelonnés circulairement, l'un à l'est, l'autre à l'ouest de la Ville de Paris. Par ce moyen, chaque circuit n'aurait qu'un fil, et ce fil serait utilisé dans toute sa longueur, depuis son départ de l'Observatoire, où il rencontrerait les centres horaires du centre de Paris, jusqu'à son retour à l'Observatoire où il n'arriverait qu'après avoir desservi les centres horaires échelonnés dans les parties excentriques de la capitale. Nous verrons à l'instant que le dispositif mécanique des horloges disposées à cet effet se prête admirablement à cette combinaison.

De cette manière, la Ville de Paris aurait donc douze centres horaires d'où on pourrait ensuite distribuer l'heure dans les quartiers avoisinants, au moyen de réseaux télégraphiques particuliers qui viendraient y rayonner et dont la disposition serait plus ou moins compliquée, suivant le système de remise à l'heure adopté.

Il s'agit maintenant d'examiner comment le double problème que nous venons de poser pourrait être résolu au point de vue des instruments chronométriques. A ce point de vue, la question n'est pas embarrassante, car deux systèmes qu'on pourrait dès maintenant adopter ont été expérimentés depuis assez longtemps pour qu'on soit certain de leur réussite. Depuis trois ans, en effet, les nombreuses expériences faites entre l'Observatoire et le Conservatoire des Arts et Métiers ont montré que l'on pouvait obtenir le synchronisme parfait de marche de plusieurs horloges en régularisant électriquement les oscillations de leur pendule par le système de MM. Foucault et Vérité, et l'on a pu reconnaître par les essais faits au lycée Fontanes, à la Mairie du IVe arrondissement et à Roubaix, que le système de remise à l'heure de M. Collin pouvait amplement satisfaire aux besoins du public. Nous allons donc entrer dans quelques détails sur ces ingénieux systèmes que l'on peut du reste étudier à loisir à l'Exposition, car l'un, le premier, est adapté à l'une des horloges exposées dans le pavillon de la Ville de Paris, quelle est réglée toutes les secondes par l'horloge de l'Observatoire, et le second est appliqué à la grande horloge que l'on remarque en avant de l'exposition de M. Collin, et qui règle un certain nombre d'horloges des kiosques.

Système de réglage des horloges de MM. Foucault et Vérité. — Ce système, imaginé dès l'année 1847 par M. Foucault, et rendu pratique en 1863 par M. Vérité, est basé sur l'action d'un ou de deux électro-aimants placés au-dessous du balancier de l'horloge à régler au point où ce balancier atteint ses écarts extrêmes, et qui actionnent une armature de fer doux, fixée à la partie inférieure de ce balancier. De cette manière, si celui-ci atteint un de ses écarts extrêmes un peu plus tôt qu'il ne doit le faire pour correspondre à l'oscillation correspondante du balancier de l'horloge régulatrice, il se trouve retenu dans cette position jusqu'à ce que le balancier régulateur ait atteint la même position, et ce n'est que quand cette coïncidence de position se produit, qu'un interrupteur adapté à l'horloge régulatrice coupe le courant et permet aux deux balanciers de partir ensemble pour accomplir leur oscillation rétrograde. Les mêmes effets se renouvelant incessamment pour chaque demi-oscillation des balanciers, ceux-ci sont forcés de marcher synchroniquement, et, par conséquent, de fournir l'heure exacte. Il faut seulement que les horloges à régler aient une petite avance sur l'horloge régulatrice, ce qu'il est toujours facile d'obtenir.

Une des parties les plus délicates de ce système a été l'interrupteur de l'horloge régulatrice, et, sous ce rapport, M. Breguet a perfectionné considérablement le système primitif. Dans ses conditions actuelles, il se compose de six leviers articulés (trois de chaque côté du pendule de l'horloge régulatrice), disposés de manière à recevoir à chaque oscillation du pendule le contact d'un frotteur à trois lames qui établit une triple communication métallique entre la pile et le circuit à chaque inclinaison du pendule, à gauche ou à droite de la verticale. Ce frotteur est adapté à l'extrémité supérieure du pendule, et si près du centre d'oscillation, que l'influence qu'il peut exercer sur la marche de l'horloge est très-minime. Nous allons voir d'ailleurs que, dans ce système, la marche de l'horloge régulatrice doit être corrigée tous les matins par l'astronome chargé de ce service à l'Observatoire.

L'expérience a montré qu'un seul des systèmes d'interrupteurs dont nous venons de parler était suffisant pour régulariser la marche des horloges à régler et que l'on pouvait introduire dans le circuit tel nombre d'horloges qu'il pouvait convenir, pourvu qu'on augmentât la pile proportionnellement. On peut en conséquence faire réagir les deux systèmes d'interrupteurs sur les deux circuits dont nous avons parlé et en introduisant dans chacun d'eux six horloges, on ne dépasse pas les limites de résistance susceptibles d'être vaincues par une action électrique modérée.

Les avantages de ce système d'interrupteur sont faciles à comprendre; d'abord, les oxydations dues aux interruptions du courant, se trouvant réparties sur trois points, sont moins fortes; en second lieu, si l'un des contacts manque par suite de circonstances accidentelles, les deux autres sont là pour le suppléer; en troisième lieu, on peut nettoyer facilement et successivement ces contacts sans altérer

20

THE TELEGRAPHIC JOURNAL.

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DR. C. W. SIEMENS'S ELECTRICAL PYROMETER.

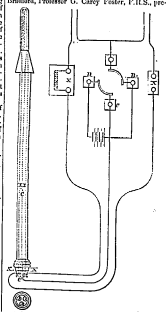
The electrical resistance of metal conductors depends upon their dimensions, material, and upon their temperature; an increase of the latter causing a corresponding increase of resistance. The law of this increase is known. Thus, the resistance of a conductor being ascertained at 0° C., it can be calculated for any temperature, and, *vice versâ*, if the resistance can be found by measurement, the temperature can be calculated. This is the principle upon which the Electrical Pyrometer is based.

A platinum coil of a known resistance at 0° C. is coiled on a cylinder of fire-clay, protected by an iron or platinum tube, and is exposed to the temperature to be determined. Leading wires are arranged to connect this coil with an instrument suitable for measuring its resistance, and from this resistance the temperature can be calculated.

The instrument supplied for the purpose of measuring the resistance is a differential voltameter. The Differential Voltameter consists of two separate glass tubes, in each of which a mixture of sulphuric acid and water is decomposed by an electrical current passing between two platinum electrodes. The gas which is generated is collected in the long cylindrical and carefully-calibred top of the tube, and its quantity is read off by means of a graduated scale fixed behind the tubes. Movable reservoirs are provided, communicating with the tubes, to regulate the level of the liquid. The current of the battery is divided (by passing a commutator) into two circuits, one of which consists of an artificial resistance in the instrument and the platinum electrodes in one tube; the other, of the resistance to be measured and the electrodes in the other tube. The quantities of gas developed in the two tubes are in inverse proportion to the resistances of their respective circuits, therefore one of the resistances, viz., that in the instrument, being known, the other can be calculated.

When required for use, the battery glasses are filled with pure water, or, in case of the power of the battery decreasing, with a solution of sal-ammoniac in water. The poles are connected to n and n' on the commutator. The small end of the tube, as far as the cone, is exposed to the heat to be measured, and the terminals x, x', c are connected to the ends of the leading cable bearing corresponding letters, and the other end of the leading cable to the terminals x, x', c on the voltameter. The differential voltameter is filled with the diluted sulphuric acid through the reservoirs, the india-rubber cushions being lifted from the top of the tubes. The commutator is then turned so that the contact springs on both sides rest on the ebonite. The liquid in both tubes is regulated to the same level (0° of scale), and the india-rubber cushions let down again. When the commutator is turned through a quarter of a circle on to the brass, the development of gas will commence almost immediately. The commutator should be turned half round every ten seconds to reverse the current. The current is kept passing until the liquid has fallen in the tubes to at least 50° of the scale, then put in its first position, so that the contact springs rest on the ebonite; the level of the liquids is read off on the scale, these numbers found in the table accompanying the instrument, and the intersecting point of the lines starting from these figures gives the resistance of the exposed coil in black, and its temperature in red, figures. For a new experiment the levels are adjusted as before.

At a recent meeting of the British Association, at Bradford, Professor G. Carey Foster, F.R.S., pre-



sented to the Chemical Science Section the report of the Committee appointed by the Association to examine and report upon the merits of the pyrometer; and the report stated that the first step was evidently to test the electrical permanence of the pyrometer, and the attention of the committee has as yet been confined to the examination of this point. At the Brighton Meeting in 1872, it was reported by them that a pyrometer whose resistance was, to begin with, 9·917 B.A. units at 10° C., had a resistance of 10·502 at the same temperature, after having been repeatedly heated to redness. This change was found by Professor Williamson to be, in all probability, due to chemical alteration of

21

means and by the same alphabet as the single needle instrument.

Prof. Palmieri has discovered a new instrument which he calls the "diagometer," and which is constructed for the rapid examination of oils and textures by means of electricity. What the apparatus will do Prof. Palmieri details thus: 1. It will show the quality of olive oil. 2. It will distinguish olive oil from seed oil. 3. It will indicate whether olive oil, although of the best appearance, has been mixed with seed oil. 4. It will show the quality of seed oils. 5. Finally, it will indicate the presence of cotton in silken or woollen textures. The professor has been complimented for this invention by the Chamber of Arts and Commerce at Naples, who have published a full description of the apparatus, with instructions for use.—(*Nature.*)

In an amusing article on "Insular Egotism" the *New York Telegrapher* gravely publishes the following interesting information:—In no other country has telegraphy acquired such perfection in actual use or been so universally adopted and used by the people as in the United States and Canadas. More actual business is transmitted daily on a single circuit by two operators in this country than by four operators on

Electric Chronographs.—By Marcel Deprez.—In every chronograph there are three distinct kinds of organisms:—(1) to print the movement of the projectile on paper; (2) registers to leave a trace on the paper at the moment when the body passes certain determined marking points; (3) a registering apparatus of equal intervals of time. Called upon to make a deep study of these machines in order to render them reliable registers, he used one of Schultz's chronographs, one of the features of which is rapid vibrations of a tuning-fork. The registering of the successive moments of the phenomenon to be studied was made by means of the induction spark. M. Marcel Deprez first determined the delay of the spark, *i.e.*, the time interval which passes between breakage of the inducting current and the spark's explosion, by causing the chronograph's own cylinder, which carried an insulated sector, to break the circuit. He commenced by turning the cylinder very slowly, when a certain mark was obtained at the moment in which the insulating sector broke the inducing current; then, spinning it round with great swiftness, a new mark was obtained, produced by the spark which struck the cylinder during this rapid movement. All the results of his experiments cannot be given; suffice it to say they showed that of all registering processes the induction spark is by far the most rapid, the *delay* being generally below $\frac{1}{10000}$th of a second. Certain serious inconveniences render its employment almost inadmissible. Indeed its production is very capricious, and much depends on the manner in which the inducing current is broken. It almost always strikes the cylinder at a great number of points, when it leaves a mark like a comet with a tail composed of sparks. When the speed of the cylinder is very great the mark becomes extremely uncertain. Notwithstanding all these inconveniences, it is perhaps preferable to other methods of registering by reason of its instantaneousness, provided, with a single coil, an extremely large number of sparks can be produced in a second. Unfortunately we cannot do so. The number of sparks produceable in a second do not exceed two or three hundred, and then only with a strong battery and a very small explosive distance. As to the use of electro-chemical paper very little is to be said: it has been abandoned because the mark presents a very uncertain ending. Lastly, electro-magnets appeared utterly inadmissible under the circumstances in which he was placed.

Elongation of Conductors by Electricity.—Various physicists have from time to time studied the modifications in the molecular state of the conducting wires, due to the passage of the electric current. Wertheim arrived at the conclusion that the transmission of the current modified the elasticity of the conductor, but Edlund, on the contrary, by a series of careful experiments, has determined such not to be the case. This latter investigator has found, however, that the elongation of the wire under the influence of the current is sensibly greater than the dilitation due to the elevation of temperature resulting from the passage of the electricity. Two calculations were made of the temperature of the wire, one deduced from the relation previously established between the galvanic resistance of the conductor and its temperature, the other from the elongation of the wire directly measured and of its coefficient of dilitation, equally known. The second mode of determining the temperature constantly gave higher figures than the first, and M. Edlund therefore concluded that the current produced a special elongation in the conducting wire which is added to the expansion resulting from the accession of heat.

Quite recently M. Streintz has taken up this subject, and, by further investigation, has sought to measure accurately the galvanic elongation for different metals.

The observations were made on wires 0·019 inch in diameter and 21 inches in length, the ends of which just touched two levers which carried mirrors placed in the prolongation of their axis of rotation. The divisions of a graduated scale were reflected in the mirrors, and thus the displacement of the extremities of the wires could be accurately read. All the wires, except those of hard tempered steel, showed a marked excess of expansion under the action of the current, which varied according to the different metals, from 11 to 27 per cent. of the dilatation of the wire under the action of heat alone when brought from the normal temperature, 68° Fah., to that fixed as a limit, 131.4°.

M. Streintz sums up his results as follows: 1. The galvanic current causes no other modification of the elasticity of a conducting wire than such as results from the elevation of the temperature produced.

2. Under the action of the current, the conductor expands more than when it is carried to the same temperature without the current; tempered steel alone does not present this excess of dilatation.

3. Galvanic dilitation does not manifest itself immediately on the closing of the current, but gradually, as does calorific expansion.

4. Galvanic dilitation is not the consequence of an electrodynamic repulsion, but probably results from a calorific polarization, or an orientation of the calorific vibrations.

Gas Lighting Apparatus.

This patent was granted to Adolph T. Smith, of New York city, March 19, 1874.

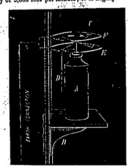
This invention is highly ingenious. It is not a telegraphic gas lighting device, but is designed to supplant matches or replace the "electric torch" of Batcheller, to which it is apparently superior.

The device is shown in fig. 2. X is the body of the burner which is made of soft iron; surrounding this is a bobbin, M. G is a vibrating contact spring secured to the bottom of the bobbin M and provided with a small armature P. The spring is extended up over the burner and made to face a rigid point, N, secured to the burner. These points are tipped with platina and are shown over the jet in the diagram in order to understand the principle clearly.

An Electric Toy.

To the Editor of the Scientific American:

I send you herewith a sketch of a scientific toy, which I have recently constructed and placed on a bracket in front of the desk in my engine room. The main belt of the engine is 30 inches in width, and about 120 feet in length, and runs from south to north, at an angle of about 45°, and with a velocity of 2,500 feet per minute; it is highly electrical.



The idea occurred to me that the electricity so developed might be made use of for mechanical or other purposes; and having seen an engraving of what is called an electrical wheel, I constructed one as shown herewith, but without the coils. A is a vial, about 6 inches in length by 1¼ inches in diameter, the bottom of which is inserted in a cavity in the bracket, B. In the center of the cork is inserted the eye end of a darning needle, the point projecting upward about 3 inches, on which rests the wheel, C, which consists of two pieces of copper wire, 1-32 inch in diameter and 7 inches in length, placed at right angles to each other; their centers are flattened and soldered together, and half an inch of the end of each arm is bent at a right angle, all in the same direction, and filed to a point. D is a copper wire, one eighth inch in diameter, one end of which rests against the needle, the other running in front of and about 6 inches distance from the belt, and terminating in 5 or 6 points, 2 inches long, projecting toward it.

On connecting the conducting wire with the needle, my wheel immediately started off at a speed of 100 turns in 50 seconds. I soon ascertained that, by placing a good metallic conductor beneath the wheel and making an earth connection, I could add materially to its speed. Accordingly I placed a copper coil, E, 5½ inches in diameter, one inch below the wheel, connecting it with the gas pipe, which accelerated its speed to 148 turns in 50 seconds. Soon my wheel began to gyrate even to an angle of 20°. This annoyed and puzzled me. I eventually found that, by adding another coil, F, one inch above the wheel, and connecting it with the earth, I not only restored its equilibrium, but also increased its velocity to 173 turns in 50 seconds.

When the air is dry and frosty, I have had it running as fast as 280 turns per minute, and the ozone given off by the wheel is apparent to the senses at a distance of several feet. It also acts as a barometer, indicating (by increasing or diminishing its speed) atmospheric changes several hours in advance. It is especially lively on the approach and during the prevalence of a northeast snow storm; but with the wind anywhere from east to south, it will scarcely move at all.

The apparatus can be easily constructed by any person of ordinary intelligence, and it makes a very interesting scientific apparatus. It can as well be located in the counting room or office as in the engine room.

328 Delancy street, New York city. EDWIN LEACH.

New Electromagnetic Station Indicator.

Mr. Charles W. White, of New York city, has patented, August 18, 1874, through the Scientific American Patent Agency, a quite ingenious station indicator, by means of which the names of places printed on an endless band are caused to appear and change by the action of mechanism, controlled by electromagnets. The rollers over which the band passes are geared to each other, and are rotated by a spur wheel, which is itself turned by a ratchet in which a pawl engages. The latter connects with levers vibrated by the movements of the magnet armatures, so as to cause the pawl to turn the ratchet, and so cause the band to move around the rollers. There are two sets of this gearing, in order that the band may be turned in either direction. In addition to this, there is a check pawl, which is lifted when the carrying pawl is operated. This locks a ratchet, so that the band is firmly held at any point until again set in motion by the mechanism. The indicators are placed in any convenient position in the cars, and from each set of magnets an independent circuit is led to the point whence the machine is to be controlled, where a suitable closer is placed in each circuit. Upon one circuit being closed, the indicating ribbon is unwound from the top roll, and wound on the lower one; the other circuit established, the reverse takes place.

The mode of locking the mechanism and the ratchet arrangement for turning the rolls are novel, and embrace efficient improvements in the electromagnetic principle for operating station indicators.

attainable would be that afforded by the use of a system of working so organised that no accident could occur without the simultaneous misconduct of all three of these parties; but practically no such system can exist. It is, however, quite possible to use a system in which an accident can only be caused by the simultaneous misconduct or neglect of two out of the three parties, and in our opinion no system which affords a less security than this should ever be employed to control the traffic on single lines. To obtain this twofold security it is essential that the driver and guard in charge of a train which is about to traverse a single line should, before starting, be furnished with absolute evidence that the station-master or inspector, from whom they receive the starting order, has for the time being the length of single line at his disposal. When the "staff" system is employed, this evidence is afforded by the "staff," which must either be handed to the driver or shown to him if he is despatched by ticket.* It is the duty of the driver to see the staff before starting, and, except by the simultaneous misconduct of the driver and the station-master or inspector, it is thus impossible that where the staff system is in use a train shall be sent off from a station which, for the time being, has not the line at its disposal. If, on the other hand, the line be worked by telegraph, then as we urged in our number of the week before last, printing telegraphs should be used, and a driver should only start when he has had handed to him a printed message received from the station towards which he is going. This message would be an assurance to the driver that the inspector from whom he received his starting order had for the time the control of the line, and that the station-master or inspector at the other end knew he was coming. When once a train was despatched no other train could be despatched in an opposite direction to meet it without the concurrent misconduct of the officials at both ends of the line. As we stated in our former article when explaining this system more fully, the great point lies in the driver not receiving a mere verbal starting order and not acting solely on the authority of the station-master or inspector by whom he is started. In other words it is essential, as we have said, that the driver should have substantial proof that the officials at the other end of the line know that until his arrival at their station they have no authority to despatch a train. Of course there is one contingency which no system can entirely guard against, and that is the chance of a driver starting without authority. This contingency is, however, an exceedingly remote one, and even it can be partially guarded against by making it incumbent upon the guard of a train to receive the same authority to proceed as the driver.

In his summing up to which we have referred, and which has no doubt been perused by most of our readers in the columns of the daily press, Captain Tyler appears to take a somewhat favourable view of the system of control in force between Norwich and Brundall, and the system has certainly one great point in its favour, namely, that it had worked for many years without mishap. It had, however, as we have shown, the serious defect that the misconduct or carelessness of one person could upset its security, whereas it is possible by the adoption of other systems to insure immunity from accident unless two persons concur in their misconduct—an arrangement which gives far more than twofold security.

TORPEDO EXPERIMENTS.

Since our last notice of the torpedo experiments against the hull of the Oberon, two more—the third and fourth of the present series—have been carried out, and the vessel still remains whole—we can hardly say intact. The results of the last experiment, however, render it very questionable whether she would not have succumbed to the force of the explosion had her inertia been that due to a vessel of her size fitted with engines and boilers, and fully armed and equipped, instead of that presented by a mere empty hull. The third experiment took place on the 5th of September last, and was carried out under precisely similar conditions to those by which it had been preceded, with the exception that the distance between the torpedo and the vessel had been decreased by 20 ft., the distances being in the first experiment 100 ft., in the second 80 ft., and in the third 60 ft. The torpedo was an iron case containing 500 lb. of Waltham Abbey disc gun-cotton, saturated with fresh water, and fired by dry discs electrically exploded. The Oberon was provided with crusher gauges as before, arranged as described and illustrated at page 126 of our present volume. The torpedo was exploded about four o'clock in the afternoon, the firing party being stationed at Fort Monckton. The usual upheaval of water followed the explosion, the effect of the latter being perceptibly felt on board the various vessels lying off the Oberon. An internal examination of the vessel after the explosion disclosed the fact that the hatchway combing had been unshipped, and the water tanks displaced as before. The live stock placed on board, and which consisted of sheep and rabbits, again escaped without injury. An examination of the bottom of the Oberon after she had been placed in dock showed that although no appreciable damage had been done to it, still the limits of safety were being very closely approached. It was, therefore, determined that for the fourth experiment the distance should only be decreased by 10 ft. instead of 20 ft. as in the last case.

As it was not improbable that the next torpedo might decide the fate of the Oberon, it was resolved to adopt such measures as would enable her to be kept afloat and towed into dock with the least possible delay should she become disabled. To this end a large quantity of iron ballast was taken out of her, and an equivalent weight in the shape of water tanks and casks stowed away in her. Most of the tanks and casks were empty, but it was necessary to fill some of them with water in order to supply the weight required above that afforded by the tanks themselves to bring the Oberon down to her proper draught. Heavy baulks of timber were set up between the paddle-box outer beams and the upper edge of the outer bottom clear of her sides, in order to afford a hold for the lifting chains. The chain cables with which the Oberon has been provided for holding her together in the event of her hull being fractured by the mine, or for enabling her to be raised, either wholly or in parts, should she be sunk, were disposed in four double loops extending over each side and round the bottom of the vessel. She had also a double length of chains placed in line with her keel connected with the transverse loops, and made fast inboard over each bow and quarter. In order further to provide for her being raised from the bottom should such a necessity arise, two vessels—the Laurel, an old sailing frigate, and the Rinaldo, a useless screw sloop—were prepared for the purpose of being used as a floating lifting power. The other precautionary measures consisted in placing ships' hand pumps in the hatchways wherever they could be worked, supplemented by ships' fire engines to keep the vessel clear of water should a breach be effected. Beyond all this was a very sensible and sailor-like arrangement, suggested by Captain Moriarty, for stopping to some extent any leak. This consisted in making fast an old sail to the bulwarks directly over the area upon which the full force of the explosion would be exerted. The sail was furled and secured by slight rope-yarn stops to the topsides, the lower edge of the sail being weighted, so that when let go it would rapidly sink and cover the fracture caused by the torpedo.

These preparations occupied some time, and caused the fourth experiment to be delayed somewhat beyond the time originally named for it to take place. Ultimately, however, it was arranged that the torpedo should be fired at 9 o'clock on Saturday last, and this programme was carried out. In addition, however, to the arrangements we have mentioned, there were others which had reference to the probability of one torpdeo exploding another in its vicinity. This question has been suggested in a very practical manner by the results of a series of experiments similar to our own, which are being carried out at the present time by the Swedish Government against a similar vessel to the Oberon. The difference, however, consists in the explosive used as a charge, the Swedish experiment being carried out with dynamite, and the English with gun-cotton. The Swedish experiments have proved that a primary torpedo charged with 150 lb. of dynamite and fired, exploded by concussion two other similar charges, each laid 200 ft. away from the primary torpedo and unconnected with it or with each other. In order to ascertain the action of gun-cotton under similar conditions in the experiments of last Saturday, a secondary charge of 100 lb. of Waltham Abbey disc gun-cotton saturated with about 30 per cent. of fresh water, was placed in a service mine case, and laid about 120 ft. diagonally away from the main torpedo. Another secondary charge, consisting of 50 lb. of gun-cotton, was secured in a piece of netting, and placed 120 ft. in another direction from the primary charge. The two secondary torpedoes were placed on a bed of soft mud at a distance of 100 ft. apart, and were held down by iron ballast. All being ready, and the Oberon being surrounded at a safe distance by the usual complement of Admiralty and other vessels, the torpedo was fired at a few minutes after 9 A.M. from Fort Monckton. The water was upheaved as on previous occasions, the outer mass catching the Oberon under her starboard side, raising her, and causing her to roll heavily for some minutes. To all appearance, she had sprung a bad leak, and was settling down. She was quickly boarded by dockyard hands, who were in attendance for the purpose, and her pumps and fire engines were manned, and the sail-cloth fracture stopper was dropped. Her cables were then shipped, and she was once more towed into dock by a couple of tugs. On the way, however, it soon became evident that there was no serious leak, and therefore no internal fracture, as the ship was quickly pumped dry, the only water she had contained being that which she had shipped from the column thrown up by the explosion.

An external examination of the Oberon, made in dry dock, soon disclosed the fact that a very marked impression had been made on her outer skin by the explosion of the torpedo. The pressure brought upon the plating had buckled it to a considerable extent, so that the longitudinal and vertical framing between the inner and outer skins stood out in bold relief. The chief seat of weakness is, of course, the region around the condenser inlet and outlet pipes, and there a number of rivets were found to have been started, the mouth of the outlet pipe was split, and the sea connexions of the condenser more or less damaged. What the results would have been if the Oberon had presented 9000 tons of inertia to the blow, as would the Hercules, instead of only 1000 tons, may be pretty well imagined. It would hardly have been possible for her to have survived the shock of the explosion. At the best, her powers of flotation would not have remained unimpaired, as they now are, and with full boilers, and her machinery in motion, she would in all probability have at once gone to the bottom. The animals on board were not hurt, but were thrown down, as they had been in every previous experiment. The water tanks were not removed, owing to extra precautions having been taken in securing them well in place with heavy timbers.

We should mention that neither of the secondary charges were fired by the explosion of the primary charge of 500 lb. of gun-cotton in the torpedo. This circumstance is due to the fact that all three charges were more or less embedded in the mud on the bottom of Stokes Bay, whilst the explosion of the Swedish secondary charges is explained by their having been—together with the primary charges—suspended 10 ft. from the surface of the water. The fifth of the Oberon experiments will probably take place in another week or so, when the distance between the torpedo and the Oberon will probably be reduced to 40 ft. The secondary charges will most likely be placed 120 ft. from the primary charge and from each other, and they will consist of wet gun-cotton discs with dry priming discs, so as to represent correctly the conditions of actual practice. The experiments with these secondary charges are being carried out by the Torpedo Committee, who, although distinct from the Oberon Committee, yet act in concert with its members.

THE CORPORATION AND THE CITY GAS SUPPLY.

In our issue of August 28th we gave full particulars of the proposed action of the Metropolitan Board of Works, in reference to the gas supply of London exterior to the boundary of the City proper. After reciting all that had been done by the Board to ameliorate the existing state of things due to the monopoly now possessed by the nine London gas companies, it was stated that the Board had resolved to apply to Parliament during the next session for an Act to enable them to erect works for supplying the metropolis, with the exception of the City.

Meanwhile, the City Corporation have bestirred themselves. The Gas and Water Committee were directed in December last to consider the bearings and consequences of a letter from the Gaslight and

* For an explanation of the staff and ticket system see page 225 of our number of September 18.

24

THE ERICSSON PNEUMATIC TORPEDO.

A GOOD deal has been heard in this country of the Ericsson torpedo, but it is only within the last few days that drawings of the weapon have reached this country. We are indebted to the *Scientific American* for the following information:—The body of the torpedo consists of a box of thin steel plates, 8ft. 6in. long, 30in. deep, and 20in. wide. The explosive is placed at the bow. During experiments a block of wood 27in. long represented the containing vessel. A tapering block 18in. long and secured to the rear of the box forms the stern, immediately aft of which are the propellers. These are of the two-bladed type, 3ft. 2in. in diameter, with a pitch of 5ft. Both revolve around a common centre, yet in opposite directions, a necessary condition, since the powerful rotary movement of a single screw would cause the small hull to keel and probably revolve, unless retained in a vertical position by the ingenious expedient of causing the rotary tendency of one propeller to counteract that of the other. The displacement is greater than might be supposed, considering the small dimensions of the body, 2000 lb. being barely sufficient to balance the weight of the whole apparatus. The motive power is a small double cylinder oscillating engine, driven by compressed air, which is transmitted through a tubular cable, connected just abaft the stern, as shown in our engraving. The air pressure also governs an equipoise rudder, secured under the bottom and near the bow. The steering is effected by applying the force of the air against the tiller on one side, counteracted by the tension of a spring on the opposite side. The action of the apparatus is such as to be wholly independent of the differential force of the compressed air and the spring tension, and it is set in motion by admitting more or less air into the cable, thereby opening, more or less, a small connecting valve.

The submersion is regulated by two horizontal rudders turning on a transverse axle, with projects from each side near the bow. These wings or rudders are so contrived and governed that they keep the torpedo at a depth of from 7ft. to 12ft. below the surface, and are provided with automatic devices, so that the latter limit cannot be exceeded. In order to note the course of craft, a light steel mast is secured to the deck. This is 12ft. in length and terminates above in a wooden ball, the forward side of which is painted sea green, so as not to be perceptible to the enemy, and the rear white, so as to be easily distinguished above the water by those despatching the torpedo. Openings are made in the engine compartment, through which the water enters, completely filling the interior space. The machinery is made of bronze with box-wood bearings, so that the water serves as a lubricant to every portion, thus doing away with stuffing boxes at the rudders, and besides, avoiding any danger of the mechanism failing to operate through rust or neglect to oil.

To the engine power of the torpedo no precise limit can be set. The whole force of the heavy engines of the torpedo boat, from which the weapon is despatched, may be used to compress air up to almost any desired point. Captain Ericsson informs us that, small as the craft is, it towed a scow, 40ft. long by 14ft. beam and drawing 2ft. of water, without trouble. Driven at a high velocity by its large screw, it seems probable that the machine would make light work of piercing ordinary torpedo netting, or at any rate the explosion of its heavy charge of 400 lb. of nitro glycerine, at such a short distance from a vessel as the length of her lower booms, would be sufficient to accomplish its purpose. Of course the torpedo hull is destroyed by the explosion, but this would be a trivial loss in exchange for the total wreck of an enemy's man-of-war. The cable, however, remains uninjured, for it necessarily becomes detached and may be readily hauled in.

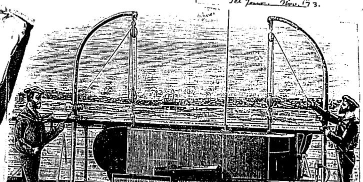
Our illustration represents the mode of launching the torpedo from the deck of the vessel. To this end the apparatus is hoisted upon swinging davits, the arms of which are previously turned over the deck. When lifted clear of the rail, the torpedo is carried out-board by revolving the davits, by bars inserted in the sockets in the broad portion of the davits, as shown. Nothing remains but to lower the machine into the water by the falls. The whole operation, we are informed, is accomplished in one minute.

A series of trials with the Ericsson pneumatic torpedo has lately been conducted on board the Intrepid, Commander A. P. Cooke, U.S.N., commanding, which has demonstrated the invention to possess a remarkable degree of efficiency. If further experiments, soon to be instituted from another torpedo boat, the Nina, prove, with slightly modified steering gear, as successful as the initial tests above referred to, we may fairly conclude that that long-sought weapon, a reliable fish torpedo, has at length been devised. As to the probable result upon naval warfare, it is only possible to surmise. Against the attack of the torpedo, there is practically no defence, for its approach cannot be seen. Armour plating, even did it extend to the keel, would prove no shield, and the Inflexible's one hundred and twenty water-tight compartments, which the English constructors hope will render her proof against such attacks, would fare badly under the terrible effects of 1200 lb. of gun cotton, with which Captain Ericsson says he could break any ironclad completely in two. We do not doubt but the same ingenuity which can devise a weapon of offence is equally competent to provide a means of defence, at least such has been the experience of the past, as evidenced by the almost uniform progress in guns on one hand and armour on the other; but what defence, save that of giving an enemy the widest berth possible, and fighting at enormously long range, is likely to prove efficacious, we are at a loss to conjecture.

A Treatise of Medical Electricity, Theoretical and Practical; and its Use in the Treatment of Paralysis, Neuralgia, and other Diseases. By JULIUS ALTHAUS, M.D., M.R.C.P., London. Third Edition, enlarged and revised, with 147 illustrations. London: Longmans, Green, and Co. 1873.

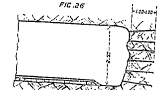
WE are glad to see a third edition of Dr. Althaus's admirable treatise. Not many years ago it was customary for the medical profession to pooh-pooh the idea of electricity curing disease, but that time has happily passed away; and it is a rarity to find a physician who does not believe in the value of electricity as a therapeutic agent. Dr. Althaus has greatly enhanced the value of this work by incorporating the most recent discoveries, and so rapid are the strides of this branch of science, that with each edition his task becomes more difficult. The chapters in the present edition are as follows:—Chapter I. Forms of Electricity; II. Electro-Physiology; III. Medical Electric Apparatus, and methods of using it; IV. Electricity as a means of Diagnosis; V. Electro-Therapeutics. Each of these chapters are subdivided, and embrace every branch of the subject. The illustrations are numerous, and well executed. We shall return to this work as soon as our space will permit.

Tel Jour. Nov '73.



struction are adopted according to the nature of the ground. These are very fully illustrated and described at pages 256 and 257.

FIG.26



ARRANGEMENT OF SHOTHOLES—VERTICAL SECTION.

The works were let by contract to M. Favre, of Geneva, in the summer of 1872. Seven tenders were received. Of these, two were withdrawn; a third did not supply satisfactory information as to the system of construction the contractor proposed to adopt; and of the remaining four, two were struck off the list. Only two competitors remained—M. Favre and the Italian Company of Public Works; but the latter required nine years to make the tunnel, and M. Favre only eight, and whereas the Italian Company would only forfeit the caution money—£320,000—if the work was not complete in eleven years, M. Favre consented to pay it over at the end of nine years. Again, the Italian Company wanted about half a million sterling more than M. Favre. The work began in June, 1872, at Göschenen, and at Airolo on the 1st of July in the same year.

FIG. 27

A NEW PHASE OF ELECTRICAL DEPOSITION. Jan 77

[12101.]—THE following experiment, which exhibits electrical deposition under a new form, I have thought might possess some interest for a few of your numerous readers. I therefore send it for insertion in your valuable journal.

Having put a few drops of H_2SO_4 in a small quantity of paraffin oil to enable it to conduct electricity, I placed the terminals of a galvanic battery in the oil. No change appeared to take place during the first four or five days. Shortly after that period I noticed that the terminal from the copper-plate had diminished in thickness, and that its extremity was worn down to a point almost as sharp as a needle. The remaining terminal had, on the other hand, increased in thickness, and near its extremity was accumulated a deposit consisting of copper (the same substance as the terminals). The paraffin appeared to have undergone no change.

E M   S. McIlwrath.

25

every system of any promise being tried — McKean's, Burleigh's, Dubois and François', and others, all being used with various results. About thirty holes, a metre deep, are bored at one operation, and then charged with dynamite, and fired in the order shown in our illustration, Fig. 4, the drill-carriage being withdrawn eighty or ninety yards, and defended by a shield from flying fragments of stone. Figs. 9, 10, 11, 12, page 256, and Figs. 14, 15, 16, 17, &c., page 257, give illustrations of the progress of the works at the north and south ends respectively. These show the driving of the heading, the enlargement of the same, the turning of the masonry arch, the subsequent excavation, and the drain, and the final completion of the tunnel.

In future impressions we propose to illustrate the more important machines employed on the St. Gothard works, and we cannot better conclude this article than by the following tabular statement, which shows the progress of the works up to January, 1874. We may add that since that date they have progressed steadily, at, so far as we can learn, about the same average rate:—

State of the Works on the 31st of January, 1874.

Description of Work for Comparison.	Northern (Göschenen) mouth. State at the end of Dec.	Northern (Göschenen) mouth. Progress per month.	Northern (Göschenen) mouth. State at the end of Jan.	Southern (Airolo) mouth. State at the end of Dec.	Southern (Airolo) mouth. Progress per month.	Southern (Airolo) mouth. State at the end of Jan.	Total at the end of Jan.
	Linear metres.	Linear metres.	Linear metres.	Linear metres.	Linear metres.	Linear metres.	Linear metres.
Heading	600·2	72·0	672·2	566·0	51·7	617·7	1319·9
Enlargement (complete and partial) of ditto ..	520·0	70·0	590·0	87·0	45·0	332·0	952·0
Masonry of arch	—	—	—	145·0	—	145·0	145·0
„ east side wall ..	—	—	—	101·9	—	101·9	101·9
„ west „ ..	—	—	—	141·6	—	141·6	141·6
„ drain for carrying off the water	—	—	—	115·3	—	115·3	115·3

Workmen Employed during the past Month.

Mean number	625	+ 9	634	524	+ 57	581	1215
Maximum number	732	—46	656	581	+ 31	612	1298

From a recent report made to the Swiss Federal Council it appears that, at the close of June, the contractors had completed nearly one-seventh of the whole distance. The progress made during July was about evenly balanced, but the advance on the Göschenen side was rather more rapid than that effected on the Airolo side.

THE DETERMINATION OF LONGITUDE BY TELEGRAPH IN CONNECTION WITH THE TRANSIT OF VENUS.

THE numerous astronomical stations erected in places widely distributed over the globe for the observation of the transit of Venus offer an opportunity for determining longitudes such as has never before occurred. Moreover, the establishment of the electric telegraph enables this in many cases to be done with an accuracy which can be obtained in no other way. The process is specially interesting to astronomers and electricians; but the principles are so simple that they admit of being understood without difficulty by any person of intelligence. Any process of determining longitude depends on the very elementary fact that the world revolves in twenty-four hours. If then the time at one place is exactly twelve hours different from another, the two places are 180 deg. of longitude apart, or at opposite sides of the globe. So to learn the longitude of any spot on the earth taken from Greenwich it is necessary only to know two things—the local time and Greenwich time. The local star time is determined with a transit instrument; Greenwich time has to be arrived at by some less easy process. The moon's place will give it, for, if the moon falls back so as to pass over any station, say Greenwich, one hour later every successive day, and if it is known in what place among the stars she ought to pass the meridian of Greenwich, then it follows if she is seen to transit *half* an hour late anywhere, that place is 180 deg. west of Greenwich, or half-way round the world, for she has fallen back half the amount she would in the entire revolution. Jupiter's satellites may be employed in a rough way for the same purpose, but as we have said, by far the most accurate determination is obtained by simply telegraphing the time from Greenwich or from any other place with which comparison is made.

The difficulty of obtaining an accurate determination of longitude has been urged as one of the objections to the adoption of Delisle's method of observing the transit of Venus, which has been taken in hand by English, French, Russian, and German astronomers. It is, therefore, of great importance to the success of the expeditions that the telegraph has been established and can be used for many stations; but the value of obtaining the longitudes accurately of so many important points of the globe is permanent, and in no way confined to the questions connected with the transit of Venus. Many are not aware of the extreme looseness and inaccuracy of the longitudes laid down on globes and maps; but this fact known, the importance of seizing the present opportunity will be felt. The map on page 246 shows the lines of stations along which the telegraph will be, it is hoped, used with success, or on which it has already been used. It will be seen that they are on a gigantic scale, and with the longitude determinations that have already been made, will go far to establish correctly most of the chief geographical features on the globe. The longitude of several principal places in America—the lines A B C and D B C on map—have, during the last six or seven years, been determined by signals through the Transatlantic cable both from England and France—that is, from Valencia and Brest. As this operation has been

... or compressed gun cotton can be effected by the ordinary combustion process.

New Electric Repulsion, and on its Application to the Theory of Comets.—E. Reitlinger and A. d'Urbanitzky.—If we approach the finger or any conductor to the luminous column produced in a Geissler tube we observe an attraction, which has been explained by the known laws of the electric influence. But on the 9th of March of this year we met with tubes in which the experiment, thus conducted, manifested, not an attraction, but a very distinct repulsion. These exceptional tubes have contained, according to M. Geissler, the one bromine and the other protochloride of tin. In addition to the repulsion there was observed in the tubes a green light, of a singular aspect, on the side towards which the luminous column was directed. Our researches showed us that this green light was due to a kind of electric phosphorescence, which we have described in the *Memoirs of the Academy of Vienna.* A spectroscopic examination did not reveal any distinction between the bromine tube and that which had contained protochloride of tin. In both cases the most distinct portions of the spectrum displayed those three well-known bands commonly attributed to the spectrum of carbon. They are the same bands which M. Vogel and others have designated as the spectrum of comets. This remarkable fact has drawn our attention to the relations between this repulsion and the repulsion exerted upon the tail of comets by the sun. The identity of the spectra may be explained by supposing that the gas introduced into the Geissler tubes no longer gives any light; that it is either absorbed by the electrodes or precipitated upon the glass; and that a trace of highly rarefied gas furnishes the luminous matter, the repulsive power of which has been observed. Chem News 1875

CONDOLING BY ELECTRICITY.—On the recent occasion of the death of Mr. C. L. Goodwin, superintendent of the Northern New York division of the Atlantic and Pacific Telegraph Company, the various operators of the division united in a meeting of condolence in the following remarkable manner:—All the stations included in that division were connected into one circuit, extending from New York to Albany, thence *via* Troy to Saratoga and return to Albany, westward to Syracuse, and *via* Oswego, Clyde, and Rochester to Buffalo and Niagara Falls, back from Buffalo *via* Auburn, Seneca Falls, &c., to Auburn again, being over twelve hundred miles of wire. Each person remained in his own office, and all the instruments were so connected that the remarks made by one operator upon his instrument were sent through all the other instruments. Promptly at 2 p.m. (Buffalo time) New York called the meeting to order. Buffalo moved that Mr. Hauff, chief operator at New York, be made permanent chairman. The motion was seconded by Troy, and carried. The chairman then suggested that Mr. McCoy, manager of the Buffalo office, be nominated as secretary, which the meeting unanimously resolved in the affirmative. Various speeches were made, and the resolutions were then read and adopted, and an adjournment then followed. The meeting was entirely harmonious throughout, and the state of the weather and condition of the wires peculiarly favourable to its success.—*Scientific American.* 1875

POCKET PHOTOMETERS. 77

A NEW pocket photometer has lately been described to the French Society of Photography by M. Schutte. The instrument has exteriorly the form of a small telescope. Putting your eye to the narrow end, and looking through at a luminous source, you see a small, luminous circle, on which it detached some figure in black. On turning the wider part of the instrument, the more you advance in the series of numbers the weaker is the light perceived; and, at length, it quite disappears. This effect is obtained by means of leaves of waxed paper, the number of which increases with the figures. Thus, it will be understood that a weak, luminous source does not allow one to see the same number as a strong one, and the variation between the figures is greater the more difference there is in intensity. Thus one may be enabled to determine the proper time of exposure.

ELECTRIC VOTE-REGISTERS.

1875— Elec. News 1875

THE following system of vote-registering, suggested by Mr. E. A. Jacquin, although totally differing from Messrs. Clérac and Guichenot's method,* possesses considerable merit. It does not, however, record its workings before the eyes of voters as Messrs. Clérac and Guichenot's system does; and partly for this reason it failed to be approved of for the National Assembly.

Two buttons are placed before each Deputy, who registers his vote by simply pressing them down; the nature of his vote being determined by the order in which they are depressed. Each button is an electrical communication with a small apparatus which encloses a supply of balls, and from which one drops whenever its corresponding button is pressed. The white-ball and the blue-ball apparatus are all ranged by themselves, and the balls fall from them into funnels, and thence through ramified pipes into two urns, by the force of gravity. They are all made exactly equal in weight; hence the number of Deputies who have voted is immediately obtained by weighing the urns.

In order to avoid as much as possible calculating the number of balls from the weight of the urn, the weight of each ball can be made 10 grms.—a very convenient size. Then on reading the weight of an urn the number of balls in it is directly proclaimed. Thus an urn weighing 1500 grms. would contain 150 balls. In speaking of the contents: the weight of the urn itself is previously balanced.

In addition to this, an automatic pointing is effected by each apparatus on small strips of paper introduced into it before the sitting, and the object of this pointing is to indicate the nature of the voting. At the close of the sitting, the pointed or dotted papers are withdrawn, collated side by side in numerical order, and form a complete detailed table of the votings for that sitting.

The battery for each Deputy, consisting of two Leclanché elements, is included in a box bearing the Deputy's number, and the wire starting from the positive pole is in connection with an electro-magnet and thence to a kind of small metallic anvil; the negative pole through another wire is in connection with a small lever placed above the anvil, from which it is held at a very small distance by a spring. The Deputy pressing upon a button, causes this lever to touch the anvil, and so to close the circuit through the electro-magnet.

The remainder of the contrivance, which each button works, is thus described:—

The electro-magnet attracting a lever releases a hinged pan containing the voting ball, and thus allows it to fall into a funnel, whence it is conveyed to the urns. At the same time that the shovel drops, a pin affixed to its bottom causes the dotting upon the paper strip to which we have already drawn attention to be effected.

The recording sheet for each voting is divided into series of three small transversal and two vertical columns. The former may be called for convenience *a*, *b*, and *c*; the latter *d* and *e*.

In explanation, let us assume that voting is about to commence, and that the transversal column *a* is ready to be dotted. Deputy A, let us assume, is voting affirmatively. He presses his left-hand knob, and his sheet is struck in the affirmative vertical column *d*, in *a*. Then every paper is raised automatically, so that *b* transversal column occupies the late position of *a*. Our Deputy then presses down his right-hand knob, which produces a dot in the negative vertical column *e*, in *b*. Should he desire to vote against a measure, the order of pressing down the knobs which we have given must be reversed. In other words—

* ELECTRICAL NEWS, vol. i., p. 13.

Journal of Chemistry 1875

FIRING GUNS BY ELECTRICITY.

THE system of firing guns by electricity while proving them, which is now in vogue in England, and which was employed in the case of the 81-ton gun, was adopted in 1856, up to which time the guns had been fired by fixing a piece of portfire over the vent by means of clay, igniting it, and then running under cover. The application of electricity was brought about by a curious accident. A number of guns were being proved in this way in the Royal Arsenal at Woolwich, and were placed for this purpose in a row on skids in front of the butts. The ignited portfires did not all burn at the same rate, and the result was that one gun went off before the others. This gun unfortunately burst, and one of the fragments, striking a neighboring gun, swung it round with its muzzle towards the arsenal, but without displacing the piece of ignited portfire over the vent. In due time the portfire fired the charge, and the gun projected its shot over the arsenal and town of Woolwich into the dockyard, where it fell, happily without doing any injury. This was in 1852, and another similar accident was narrowly escaped in 1855, when a mortar which was undergoing proof was swung round in the same way, but, fortunately, not until after it had discharged itself. Mr. M'Kinlay, the proof-master, was led by these circumstances to contrive a mode of firing guns by electricity. This he successfully accomplished in 1856, when the "galvanic tube" was introduced. In this tube a steel or platinum wire is embedded in a charge of powder, and this wire forms a link in the circuit of a galvanic battery. The retardation of the current, due to the inferior conducting power of the steel or platinum wire, causes it to be raised to a red heat, and by this means the powder is exploded. This system was in use until 1862, when the Abel "electric tube" was invented. In this the steel wire is replaced by a priming charge, consisting of subphosphide and subsulphide of copper, with a little chlorate of potash, and in this composition the terminals of the two insulated copper wires that conduct the electric current are embedded. The points of the wires are about one sixteenth of an inch apart, and when the current ... is sufficiently retarded by the separation of the wires and sufficiently accelerated by the sensitive composition to pass from one wire to the other in the form of a spark, by which means the tube is exploded. A magneto-electrical machine, specially designed for this purpose, is used for exploding the tube in preference to the galvanic battery, though any other electric agency could of course be used in doing it.

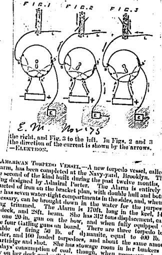
FRENCH ACADEMY OF SCIENCES.

Scientific Am. Suppl. 26

APRIL–MAY.

On Electric Fuses. By M. Ris.—The fuses employed for the electric inflammation of detonating mixtures may be disposed either for tension currents or for quantity currents. With the first the firing is produced by a spark generally resulting from induction apparatus; with the second, by the calorific action of energetic couples, of which the current is transmitted by a conductor of large section to a very fine platinum wire, which it heats to about 472° Fah. If it be attempted to fire an induction fuse by a battery current, a large number of elements is found necessary; and on the other hand, platinum wire-fuses can not be ignited by a tension current. The author suggests rendering induction fuses conductors, by incorporating with the detonating mixture (usually of chlorate of potash base) a small quantity of pulverized platinum sponge. Fuses are thus obtained, which are inflammable either by induction or battery currents.

[23820.]—**Drum and Handle Commutator.**—I remember once seeing in Ganot's "Physics" a sketch and description of a drum commutator. It was, if I remember right, similar to the following:—The circles in each figure are made of ebonite or wood, the seven black parts on it are metal, which are connected by wires in the order given in the diagram (of course the wires are insulated from each other). A A are metal springs, connected with the battery as shown. S S are similar springs connected, the one with the coil C C, and the line wire L, and the other with the earth-plate E. Fig. 1 shows the position of the commutator when the needle is vertical, Fig. 2 when the needle points to



the right, and Fig. 3 to the left. In Figs. 2 and 3 the direction of the current is shown by the arrows. —ELEKTRON.

AMERICAN TORPEDO VESSEL.—A new torpedo vessel, called the Alarm, has been completed at the Navy-yard, Brooklyn. This is the second of the kind built during the past twelve months, both being designed by Admiral Porter. The Alarm is entirely constructed of iron on the bracket plan, with double hull and bottom. She has seven water-tight compartments in the sides, and, whenever necessary, can be brought down in the water for the purpose of being trimmed. The Alarm is 170ft. long in the keel, 140ft. on deck, and 28ft. beam. She has 312 tons displacement, carrying one 20-in. gun on the bow, and when fully equipped will have four Gatling guns on board. There are three torpedo bars, capable of firing 50 lb. of dynamite, equal to 400 lb. of powder, and 100 loaded torpedoes, and about the same amount of cartridge and shot. She has stowage room in her bunkers for five days' consumption of coal, though, when necessary, she can carry on her deck coal sufficient for three days more. The engines and torpedoes are worked from the wheel-house, and need but one person to work them. Accommodation is given to six officers and 60 men, and when out on duty she will carry two months' provisions. She is supposed to be very fast, and will be able to make 15 knots an hour easily.—*Times.*

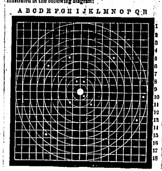
June 1875

WE noticed some time ago, says the *Pall Mall Gazette*, the force and originality of the views which Admiral Porter took occasion to impress upon his countrymen in the annual report on the United States' navy. Those of his suggestions which referred to the construction of a single small but efficient ironclad squadron, backed by a few swift corvette cruisers, to supersede the present antiquated and almost useless vessels on the list, remain still in abeyance. But the late votes of Congress have been applied partly to another, the improvement of the offensive torpedo service. Admiral Porter avowed his belief that torpedoes used merely passively would greatly disappoint their designers; and he even satirised the late experiments made by projecting them from the bows of slow, worn-out steamers. But he expects great things from a bold use of these weapons offensively by properly constructed vessels, and the new torpedo steamer, the Alarm, lately launched at Brooklyn, is the first attempt to give practical effect to his views. As in the case of the Dantzic torpedo boats of Germany, speed is a special object, and the lines are consequently fine and the engines powerful. But the Alarm is over 300 tons measurement, thus many times larger than the similar models of the Baltic builder, and is to carry one very heavy gun as a reserve, in case her torpedo boom fails, with Gatling guns for her own protection from boat attacks. As she is built with a wheelhouse, this, as well as her size, will prevent her having the comparative invisibility on which the German inventors much rely for the efficiency of their squadron. But, on the other hand, the Alarm is constructed to face a sea in which their low and fragile vessels would be quite useless.

Engineering June '75

28

[53] TRANSMITTING SHOTS ON THE TARGET BY TELEGRAPH.—After the explanation we gave on page 1 of our January number for 1871, and which we illustrated by engravings, how portraits, drawings, and hand-writing can be transmitted by telegraph, the transmission of so simple a thing as the marks of shots on a target offers no difficulty, and can not be much of a secret. This indeed is so simple, that it does not even require the peculiarly constructed apparatus, but may be transmitted by letters and figures in various ways, one of which is illustrated in the following diagram:



Two copies of the target were drawn on paper, and like diagrams, divided into 321 squares by 18 vertical and 18 horizontal lines; the vertical columns were marked by 18 letters of the alphabet, the horizontal by 18 figures, and thus any square may be indicated by a letter and a figure. One of these diagrams is carried to Dollymount and one left here; at Dollymount the position of the shots on the target is copied on the diagram as near as possible, and every shot is then found to correspond with one of the squares. Thus for instance, the 11 bullet marks are placed in various squares, and may thus be expressed H5, K11, H11, N5, J10, R10, E6, I8, J8, E15, and Q18; these are transmitted by cable, and the corresponding squares marked here, from which the target may be reconstructed, the division line between I and J, and between 9 and 10 corresponding to the bull's-eye. It will be seen that this representation is not absolutely correct, but near enough for all practical purposes.

Electric Fall Machines.

These are for demonstrating the laws of falling bodies. In one arrangement, a brass ball is hung by a thread some hight above the ground. Under it, at distance=1, are two metallic balls connected with the poles of an electric machine; they are so far apart that a spark cannot pass between them, but if the suspended ball drop between them a spark will pass. Further down, at distance=4, then=9, etc., are similar pairs of balls. The thread of the suspended ball being burnt, the latter falls between the successive pairs, giving passage at each pair to the current, and simultaneously the spark in another part of the circuit strikes a revolving soot-blackened drum, making a mark. The distances between successive marks are found to be equal. In a second arrangement, there are two cylindrical conductors, insulated and vertical, with a metallic ball suspended between them at the top, hardly filling the interval, and sufficient to enable a spark to pass between the cylinders, which are connected with the poles of an induction (secondary) coil. One of the cylinders has a coating of soot-blackened paper. The thread is burnt, and the ball falls; sparks are made to pass at regular intervals of time, by means of clockwork, interrupting the battery current. Each spark leaves its mark on the blackened surface; and thus are shown the spaces passed over in equal times.—*M. Waldner.*

Sci Amer Aug '75

THE TORPEDO PRACTICE AT NEWPORT.

The torpedo practice during the recent fleet drill at Key West, it will be remembered, was not exactly of a nature calculated to impress the public mind with a sense of the tremendous destructive force of bags of powder poked out on the ends of sticks; and consequently, since that time, slurs upon our naval torpedo system have been more frequent than commendations for the efforts of the very zealous corps of officers, who, for several years past, have been quietly working and experimenting, at their station on the bleakest of the islands in Newport Harbor. With the publication of the excellent results of the recent trials at Newport, however, the cloud which has obscured the labors of the experimenters is dispersed; and, we must admit that, in lieu of sticks and powder sacks, the torpedo officers, Professor Moses Farmer and Lieutenant John P. Merrell, have developed for us a means of warfare of terrible efficiency.

The recent trials took place on successive days, in the presence of a congressional committee, and a large concourse of spectators. The initial experiment was the explosion of a ground torpedo of fifty pounds of powder enclosed in an iron-cased shell. This was blown up by Professor Farmer's dynamo-electric machine. Two fifty pound torpedoes were then fired by the contact of a boat with the circuit closers; and the blowing up of apparatus improvised from ordinary water breakers followed, to show how easily these destructive weapons could be constructed from the simplest materials, and without special machinery.

The plane table was used in the explosion of a three hundred pound torpedo, the current being established at the instant the approaching vessel was seen through properly adjusted sights. A column of water, two hundred feet high, marked the tremendous violence of the escaping gases. An attempt was made to blow up an old hulk, by the aid of submarine torpedoes; but through some mal adjustment of the latter, the vessel, though badly damaged, was not destroyed. An excellent feature of the operation was, the firing of a torpedo through a mile of cable, the main object being to show that this means of offense or defense could be safely carried on beyond the range of the enemy's fire. An explosion of 500 igniters simultaneously, proving that several mines could readily be blown up at once, concluded the experiments of the first day.

An old coal schooner formed the objective point of the second day's operations, the interest of which was greatly hightened by the participation therein of the new ironclad torpedo boat Intrepid. This vessel is a small steamer, built expressly for torpedo manœuvering. She steams at a rate of about nine knots per hour. The hulk being stationed

Sci. Amer [SEPTEMBER 5, 1874.

out in the stream, the Intrepid backed astern for about a mile in order to get good way on, and then rushed ahead at full speed. The Harvey torpedo, which she towed on her starboard side, was brought in contact with the hulk and, at the instant of touching, fired by an electric fuse, smashing in a huge hole in the vessel's side. Immediately the Intrepid dashed up for a second trial, and this time exploded a spar torpedo, rigged out from her port side, directly under the bottom of the fated craft. A fearful explosion, followed by the hurling aloft of great fragments of wood and masses of water, showed that the weapon had done its work. The ship was literally torn to pieces, leaving but a few large portions drifting about. A second torpedo blew these out of existence, and the total disappearance of hulk marked the close of, probably, the most successful extended series of torpedo experiments conducted under naval auspices in this country.

29

[22382.]—Felling Trees by Electricity.—I am afraid "Landowner" will have to give up the idea of felling trees by heated platinum wire. The felling can be accomplished, but the cost will far exceed manual labour, beside the great bulk of apparatus, and the great care necessary for transporting the batteries from place to place. Especially difficult would this be in a plantation or forest thickly wooded, and, again, the time occupied would be considerable. The sap and other juices in the alburnum and duramen would considerably impede the burning effect of the wire. I should imagine that some 500 Bunsen's cells would be requisite for an ordinary oak. Just picture to yourself charging 500 cells, if ever you have charged 50. I should imagine you would rather fell 20 trees with the axe than charge 500 cells to do the work; and besides this the platinum wire must be strong, and probably five feet long—this alone would cost from £7 to £10. I would like to hear what friend "Sigma" has to say on this subject.—W. J. LANCASTER.

The Manufacturer and Builde

STEAM AS A MAGNETIZER.—Steam has been used as source of electricity in the steam electric machine of Sturgeon, already described in these columns; now it is announced by Donato Tommasi as a source of magnetism. He states that if steam of 5 or 6 atmospheres pressure is passed through a copper tube of one-tenth of an inch in diameter, wound as a helix around an iron cylinder, the iron will be magnetized, and attract other iron, act on the compass-needle, and manifest other magnetic phenomena.

We hope that this simple discovery will soon be verified by those who have the conveniences for such an experiment; if correct, it opens a new field of investigation, which to our great surprise has not been entered into by the alleged discoverer. The first matter for investigation must be to compare the steam current with the electric current, and to find if steam corresponds with the positive or with the negative current, that is, if the boiler giving the steam corresponds with the zinc pole of the battery or with the other, (carbon, platinum, etc.,) which question is easily settled by observing which end of the iron bar acquires north or south polarity. The next point of investigation is the increase and decrease of this polarity with the increase and decrease of steam pressure. The announcement being of such a nature as to appear incredible to us, we are anxious regarding its verification.

[21560.]—Amalgamating Zinc with Mercury. A. J. Slade must put his zinc rod in a dilute solution of sulphuric acid, having the mercury on a plate. Take the rod from the solution, and with a little tow rub on the mercury and it will amalgamate.—W. INGHAM, Rochdale.

175

[21560.]—Amalgamating Zinc with Mercury.—Your mode of amalgamating the zinc of your battery is quite the correct one—but you make a blunder if you suppose that amalgamation will prevent the zinc being eaten away. It will only do so while the battery is not in action, *id est*, when the current is not passing. So soon as the current passes, so soon is the zinc acted upon and dissolved. Were it not so, electricity could be had for nothing, and steam be a thing of the past. —S. BOTTONE.

[21560.]—Amalgamating Zinc with Mercury.—Put the rod into a strong solution of sulphuric acid and water for a few moments; take out, and plunge into water; brush the rod clean, particular care being exercised in brushing the holes in the rod; now dip again into the solution of sulphuric acid and water and rewash; afterwards pour over rod some mercury; then well rub the mercury into the zinc, and be particular in amalgamating the worn holes in the rod; the whole outside should have a dull silvery appearance; the presence of a dark surface will soon show its effects when battery is in action.—W. J. LANCASTER.

[21560.]—Amalgamating Zinc.—Do not do it for a Daniell battery, as it is mischievous, as it causes the copper to adhere to the zinc; use a half-saturated solution of sulphate of zinc, or else a strong one of common salt instead of acid, and the battery will work more steadily, only with a little less current, and with much less waste of material. Your zinc is probably cast, which is difficult to amalgamate; and, in fact, to amalgamate an old zinc for the first time requires very carefully cleaning with acid.—SIGMA.

GERMANY now possesses two torpedo vessels, the Ziethen, which was constructed in England, and launched last year, and the Uhlan, which was launched at Stettin the other day. She has cost close upon £30,000. The Uhlan carries immediately under her bows a torpedo which is intended to explode within the vessel at which it is directed, and the force of the charge of dynamite which will be exploded by the collision is calculated to be sufficient to blow the other vessel to pieces, though the torpedo itself is no bigger than a football. Measures have been taken to protect as far as possible the Uhlan herself from being destroyed by the explosion. The *Broad Arrow* calls attention to the enormous power of her engines as compared to the vessel itself. They are of 1000-horse power when at high pressure, and take up so much room that there is little space left for the coal-bunkers and the berths of the officers and seamen. The unusual proportion of steam power has been given in order that the vessel may be able to travel through the water very rapidly. When the torpedo vessel is about to enter into action for the purpose of breaking the line of battle formed by the ironclads of the enemy, divers will attach to her beakhead fulminating cartridges, and she will proceed at full speed, the crew having in the meantime lowered and embarked upon a raft which is to be kept on board for that purpose.

Eng 7 May '76

Longitude by Telegraph.

The *Philosophical Magazine* has an article on the determination of the longitude of Cairo, from Greenwich, by the exchange of telegraph signals, by Captain C. Orde Brown. The actual experiments were between Porthcurnow and Alexandria, the whole series of cables being joined direct. The total length of cable was 3,222 nautical miles; 40 Menotti cells were used, although signals were read with 12 cells. The mean loss of time before the signal or make of circuit was visible was 134 seconds, and that before break of current signal was 1·28 seconds, the mean being 1·31 seconds.

July '76

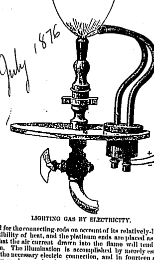
Electricity as an Aid to Egg Hatching.

The *Oilstereinische Landwithschaftliche Wochenblätter* states that Dr. Virson, Superintendent of the Italian experimental silk farm at Padua, has discovered that the hatching of silkworm eggs, of suitable age, may be accelerated by a period of 10 or 12 days, and a yield of at least 40 per cent of silkworm caterpillars secured, by exposing the eggs to a current of negative electricity from a Holtz machine for a space of 8 or 10 minutes. It is suggested that the same method might perhaps prove useful in promoting the hatching of hens' eggs and in hastening the germination of various seeds.—*Quarterly Journal of Science.*

30

LIGHTING GAS BY ELECTRICITY.

The French Assembly Chamber at Versailles is illuminated by 850 gas burners, to ignite which, M. Gaiffe has devised the very simple arrangement represented in the annexed engraving. Two isolated bent iron rods terminate in platinum points, the ends of which are separated by about .0003 inch, and are placed exactly in that portion of the flame which is in contact with the air. All the igniters of the same group of burners are connected together so as to form a circuit. Iron is



1 July 1876

LIGHTING GAS BY ELECTRICITY.

used for the connecting rods on account of its relatively-low conductibility of heat, and the platinum ends are placed as stated, so that the air current drawn into the flame will tend to cool them. The illumination is accomplished by merely establishing the necessary electric connection, and in fourteen seconds every gas-burner in the large hall is ignited. Substantially the same method of lighting is employed at the Capitol in Washington, and in the principal theatres and public buildings of New-York.

[21620.]—Electricity and Deafness.—"Deafness treated by Electrolysis," by Dr. H. Campbell, published by Longmans and Co., London.—CLERICUS, M.A., F.S.A.

[21651.]—Magneto-Electro Machines.—This can be done by unwinding the coils, and winding over with finer wire, say No. 34. The wire used on these machines is usually too heavy for shocking purpose, and, I presume, that is what is wanted.—TELE LINEMAN.

NEW MULTIPLYING CAMERA.

FIG. 1 shows the front view of the box, with the lens placed in position for making an image on one end of the plate, the plate being placed horizontally. The lens is brought into position for the other end of the plate by moving it to that side, the piece to which the end is fastened (a, Fig. 1) rotating on the screw b (Fig. 1), thus describing an arc of a circle around the point b.

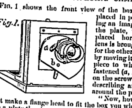


Fig. 1.

"Now, how to make one: First make a flange head to fit the box you wish to use; then make a plate the size you wish to work—a one-fourth size, for instance—and draw lines as in Fig. 2, thus finding the centre, c, c, of the two halves. Now measure the distance from c to c. Find the centre of the flange head e, Fig. 3. Then mark a point at the right and one at the left of this centre, both the same distance from it, and from each other the same distance that the points c and c (Fig. 2) are apart. Around each of these points (a and b, Fig. 3) describe circles the size of the back end of the lens, or a little larger, to permit the lens working freely. Mark point d, Fig. 3, ... This is where th...

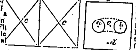


Fig. 2.

Fig. 3.

NEW ...

M. TROU... electric pro... on the fact... with that ... of four di... revealing ... sented full... couple enc... zinc and ca... is filled w... long as th... liquid is ... excite it, ... ploring ... making a ... facilitatin... device, Fi... communic... vibrates a...

June '76

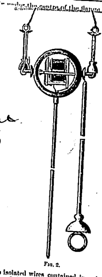


FIG. 2.

magnet are two isolated wires contained in a single protecting tube. The ends of these wires protrude slightly beyond their envelope, and when they touch a conducting substance, the current is established through the electro-magnet, and the needle is caused to oscillate.

In examining a wound, the first operation is to insert the canula, Fig. 3, in which a solid mandrel is inserted. By this

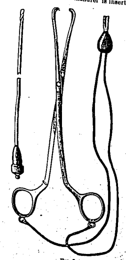


FIG. 3.

means alone the presence of the solid body can be often recognized; but in many instances the projectile becomes enveloped in the tissues or in a morsel of fabric carried in with it. This being the case, the solid mandrel is withdrawn and the canula only left in the wound. The rod of the revealer, Fig. 2, is then inserted, and the sharp points of the wires easily pe...

ELECTRICITY AS AN EXECUTIONER.

The revolting scenes accompanying the execution of several criminals in this vicinity are well calculated to bring to public notice the disadvantages of hanging as a mode of capital punishment.

The teachings of Science are heeded and sought for in the building of prisons, in the management and care of convicts, and in every modern correctional system; and yet in so simple and easy a process as the extinguishing of human life, they are utterly ignored.

The most certain and painless death known to Science is caused by the lightning stroke, or by, what amounts to the same thing, the electric shock. When a powerful discharge of electricity is received in the body, existence simply stops, and the reason is obvious. Helmholtz has proved that, for any vibration which results in sensation to reach the brain through the nerves, one tenth of a second of time is required. Furthermore, time is also needed for the molecules of the brain to arrange themselves through the effect of that vibration, through the motions and positions necessary to the completion of consciousness, and for this an additional period of one tenth of a second is expended. Consequently, if, for example, we prick our finger with a pin, it takes two tenths of a second for us to feel and recognize the hurt. It can easily be conceived, therefore, that if an injury is inflicted which instantly unfits the nerves to transmit the motion which results in sensation, or if the animating power is suddenly suspended by an injury to the brain before the latter completes consciousness, then death inevitably follows with no intervention of sensibility whatever.

Now a rifle bullet, which traverses the brain in the one thousandth of a second, manifestly must cause this instant stoppage of existence, and proof of this is found in the placid faces of the dead, and in the fact that there is nothing more common than to find men lying dead on battle fields, shot through the brain, but with every member stiffened in the exact position it was in when the bullet did its work. But a rifle ball is slow beside the electric shock. Persistence of vision impresses a lightning flash on the retina for one sixth of a second, but its actual duration is barely one one-hundred thousandth of a second.

The effect of the shock on the system is excellently described by Professor Tyndall, who, while lecturing before a large audience, inadvertently touched the wire leading from 15 charged Leyden jars, and received the whole discharge through his body. Luckily the shock was not powerful enough to be fatal; but as the lecturer regained his senses, he experienced the astoundishing sensation of all his members being separate and gradually fastening themselves together. He says, however, that "life was blotted out for a sensible interval," and he dwells with much stress upon the opinion that "there cannot be a doubt that, to a person struck by lightning, the passage from life to death occurs without consciousness being in the least degree implicated. It is an abrupt stoppage of sensation, unaccompanied by a pang." So much for the death which, by suitable alteration of the law, we would have substituted for slow strangulation. The next point is its practical accomplishment.

Instead of building a gallows and providing rope, the sheriff, advised by a competent electrician, would procure a powerful Ruhmkorff coil and a heavy battery. These instruments would rarely need replacing, and would last indefinitely for other executions. The battery and coil should be of sufficient strength to deliver an eighteen inch spark. In case of their being more than one person to be executed, all of the condemned would be conducted with all due ceremony to the place of execution, the left hand of one man handcuffed to the right hand of his neighbor, and the conducting wire fastened to bracelets on the disengaged wrists of both criminals, if only two are to be hanged, or to the wrists of the outer men, if more than that number are to suffer. The culprits being seated so as to be seen by the legal witnesses, the sheriff presses a button. The current is instantly established from the coil, passes through the bodies of the men, and all is over. With a competent electrician, who might be a member of the police force, and specially charged with the duty, there would be no possibility of mistakes. The same ignominy which attaches to the gallows would be transferred to this mode of destruction, while the peculiar death by lightning, which, among the ignorant of all nations and ages, has been the subject of profound superstition, would without doubt, through its very incomprehensibility and mystery, imbue the uneducated masses with a deeper horror.

J. F. H. says: "I have six volumes of the SCIENTIFIC AMERICAN, in which I can find nearly everything that is known as to engines and machinery."

31

CAN WE PROTECT OUR BANK VAULTS?

Aug 1876

Seven armed men recently entered the house of the cashier of the Northampton National Bank, at Northampton, Mass., and compelled that officer at the muzzle of the pistol to reveal the combination of his safe vault. Then they bound and gagged him and his entire family of seven persons, quietly waited until the bank's night watchman had departed, opened the vault and safe, and stole $750,000 in cash and securities. The annals of crime can show few more audacious robberies than this, nor do we know of one which has excited a wider spread feeling of insecurity or a more general distrust of all modern burglar-proof devices. Certain it is that no lock, however intricate, is safe so long as the means of opening it is in the hands of any one person; for no man, however brave, can withstand the persuasions of a night attack on his family and of a cold pistol barrel pressed against his temples in order to make him hand over his keys or divulge the information demanded. It may well be asked if seven men can plan and successfully carry out such a scheme, whether twice seven men could not perpetrate even a more gigantic robbery; and when we consider the matter in the light of the elaborate precautions taken by the thieves and their intimate knowledge, which they spend weeks in acquiring, of a marked point of attack (all detailed recently by a convict captured in a similar undertaking), it is but natural at first to doubt the safety of any bank or strong box. But on the other hand, it is reasonably certain that, if the Northampton bank people had been as vigilant as the thieves, the robbery could not have occurred; and it seems to us that, if the means which Science offers for protecting our valuables were fully used, such robberies would be impossible, or at the least be very difficult, of perpetration. Suppose, for instance, a chronometer lock had been in action on the Northamption safe. Then what would have availed the binding and gagging of the family of the unfortunate cashier, and an assault on his person, since he would have been as powerless as the thieves to enter the stronghold? At a certain time enxt day, when all the employees of the bank would be at their desks, the safe could be opened; until then, if properly made, nobody could stir its doors. Rendering it the duty of two bank officers, one as a check on the other, to assure themselves that that lock was in working order at the last thing before closing the bank for the night, would prevent any tampering with the mechanism; and should the lock be inoperative, the very circumstance would instantly suggest extra vigilance during the night and until the difficulty could be remedied.

Another safeguard is found in never trusting the means of opening the safe to a single individual, a plan frequently adopted in banking institutions in cities. There might be, for instance, three locks to a door; and the key or the combination which throws back each could be in the possession of a different officer, so that no one of the trio could enter alone. This would necessitate the robbers intimidating three persons instead of one. Or the knowledge of a combination might be kept a secret, by the president, for example, and the cashier possess only a key to be used in connection with the combination.

There is much safety to be found in properly constructed electric devices. Why, for example, has not somebody invented a thief catcher—a couple of metal knobs which must necessarily be turned in attempting to open a door? At night, lead a powerful interrupted battery current to those knobs. When the burglar grabs them they will grab him, for he cannot let go, as every one knows who has tried to release the handles of the simple magneto-electric machines from which itinerant scientists at country fairs offer to administer shocks for a penny or two each. The burglar, besides, will get so thorough a shaking that he would convert himself into an alarm, and yell loud enough to awaken any somnolent neighborhood. Electric wires might be laid from every door in the bank to convey an alarm, say to a police station or any other desired point; and if those wires were so placed that cutting them in advance could quickly be told through the breakage of the circuit, tampering with them could be found out in time and proper precautions taken.

It has been suggested that the next advance of the thieves will be a day attack on a bank, through the use of an exploding shell tossed in among the clerks, and a rush for the funds in the confusion. For this, the only remedy appears to be constant watchfulness, or the encasing of the people handling money in a separate armored room, and not dividing them by a mere wood and glass partition from the crowds which often congregate outside the tellers' windows. We have some banks in our mind whose counting rooms are very poorly suited to withstand an attack of the above kind.

We think that there is abundant ingenuity in this country to provide means of frustrating the smartest and most audacious of burglars; and that if inventors will set about it, devices much more efficacious even than those which have occurred to us can be produced. At any rate it is hardly time to suggest the abolition of banks, as does a daily contemporary of this city, and thus admit that we are outwitted by rascals, until we have seen what the inventors can do, and certainly not before we have fairly tried the safeguards with which we are already provided.

Electricity as an Executioner.

To the Editor of the Scientific American:

In your paper of January 8 is an article on the above subject. It is very suggestive. Should the electric fluid be used to shuffle off the mortal coil of criminals, the judge in pronouncing sentence would have to say: "The sentence of the court is that you be taken to the county jail, and thence to the place of execution, where you will be struck with lightning until you are dead, dead, dead!"

We might go still further with improved methods of dealing with culprits. Experiments could be made to determine whether human beings could be frozen in such a manner that life would return when the body was thawed out, as is the case with fish and other animals. If successful, instead of long imprisonment at the expense of the State for food and clothing, and the risk of escape, criminals could be securely incased in blocks of ice, and stored away in refrigerators during their allotted term. Had Tweed been thus immured, there would now be less anxiety about him. Then, again, any one dissatisfied with the hard times could step into the machine, and request a friend to block him up in ice until specie payment was resumed.

The length of this kind of improvement would add years, but not age, to the prisoner. With proper care, we should be immortal. A hundred years would be as one day. Troublesome mothers-in-law could be disposed of for a time, care being taken not to break them in two in the act of storing.

Philadelphia, Pa. Feb 76 S. Brown.

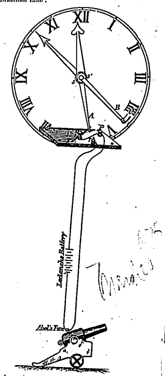
MARCH 17, 1876.] Engineering

THE TORPEDO SHIP "ZIETEN."

THE torpedo question was practically advanced another step yesterday week by the launch of the Zieten from the yard of the Thames Iron Works and Shipbuilding Company, at Blackwall. This vessel has been built for the torpedo service of the Imperial German Government, and she is intended to carry out a series of experiments at sea with the Whitehead or fish torpedo, the patent right of which the above-mentioned Government acquired last year. The Zieten is an unarmoured iron-built ship 226 ft. long, 28 ft. broad, and 18 ft. 6 in. deep. Her burden is 87211 tons. B.M., and her load draught 11 ft. 8 in. She will be propelled by twin screws which will be driven by a pair of engines by Messrs. J. Penn and Sons of 2500 indicated horse power, from which a speed of over 16 knots is anticipated. The Zieten is fitted with two tubes placed in line with her keel, one forward and the other aft. They are 6 ft. below water line and from them the torpedo is to be expelled by means of compressed air. The outlet of the forward tube is about 16 ft. back in the fore body of the ship, and a triangular portion of the hull is made to hinge in the stem and lift into a water-tight well, so that there is no projection to interfere with the speed of the vessel. The Whitehead torpedo as acquired by the German Government is, we are informed, an advanced example of the weapon. It is cigar shaped, 16 ft. 6 in. long and 1 ft. 3 in. in diameter at centre. Within the torpedo is a chamber for containing the compressed air with which the propeller of the weapon is to be worked. The torpedo is to be expelled from the tube at a speed of 20 knots per hour, and after expulsion a speed of 12 knots is to be obtained by means of the self-contained propelling power of the torpedo. It is expected that this speed will be maintained for a distance of 600 yards under water, the true line of horizontal travel being preserved by regulating mechanism with which the weapon is provided. It has of course to be determined by experiment, and by very careful experiment too, whether this weapon will prove successful, and justify the time and money which have been expended on it in our own and other countries. If it realises all the expectations formed of it, and can be truly delivered from a ship more or less in motion riding on the sea, against another ship similarly circumstanced, perhaps moving with full steam on and discharging her guns at the torpedo vessel—if, under these circumstances, the Whitehead torpedo prove effectual, then it will be one of the most remarkable inventions of the age. The launch of the Zieten took place in the presence of a distinguished company, which included Count Münster, the German ambassador; Countess Bismark, who christened the vessel; Baron Brinken; Admiral Stewart; Mr. E. J. Reed, C.B., M.P.; Mr. Barnaby; Mr. Zarnack, the designer of the Zieten, and representatives of the Austrian, Turkish, Spanish, Portuguese, and other governments.

THE ELECTRICAL TIME GUN AT PERNAMBUCO.

THE following description of the manner in which the time gun is fired at Pernambuco is given by Mr. Andrew Jamieson, assistant engineer and electrician on the Western and Brazilian Line:



In the above sketch the large circle is to indicate the dial face of the large clock fixed in the tower of the Arsenal de Marinha, Pernambuco, which, you may remember, is some 400 yards from the S. and B. Telegraph Office. S is the hollow spindle of the hour hand, S_1 the spindle for the minute hand. To these spindles I firmly fixed, at about four feet from the face, or inside end of hour hand spindle, two large levers, A and B, two feet in length, and diametrically opposite to the clock handles (inside the tower). To the end of lever B was attached two platinum-pointed springs, the points of both levers A and B being well *insulated* from their attachment to the minute hand spindles by the intervention of suitably arranged pieces of ebonite. Immediately underneath the plane of motion of these levers (A and B) was fixed on a neat mahogany stand an ebonite slab (I) of some 10 in. by 6 in. by ¼th in., at the centre of which was screwed a terminal O, with a lever L radiating upon O in a horizontal plane, but unless acted upon was kept in an angular position, by a light spring, across the length of the ebonite slab. This spring and lever L were so adjusted that when the hour hand came to ten minutes to twelve, noon, the end of lever A fixed to same spindle (as the time drew nearer and nearer to twelve) made contact and gradually brought L to a position at right angles to the length of the ebonite slab, whereby the other end T_1 of L was now in a position to make contact with the more quickly passing lever B at its platinum point t_1, and at the same moment (the sixth stroke of the clock) spring t_2 comes in contact with a spring attached to terminal T_2, which is in electrical connection with one pole of a 30-cell Leclanché battery, the other pole communicating by means of an underground cable, with one side of an Abel's patent fuse inserted in the touch-hole of the cannon, while the other side of fuse is returned to the central terminal (O) of lever L by another cable attached to P, and from thence by wire to O, so that when t_1 touches T_1, and t_2 T_2, the circuit is completed, the fuse exploded, and the gun fired. The levers A and B move on, L falls back to its angular position under action of the aforementioned spring, and is only affected by A and B twelve hours afterwards, but as the ends of the cable are freed by the explosion, and the gun only loaded once in the twenty-four hours—namely, at 11 A.M.—the electrical current flows but once in the twenty-four hours.

ELECTRICITY IN EAR DIAGNOSIS.

A DISEASED ear can not be considered fully examined and the means for its cure exhausted, until the galvanic current has been used in a scientific manner. It has been observed, both by ourselves and other careful observers, that a sensation of sound is perceived, even in the healthy ear, when one of the poles of a battery is placed in the auditory passage when filled with salt and water, and the other connected with different parts of the body.

Some recent writers are in doubt upon this subject, and state that this has not been proved to their satisfaction; and

No. 12. MARCH 18, 1876.

some recent experimenters attribute the subjective auditory phenomena observed by Brenner and others to stimulation of branches of the facial, and through this nerve to the action of the muscles of the middle ear, particularly the stapedius.

Dr. Poorten, in a review of the theory concerning the origin of the subjective symptoms consequent upon the application of the galvanic current, gives the results of experiments upon himself and others, and disproves the theory, founded by Wreden, upon the supposed action of the current upon the stapedius and tensor-tympani muscles. The experiments consisted in the use of Siegle's pneumatic speculum (before referred to), by which the membrana tympani was drawn outward, and traction made upon the tensor-tympani and ossicles, or, on the contrary, relaxation. Under these circumstances, the galvanic current gave precisely the same reaction that it did before the use of Siegle's speculum. Dr. P. concludes that the action of the stapedius muscle by Wreden (namely, the production of intra-labyrinthine pressure by its contraction) is not only disproved, but is denied by later observers. That neither the facial nerve, the branch of that nerve passing to the stapedius muscle, nor the muscle itself, are directly acted upon by the galvanic current. Subjective symptoms were educed by the action of the galvanic current, when the contraction of the stapedius muscle was prevented.

We firmly believe that the auditory nerve can be excited by the galvanic current, if properly applied, and there is no resulting paralysis. We have performed numerous experiments upon our own ears, as well as other persons'. The mode of its impression, or the way that it is connected with that nerve, may be by the facial, for we know that there is in the internal auditory canal a few facicles of fibres, which constitute what Wresberg has termed the "portio-intermedialis," forming a connecting link between the auditory and the facial. Confirmation of the above has been given by means of the rods of Koenig.

Blake finds that the passage of the current increases not only the limit of perception of musical tones, but also the intensity of perception—the degree of increase in intensity of perception being a measure of the degree in which the auditory nerve responds to the stimulus. We believe that the galvanic current is a most valuable auxiliary in the treatment of diseases of the ear, and must not be omitted, especially in cases of a nervous character, after all symptoms of disease of the external and middle ear have disappeared or been removed. Of the mode of application, which is of importance, and the kind of electricity which is most useful, we are unable to enlarge at this time.—*Medical and Surgical Reporter.*

ELECTRIC CHRONOGRAPH.

Captain Watkin, R.A., exhibited a series of instruments for assisting artillery operations in time of war, and an electric chronograph for measuring very minute intervals of time by the free fall of a weight. These also would require drawings and more space than we can spare on the present occasion to render them intelligible to our readers.

Sc. Am. Supp. June 9/76

GREAT INDUCTION COIL.

In the meeting-room of the Royal Society, Mr. Spottiswoode, Treas. R. S., showed his giant induction coil. Discharges through large vacuum tubes by this fine instrument illustrated in a remarkable manner the two induced currents produced by the "make" and the "break" of the primary current as well as the striæ and stratification of the discharge.

The soirée was very largely and influentially attended; there were but few absentees of men celebrated in science, and among other eminent guests we noticed the Marquis of Salisbury, the Poet Laureate, the Duke of Teck, Dr. Schliemann, and Sir George Nares. We are only expressing the feeling of every one who was present when we congratulate Dr. Hooker and his Council on the eminent success of the evening.—*Engineering.*

NEW PHOTOMETER.

By P. MUNZINGER, Philadelphia, Pa.

FIGURE 1 is a vertical diametrical section; Fig. 2 is a reduced plan view.

Consists of a candle-socket A on the end of an axial rod B, of a float C, contained in a water-chamber D. The vertical motion of the float is retained at the top by the socket-rod passing through a guide-frame E, and at the bottom by an axial guide-rod F of the float and a guide-tube G, which forms a reduced extension of the chamber D. A candle H is placed in the socket A, and water is poured in the chamber D until the float C rises to the zero-point of the stationary

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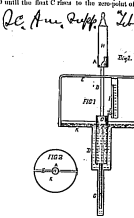


NEW PHOTOMETER.

scale I (graduated in grains), as shown by the index J fixed to the float. On the candle being lighted, its burning and consuming increase the specific lightness of the float, which gradually and imperceptibly rises in the water, and keeps the burning-point of the candle, without variation, at the same altitude. The index J, rising with the float, shows on the scale the candle consumed in grains. To preclude any possibility of the chamber D not having sufficient water capacity to float the index J to the zero-point of the scale, a dish or an enlargement K of the chamber D can be used to hold the additional supply of water.

A TORPEDO COLLEGE IN CHINA.

THE first quarterly examination of the students of the Imperial Torpedo College, Tientsin, China, was held (says a correspondent in that country) on the 21st July, under the direction of His Excellency Li Hung Chang. The College was removed from Foochow to head-quarters at Tientsin, in April last. There are at present thirty-six students, which number it is intended to bring up to forty. Several of the students have received a thorough English education at the Government Schools at Hong Kong, while others have passed a three years' course at the Naval Schools at Foochow Arsenal. His Excellency Li Hung Chang arrived at the College at 8 a.m., and the examination at once commenced. The subjects for examination were—Proficiency in the English Language, Translation of English into Chinese and *vice versâ*, Telegraphy and Electrical Testing, &c. In the afternoon a large number of torpedoes were placed in position by the students, and the use of the "firing arcs" shown by the Director, Mr. J. A. Betts, M.S.T.E.; rafts representing boats were destroyed as they passed over the various lines of torpedoes, the officials seeming much impressed with the precision with which each particular torpedo was fired. Some experiments were made with gun-cotton manufactured at the College.

Nov. 76

34 b

DRIVING HORSES BY ELECTRICITY.—The French papers tell us of a wonderful invention, which will enable the feeblest among us to "which the world with noble coachmanship." The horse of the future is not to be driven by ordinary reins, but by electricity combined with them. The coachman is to have under his seat an electro-magnetic apparatus, which he works by means of a little handle. One wire is carried through the rein to the bit, and another to the crupper, so that a current once set up, goes the entire length of the animal along the spine. A sudden shock will, we are gravely assured, stop the most violent runaway or the most obstinate jibber. The creature, however strong and however vicious, is "at once transformed into a sort of inoffensive horse of wood, with the feet firmly nailed to the ground." Curiously enough, the very opposite result may be produced by a succession of small schocks. Under the influence of these the veriest screw can be suddenly endowed with a vigor and fire indescribable, and even the *Rosinante* of Don Quixote would gallop like a Derby winner. What is the effect upon the condition of the horse is not stated, but the Siècle finds itself able to congratulate M. F. Fancher upon "an invention equally original and salutary," and one which places in the hands even of an infant a power over the horse which is as sovereign as it is invisible.

NOTES ON TORPEDOES.—No. III.

CIRCUIT-CLOSERS.

THE efficiency of electrical torpedoes must necessarily depend on the self-acting arrangement employed for closing the electrical circuit when the buoy enclosing the mechanism is struck by a passing vessel. To contrive an efficient apparatus for effecting this has in consequence been the chief aim of those inventors who have given special attention to this branch of electrical science.

But although, as we have remarked, the circuit-closers have monopolised the greater share of attention, the various appliances appertaining to them and requisite for their perfection as a means for bringing about the explosion of submarine charges, have not been neglected, as the elaborate instruments in present use sufficiently testify.

The exhaustive series of experiments which were instituted by the Government and carried out in the Medway, with a view of ascertaining the merits or demerits of the relative circuit-closers invented by Professor Abel and Quartermaster-Sergeant Mathieson, afforded marked proof of the superiority of an arrangement employing no exterior mechanism over that which necessitates the use of external appliances for communicating the blow of the ship to the internal apparatus.

Fig. 1.

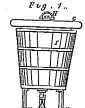
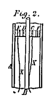


Fig. 2.



The form of circuit closer employed by Professor Abel during these experiments is shown in the illustration, Fig. 1. Outwardly it is not the best form, the three iron legs on which it stands giving it a clumsy appearance, but it possesses the advantage over those previously invented and experimented on by him, of enclosing a water-tight chamber for supplying the requisite buoyancy.

The general electrical arrangement is similar in character to Professor Abel's earlier circuit-closers, the electric chamber being formed by a fixed brass cylinder passing vertically through the centre of the vessel. Within this cylinder, which is left open at both ends, a movable brass tube extends vertically through the entire length, its lower extremity working upon a universal joint, while the upper end projects through the top of the vessel and is attached to a strong teakwood disc resting upon the outer case and projecting slightly beyond its rim. Encircling the upper extremity of the brass tube, is a thick india-rubber ring which serves to hold the whole combination rigid, and by its resistance varying with its thickness regulates the force which must be used to close the electrical circuit by reducing the distance between the contact points.

Referring to Fig 1, I is the wood jacket constructed of well seasoned timber, cut into segments, dowelled together and bound with wrought-iron hoops shrunk on and secured by means of coach screws; J is a portion of the apparatus which protrudes below the enclosing vessel, K K K are three iron legs or feet to which is attached a three-legged mooring chain; G is the wood disc for receiving the concussion of passing vessels, and H the hoisting ring.

The closing of the circuit is accomplished by attaching to the upper end of the movable brass tube an ebonite collar, which serves to insulate a copper band encircling it; this band is separated by a small space from a corresponding metallic ring attached to the fixed tube, but insulated from it by means of a collar of ebonite.

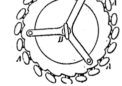
At the lower extremity of the cylindrical chamber two insulated wires are introduced, one of which is soldered to the copper ring surrounding the movable tube but insulated from it; and the other is connected in a like manner to the insulated brass ring attached to the fixed cylinder. This arrangement may be better understood by reference to Fig. 2, which represents a section of the electric chamber showing the contact rings; A is the fixed cylinder, B the movable brass tube, E D the ebonite collars, C, F the metallic rings, and X X the insulated wires.

It will from this be easily understood that a blow imparted to the edge of the external teak disc would be transmitted to the movable tube B, by which means the metallic rings F G would be brought into contact and the circuit at that point closed.

The principal demerit of Abel's circuit-closer is its inability to fuse platinum wire with uniform success. And in addition to this the necessity of an external appliance for communicating the blow of the ship to the interior apparatus marks it as much inferior to those circuit-closers which possess the advantage originated by Captain C. A McEvoy, of employing no external mechanism to set the apparatus in action, while its liability to get out of order is alone sufficient to justify its non-adoption.

On the whole we are inclined to think that the only feature of merit which the invention possesses, is the employing of a water-tight chamber for supplying the requisite buoyancy, entire dependence on wooden bodies for this purpose having proved objectionable in practice, from their liability to become water-logged after having been in use a few months. Fig. 3 represents a plan of the Austrian circuit-closer, which, although objectionable from the employing of external appliances for actuating the interior mechanism, is superior as regards its circuit-closing properties to the one designed by Professor Abel. The circuit-closing arrangement consists of a nave turning on a fixed centre, and fitted with a series of arms equal in number to the external buffers A A A, with the plungers of which their extremities make contact, the arms being so arranged, that the striking of any one of the buffers, and consequent forcing of the plunger into the interior, communicates itself to the nave by means of the arm corresponding to the buffer struck, thereby causing it to revolve through a fraction of a circle, and thus abridge the distance between two contact points placed near the centre of the apparatus, and so closing the electrical circuit.

Fig. 3.



The mechanism is rendered self-adjusting by means of suitable springs, which also serve to keep the whole combination rigid while at rest.

As far as we have been able to learn, the experiments made with this circuit-closer by the Austrian Government have been fairly successful. But however good the result obtained may appear, the necessity for employing external machinery for communicating the blow of the ship to the interior apparatus marks it as objectionable, and much inferior to that class of circuit-closers which, having no exterior appliances, are capable, like McEvoy's cheap and simple contrivances and Mathieson's more elaborate and costly apparatus, of being enclosed in a buoyant chamber of any shape and any material.

Captain C. A. McEvoy's circuit-closers have been fully described by previous writers on the subject, and are in consequence pretty generally understood, we shall therefore make our description of them as brief as possible. Each of these cheap little contrivances possess the merit of great simplicity. They have, as already stated, no external mechanism, and are furnished with air-tight chambers to impart adequate buoyancy. *His circuit-closer, patented 1871, consists of a brass tube 1 in. in diameter, at the upper extremity of which the apparatus occupies a length of about 4 in.; in this space an ebonite cylinder is fitted, plugged at its lower end; through the plug is fixed a wire spring carrying a metal ball. At the upper end of the inner surface of the ebonite cylinder, a metal ring is let in, so as to partly surround the metallic ball,* a thin metal bridge crosses the upper end of the ebonite cylinder, and is in constant contact with the ball, so long as the spring and ball remain in a central position, but on being disturbed by the concussion of a passing vessel, the ball is thrown from its central position, and makes contact with the surrounding metallic ring, resuming its original position immediately. The method of connecting up this instrument for service is very simple, and may be easily explained. An insulated wire leading from the electric battery on shore, is attached to the fixed end of the spring carrying the metal ball; electricity will thus flow through the spring and ball, along the metallic bridge to the outer metal tube, and so to the outer iron case of the vessel, which serves for earth. This arrangement furnishes a constant test for insulation.

To cause the ignition of a charge, a second insulated wire is used, one end of which is attached to the insulated metal ring surrounding the metallic ball, the other extremity being attached to the electric fuse. The current of electricity in this case would, on the concussion of a vessel throwing the ball from its central position against the insulated metallic ring, be diverted from the bridge to the metallic ring, through the fuses to earth, and so explode the mine.

McEvoy's second circuit-closer, in which the closing of the circuit is effected by the canting of a conical weight, occupies a slightly increased space. As in the case of his previous invention, the apparatus is enclosed in a cylinder placed in the upper end of a brass tube; the base of the conical weight rests on the bottom of the cylinder, through which a spindle passes, and is pressed up against the weight by means of a spring. Attached to the spindle, but insulated from it, is a strip of metal held down by the conical weight, out of contact with two metal tongues, to which are coupled two insulated wires, one of which is attached to the cable leading to the electric battery, and the other to the outer iron case (or earth).

When the vessel is struck with sufficient force to incline it beyond a certain angle, the conical weight is momentarily tilted over, relieving the spring, and allowing the spindle to rise until the strip of metal makes contact with the two metallic tongues, thus completing the circuit.

McEvoy's third circuit-closer, by reason of its extreme simplicity is especially adapted for use in all kinds of electro-mechanical torpedoes. It consists of a small ebonite cylinder fitted with a metallic cap, to which is attached one pole of the battery. The ebonite cylinder is partly filled with mercury, which is in electrical contact with a metal pin passing through the base of the ebonite cylinder, and in connexion with the other pole of the battery; the circuit is completed by a blow jolting the mercury into contact with the metal cap.

We understand that in addition to the mercury circuit-closer which we have described, Captain McEvoy employs another arrangement in which the closing of the circuit is also effected by the agency of mercury. A sectional elevation ar

WEIMER'S CHARGING APPARATUS FOR BLAST FURNACES.

CONSTRUCTED BY MESSRS. WEIMER AND BIRKENBINE, ENGINEERS, LEBANON, U.S.A.

(*For Description, see following Page.*)

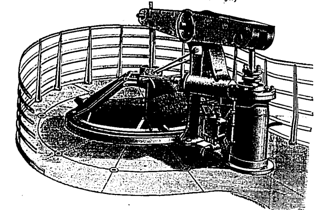


FIG. 1.

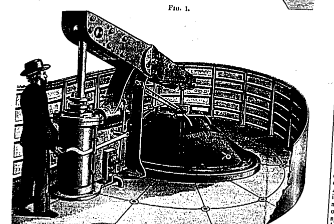
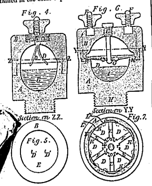


FIG. 2.

plan of this contrivance is shown in the illustration, Figs. 4, 5. It consists of a brass cup A, made with a screw projection for securing the apparatus to the upper end of a brass tube similar to those already described as being employed in his previous circuit-closers. B is an ebonite cap fitted with a brass terminal C, to which is connected one pole of the electric battery, the other being put to earth. To the lower extremity of this terminal two metal tongues D D are soldered, their tips being separated by a small space from the mercury E contained in the brass cup A.



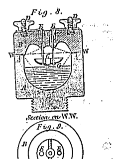
It is obvious that when the torpedo is struck, the surface of the mercury becoming agitated would make contact with the metal tongues D D, thus completing the circuit, the current of electricity flowing from the battery along the insulated wire to the terminal C by the tongues D D, to the mercury E and cup A along the brass tube to the outside of the iron vessel to earth. The ends of the tongues D D should be platinised in order to insure as perfect a contact as possible, unplated copper being objectionable from its liability to corrode.

A design for another mercury circuit-breaker is given in our illustration, Figs. 6, 7. It consists of a metal cup A containing the mercury and fitted with an ebonite cap B, into the centre of which a metal pin C is secured, to carry the contact-breaking disc shown in section at G D. Ebonite arms, E E, project from an ebonite boss, these arms serving to insulate from each other the metal bridges D D D, turning on a swivel joint at J. K K K are platinum contact points, and L L' two insulated wires in connexion with the opposite poles of an electric battery. It will be easily understood that when one pole of a battery, the other pole of which is put to earth, is connected with the insulated wire L', the current will travel from K to K by means of the conducting wire M, employed to unite each two contact points separated by the ebonite arms E, and traversing the intermediate space by means of the metallic bridges D D D, would flow to the insulated wire L² and so to earth. When the vessel enclosing the apparatus is struck by any hard substance, the mercury I is jolted against one or more of the metallic bridges, momentarily raising it out of contact with the contact points K K and so breaking the circuit.

As a portion of the mercury would in all probability escape into the upper cell during the action of the instruments, two small ports are provided at G by which it may be returned again to the lower cell.

It is obvious that the apparatus just described could be inclined until its vertical axis assumed an horizontal position without breaking the circuit, for as the mercury by reason of its weight raised the metal bridge or bridges, it would flow in and establish mercurial connexion between the points K K. Of course this could not occur in any case of concussion with passing ships, the vibration of the apparatus and inclination at which the contact points are set obviating all possibility of it doing so, even were not the mechanical action set up in the instrument by concussion totally different to that produced by the rocking motion of the waves.

Figs. 8, 9, illustrate again another form of mercurial circuit-closer. The closing of the circuit in this instance is accomplished by the concussion of a vessel jerking the mercury into a small receiver, from which it returns again to its original position through a small hole pierced in the centre of the base.



The receiver is formed of two metallic sections secured together, but insulated one from the other by means of a strip of ebonite, and is provided with a narrow ledge running round the interior of the rim, in order to prevent the mercury that had been thrown into the receiver by the concussion of a ship being again ejected by the recoil. It is apparent that so long as any mercury is contained in the receiver, the small insulated space between the two metallic sections would be bridged over and the circuit closed.

The apparatus will be easily understood on reference to the sketch, A is an ebonite cup fitted with a cap B, also of ebonite, C the receiver, held in position by the conducting wires E E connected with the terminals D D, and G is the mercury, which may either be contained in a vessel of the form shown in our illustration, or as represented by the dotted lines.

Should the buoyant vessel enclosing the instrument be not be struck with sufficient force to jerk the mercury into the receiver, the closing of the circuit would still be effected, though less perfectly, by the contact of the mercury with its exterior. But if the form of cell shown by the dotted lines be employed, it will be necessary to insulate the whole of the external surface of the receiver, in order to prevent the closing of the circuit being brought about by the rocking motion imparted to buoyant objects by the action of the waves.

Captain C. A. McEvoy's circuit-closers are each constructed to act as breakers or closers of the circuit as desired. This is accomplished by adding or removing a spring to the spring ball instrument, a washer to the conical weight, or a small cup to the mercurial machine.

ALLEY'S BEARING FEELERS.

Nearly eleven months ago (vide page 120 of our nineteenth volume) we illustrated and described an arrangement of "feeler" for bearings, designed by Mr. Stephen Alley, of 28, Renfield-street, Glasgow. This "feeler" consisted of an arrangement whereby the melting of a plug of hard lubricant caused by the heating of a bearing allowed a spring to drive a hammer and make a number of strokes on a bell, thus calling attention to the fact that the bearing had become heated. This arrangement acted well, and was successfully applied on shipboard; but for mills and factories, where the attendants are often absent from the engine rooms, &c., an alarm continuing a longer period was desirable. This led Mr. Alley to design the modified arrangements we illustrate on page 96, in which the alarm is given by a tapper fixed to the revolving shaft striking against the clapper of a bell. This bell, as will be seen from the engraving, Fig. 1, is hung from the end of a lever which is supported in a raised position by resting on a knife edge formed at the side of a hollow spindle which rests on the top of a hollow fusible plug A, inserted in a casting which can be screwed into the top of the bearing. The plug A is made of hard lubricant, and on its melting the hollow plunger on the spindle c falls, thus lowering the bell so that its clapper is acted upon by a wooden striker fixed to the revolving shaft. When the plunger c falls the glass globe containing oil falls with it until the collar a of its mounting comes into contact with the tubular part b of the main casting. This arrests the further fall of the globe, and the plunger c continuing to fall, parts the conical joint shown, and allows any oil that may be in the glass globe to flow down at once through the holes d on to the bearing. In Fig. 2 the arrangement for discharging the oil just described is omitted, and the arrangement simply gives an alarm on the bearing heating and melting the plug A.

The third arrangement shown by Fig. 3 differs from the others inasmuch as no fusible plug is employed, but the alarm is brought into action by the heating of the bearing causing the expansion of mercury or other fluid confined in the chamber d, this expansion forcing up the plunger c and so depressing the bell. A modification of this arrangement has been designed by Mr. Alley as a "feeler" for use on the bearings of marine engine connecting rods or other moving parts. In this case the alarm bell would be fixed to the framing of the engine, and the end of the plunger c would be allowed to project through the cup f. When forced outwards by the expansion of the fluid this projecting part would come into contact with the bell striking it at each revolution. In such cases the confined fluid has an advantage over the composition plug inasmuch as it does not require to be renewed each time the apparatus is brought into action, and thus there is no necessity for stopping the engine.

Considering that numerous important fires in mills have originated in hot bearings, Mr. Alley's "feelers" are well deserving of the attention of millowners, and we hope to see them extensively used.

BLAST FURNACE CHARGING APPARATUS.

In the United States as in this country the advantages derived from working blast furnaces with closed tops are being largely recognised, and on page 97 we give illustrations showing an arrangement of charging apparatus, invented by Mr. P. L. Weimer, and manufactured by Messrs. Weimer and Birkenbine, blast furnace engineers, of Lebanon, Pennsylvania.

According to this plan the tunnel head of the furnace is fitted with the usual form of bell, hopper, and lip-ring, the lower part of the bell and the bottom of the lip-ring being turned off so as to make a tight joint. On the top of the hopper is placed an iron cover, provided with three or more openings (the engravings show three openings), which can be closed at will by sliding doors. The rod supporting the bell passes through the top of the cover, and is attached to one end of a beam, which is supported upon a casting of sufficient strength, combining two cylinders, one horizontal and the other vertical, with their necessary ports, &c. The piston in the horizontal cylinder is connected by means of piston and connecting rods with a revolving plate on top of the cover, to which the doors are attached. These doors are hung on hinges, so that in case of any excessive pressure they will open, or it may at some time be desired to lift one or the other of them. The piston in the vertical cylinder is connected by a piston rod with the end of the beam opposite that to which the bell is attached.

Fig. 1 on page 97 represents the bell closed and the hopper ready for its charge, which is supplied by means of the usual charging barrows dumped through the open doors. When the charge is to be dropped the attendant depresses the left-hand lever, shown in Fig. 1, which, admitting steam into the horizontal cylinder, causes the plate on top of the cover to revolve and carry the doors with it, thus closing the openings. A small safety valve placed on the cylinder prevents risk of damage by too sudden closing. When the doors are closed the right-hand lever, Fig. 1, is raised, which, by admitting steam into the vertical cylinder, drops the bell and its charge. By depressing the same lever the bell is raised again to its position, and the valve arrangement is such that the movement is under the easy control of the operator, who can bring the bell to its place as gently as he pleases. The screw on the rod supporting the bell admits of its exact regulation, and the swivels admit of perfectly free motion; the top of the cover acting as a guide.

When the bell is in place the left-hand lever, Fig 1, is raised, which causes the doors to open. Fig. 2 is a view of the apparatus with the bell dropped and the doors closed; it also shows the opposite side of the supporting casting. The apparatus can be operated by steam, air, or water-power, and can readily be removed in case any repairs are necessary at the tunnel head. Special provisions are made to obviate difficulty when a bell falls into the furnace or accidents occur. The only gas which escapes is, obviously, so much as can be contained within the space between the bell and the cover—a very small amount. Mr. Weimer states that with the usual mode of dropping the bell a fair approximation of the daily waste of gases from a moderate sized furnace would be from 60,000 to 100,000 cubic feet, a quantity which is surely worth utilising. This apparatus also obviates the necessary changes in temperature and pressure, which must follow the opening of the full area of the tunnel head every few minutes. The arrangement we illustrate has, we understand, been applied to a number of furnaces in the United States.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Reduction in the Price of Coal.—Yesterday many of the coalowners and merchants of the district lowered their prices by about 1s. to 1s. 9d. per ton. The demand has not for some time been at all up to what it usually is at this time of the year, so that the output is above the requirements of the market—hence the reduction. Coke, however, is unchanged at 18s. to 19s. for local and 22s. to 21s. Durham.

Proposed Reduction of Ironworkers' Wages.—Last week the puddlers and other first processes men at the works of John Brown and Company, and Charles Cammell and Com-

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35

PHOTOMETER. 76

Here is also a photometer, or light-measuring apparatus, in reality a triple machine, so that three observers can measure the value of a sample of oil at once. The standard for measuring the value of oil for illuminating purposes is a certain amount of wax candle, burned in a given time; the candle is burned and weighed at the same time that the oil is also burned. The lamp and candle are placed at the opposite ends of a long wooden bar that is graduated, and carries a small sliding carriage; on the carriage are two small mirrors set at an obtuse angle to each other, and midway between them is a small screen of ground glass with a small spot in the centre, that is semi-transparent. Turning the screen directly towards one's self and looking on both sides of it, the reflection of the spot is seen near the centre of each mirror. The lamp and candle being provided with covers, pierced by small slits opening towards each other, and the room being darkened, the rays of light from both the lamp and the candle are allowed to fall upon the spot in the screen, in fact to meet there, and neutralize each other; then the observer slides the carriage along, until by the equality of the two images, as seen in the mirrors, the neutralization of the rays is seen to be perfect, and the graduated scale at that point shows the comparative illuminating power of the flame; the carriage of course being nearest to the weakest light, by the usual proportion of the square of the distances, which is accounted for in making the scale. The object and value of the experiment are apparent upon considering the number of the lighthouses, and the amount of oil consumed, making it essential to have the very best article the market can produce.

ELECTRIC FALL MACHINES. 1877

These are for demonstrating the laws of falling bodies. In one arrangement a brass ball is hung by a thread some height above the ground. Under it, at distance = 1, are two metallic balls connected with the poles of an electric machine; they are so far apart that a spark cannot pass between them, but if the suspended ball drop between them a spark will pass. Further down, at distance = 4, then = 9, etc., are similar pairs of balls. The thread of the suspended ball being burnt, the latter falls between the successive pairs, giving passage at each pair to the current, and simultaneously the spark in another part of the circuit strikes a revolving soot-blackened drum, making a mark. The distance between successive marks are found to be equal. In a second arrangement, there are two cylindrical conductors, insulated and vertical, with a metallic ball suspended between them at the top, hardly filling the interval, and sufficient to enable a spark to pass between the cylinders, which are connected with the poles of an induction (secondary) coil. One of the cylinders has a coating of soot-blackened paper. The thread is burnt, and the ball falls; sparks are made to pass at regular intervals of time, by means of clockwork, interrupting the battery current. Each spark leaves its mark on the blackened surface; and thus are shown the spaces passed over in equal times.—*M. Waldner.*

The Loffel Mechanical News. July, 1887.

There is a great difficulty in keeping coffee at its proper temperature throughout the day; overheating spoils its aroma, and underheating gives it a stale taste. M. Honore, a cafe proprietor, of Luneville, has invented a very simple apparatus to meet the difficulty. He immerses in the coffee a mercury thermometer, open above, and containing a float connected rigidly with a metallic needle, the other end of which moves on a dial. As the normal temperature of the coffee may vary between 88° and 95° C., the part of the dial between these terms is made of ebonite. Should the needle pass beyond them in either direction, electric contact is made and a bell is rung. In one case the heat requires to be intensified; in the other to be let down. The invention might be easily completed (says L'Electricite) by adapting an electro-magnet, which would close a gas-cock when there was too much heat and open it when there was not enough. A small jet might be kept constantly lit. It is further suggested that small electric lighting instruments might be substituted for matches in cafes.

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Torpedo Improvements.—The Whitehead or "fish" torpedo, which has cost this country a very large sum of money in order to possess its secret, and to perfect and manufacture it in large numbers, is the object of continual study and experiment, in the hope of further increasing its powers, and counteracting the various devices which have been suggested as expedient for resisting its attack. With the improvements contrived since it has been in the possession of the Government the torpedo can be set to run a straight course of a thousand yards under water, and explode on striking its object; it can be arranged so as to half-cock or full-cock its trigger when nearing the enemy's ship, to rise near the water-line or sink to the keel, as may be desired, and if it misses its aim it will release a safety-pin, and go quietly away, to be recovered at leisure. Its attack, however, could, it is thought, be effectually guarded against by surrounding the threatened ship with a strong net 40 feet or so from the hull, and it is to meet this difficulty that official research is now directed. It is the weakest point of the formidable fish that, being driven by an air-engine, the speed diminishes with the decreased pressure in the air-cylinders, and that, although a very high speed is ensured throughout the whole journey, the pace is lowest at the further end of the course. There does not seem any help for this, but various expedients are being tried to reduce the weight of the torpedo and thereby obtain increased velocity, and it is in contemplation to make a considerable diminution in the amount even of the charge. Recent experiments have proved that a few ounces of gun-cotton, when exploded in contact with an object, will exercise an effect far more destructive than a much larger quantity placed at a few yards distance, especially in water; and, provided the torpedo struck a fair blow on the side of the ship, it would matter little whether it contained 500 lb. of gun-cotton or only 50 lb., for either would burst the sides of the thickest armour afloat. What is wanted is a rate of speed which will tear through the enemy's network—a store of energy at the end of the race for another encounter.

77 9 Jan 77

TORPEDOES.

Lieutenant-Colonel Martin, Box Grove, Guildford, late commanding 4th (King's Own) Royals, writes to *The Times* on the subject of an "International Anti-Torpedo Association," which, he states, he is about to set on foot. He says: "When explosive bullets and chain shot were invented, and actually used in war, nations unanimously agreed to discontinue their use, and prohibited their manufacture; yet explosive bullets and chain shot, it must be admitted, are harmless as compared with torpedoes. Poisoning is prohibited in war. Why not prohibit torpedoes, which are actually more subtle and deadly than poison, there being no antidote to or escape from them? For instance, were I allowed to fire from a mortar gutta-percha bags filled with strychnine and charged with a 'burster' and time-fuse to cause the bag to burst and scatter its diabolical contents over some obstinate city or fort which would not capitulate, this visitation would be far more merciful in its way towards the people of that city or fort than torpedoes would be against crews of ships, because strychnine could be seen, and avoided by flight, whereas, on the other hand, torpedoes secretly moored, or even fish torpedoes, insure complete, sudden, unexpected, and unavoidable destruction. Several clever artisans have already been killed by merely pumping compressed air into the tails of unloaded fish torpedoes. Had these torpedoes been loaded with gun-cotton for service on board ship, and even if one of them exploded from careless handling during action while compressed air was being applied to start it, or if by chance a shot or shell struck the ship at the time of starting a fish torpedo on its death track, the fearful consequences may be easily imagined. As a proof that governments appreciate the danger they incur by the use of torpedoes, I may here state it is well known that after the Austro-Italian wars all the picked-up torpedoes proved to be 'dummies.' It is our bounden duty to keep pace with other countries, but every one will admit that the sooner the International Anti-Torpedo Association has accomplished its task the better for humanity."

[28075.]—**Electric Lock.**—Perhaps the following simple method will suit "Ironmonger:"—Procure a bar of iron about 18in. × 2in. × ¼in.; fix this bar behind the door, so that it can be worked by a knob from the outside; about 9in. from one end cut a notch about ¾in. broad and ¼in. deep in the top edge of the bar, fix a piece of soft iron about ½in. square and 3in. long, made in the shape of a T, so that when the door is fastened by the bar it will drop into the notch and hold the bar fast; about ½in. above this

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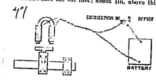
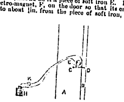


fix an electro-magnet, which must be connected with a battery in such a manner that the connection can be made in your office. Instantly connection is made the magnet will lift the piece of iron from the notch and the bar can then be moved by the knob from outside. On connection being broken the piece of iron would fall into the notch. Again, when the bar was replaced a bell might be fixed in office to be rung by the boy when he is ready to open the door. The following is a rough sketch of the bar, &c.—F. J. W.

[28075.]—**Electric Lock.**—I think the following plan would be found suitable: Let A be the door and B the post against which it closes. Have an ordinary latch, C D, and fix on it a piece of soft iron E. Fix an electro-magnet, F, on the door so that its ends come to about ¼in. from the piece of soft iron, E.



The wires from the electro-magnet, F, are connected with the battery, H, but are interrupted at K by a knob-pushing arrangement. Now, when you press the knob, K, the circuit is completed, F becomes a magnet, and attracts E, drawing up the latch from the catch, D. I should advise you to buy a Leclanché battery. All the rest you can make yourself.—C. Detaille.

37

this means of overcoming the mischief which such an action might have cannot be too highly regarded.

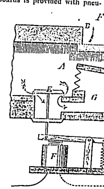
NEW APPLICATIONS OF ELECTRICITY TO ORGAN BUILDING.

A concert organ has recently been erected in Chickering-hall, corner of Eighteenth-street and Fifth-avenue, in this city, which is remarkable for the numerous entirely novel and ingenious electrical and pneumatic inventions which enter into its construction. The instrument is one of considerable magnitude, having three manuals, a compass of 58 notes, 29 pedal notes, 33 stops, and the necessary couplers and mechanical accessories. So far as the location of its parts is concerned, it is really three organs in one; that is to say, a portion of the pipes are on one side of the stage, a portion are some 60 feet away on the other side, while a complete though small organ, used for echo effects, is placed on the roof of the hall, and about 175 feet distant from the single set of keyboards at which the entire apparatus is manipulated.

The portion of the instrument which is directly in rear of the keyboards is provided with pneumatic levers, so that the pressure on a key, instead of acting directly upon the valve of the pipe to be sounded, opens a valve which admits air into a small bellows. The latter, in its movements, actuates the pipe-valve, and thus performs the heavy work, so that the merest touch is sufficient to move the key. With the exception of this ingenious, pneumatic device, all the rest is directly mechanical, and, since it does not differ from the usual church-organ arrangements, needs no further reference. In the other two organs, however, are found the curious electro-pneumatic inventions which have seemingly revolutionized the art of organ building, for by their aid not only can new effects be produced, but one or a dozen organs can be played at once, and all their stops perfectly controlled, and this irrespective of whether they are located within ten feet or ten miles, or in fact any distance, from the player.

We propose to explain, by the aid of the annexed diagrams, first, how the pipes are sounded through pressing the keys, and, second, how the stops are manipulated. For the benefit of those unfamiliar with organs, it may be stated in advance that, by means of stops, air is admitted from the main bellows into any desired set or sets of pipes. Each set of pipes gives a different quality of tone, and thus the performer may select just such sounds (flute-like, trumpet-like, &c.) as best suit the character of the music. Having regulated his instrument by adjusting the stops, his fingers, by pressing the proper keys, open the valves leading to the individual pipes, and thus the instrument is played. In order to apply electricity to the object first mentioned above, it will be obvious that the keys must act exactly as do the keys of an ordinary telegraph instrument—that is, on being pressed down, they must establish a current which, passing over a connecting wire, actuates mechanism at a distance. This is precisely the case, so that the organist has no power to exert beyond the very light pressure necessary to so move the keys. Each key controls its circuit; and as the mechanism is the same for each, a description of one will suffice for all.

Fig. 1.



In the diagram, Fig. 1, A is a part of the air chamber, in which air, led by an air trunk from the air bellows, is kept compressed. B is the pipe corresponding to the key whose operation we are considering. There is an opening between the air chamber and pipe, closed, as shown by the valve, C. Attached to this valve is a small bellows, D. Through the bottom of the air chamber is another orifice, in which plays the double valve, E, the stem of which is continued downward, and is attached to the pivoted armature of the electro-magnet, F. Said armature is provided with a spiral spring, the effect of which is to hold it away from the magnet, and so to shut the lower part of valve, E, while holding the upper part open. This being the case, a portion of the compressed air in A will pass under the valve, but, being unable to

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THE ELECTRIC CANDLE.

The value of electricity as a source of artificial light has always been recognized, and its utilization has frequently been attempted. The great obstacle, however, which has hitherto prevented the practical attainment of this object is the difficulty of subdividing an electric current, and pro-

No. 78. June 30, 1877.

ducing a number of lights from one main source. This subdivision of the current, as it flows from the generator, has several times been attempted, and in some cases—experimentally, at least—it has been attended with success. The fine carbon points were, however, quickly consumed when burnt in contact with oxygen, and thin platinum wires melted as soon as they began to give a perfect light, and, so far as we are aware, no system of subdivision of electricity has come into practical operation.

About the first who attempted to solve the problem was, M Lodyghin, of St. Petersburg, who, some few years since, used a vacuum, burning the carbon out of contact with the oxygen of the atmosphere. The details of his apparatus, however, were imperfectly worked out, and failure resulted.

M. Kosloff then took up M. Lodyghin's idea, and in time succeeded in producing an efficient means of subdividing the electric light. By forming the holders for the carbon points of a special metal, and producing the light in a vacuum lamp, excellent results were produced.

M. Kosloff's apparatus was exhibited in London in May, 1874, and some very successful trials were made with it, and reported upon by us at the time. It does not, however, appear that this invention went beyond the phase of experiment, at least in England, although it was an invention of great promise. Hence, wherever electricity has been utilized, as in lighthouses and for signalling or other purposes, the constant shortening of the carbon points by combustion has to be compensated for, and followed up by clockwork, so that the necessary distance between the points is preserved as nearly uniform as possible.

It has remained for another Russian man of science—M. Paul Jablochkoff, who was formerly in the Russian military service—to demonstrate in practice the feasibility of subdividing the electric current. He has worked out his results in the form of an electric candle, which governs the production of the electric light, and supersedes the ordinary clockwork arrangement. By it he has, moreover, demonstrated the possibility of obtaining several lights from a single source of electricity.

The first practical trial of this system was made two weeks ago at the Magasins du Louvre, and the experiments were attended with perfect success. The Marengo Hall was the apartment lighted, and six electric candles were sufficient to shed around a very bright light, which was softened by being transmitted through oval glass globes. Some idea of the comparative value of gas and the electric light under notice may be formed when we state that the Marengo Hall is ordinarily illuminated by means of one hundred argand gas burners of the largest size. The cause of the wide difference between this and other electric lights lies in the fact that electricity plays, so to speak, only a secondary part in producing the light. The light is principally the result of the combustion of the refracting material, which occupies in the electric candle the same position as does wax or tallow in ordinary candles.

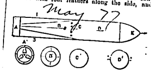
The electric candle, as originally designed by M. Jablochkoff, consisted of what may be termed a double wick and a surrounding material. The wick consisted of two carbon points, about four inches long, embedded parallel to each other in an insulating substance, by which also they were separated from each other. This material, which was consumed as well as the double wick, was composed of several ingredients, forming a combination known only to the inventor. Each of the carbon points terminated at the bottom in a small metal tube into which the conducting wires were led. With these candles a series of experiments was some time since carried out by a War Office Committee of Royal Engineers at Chatham. It was then demonstrated as one result that the system gave fifty per cent. greater power of light than had ever before been obtained from any electric light. The next development of the electric candle by M. Jablochkoff was to denude it of its outer casing, leaving merely the double wick with a strip of the insulating compound between the carbon points, which terminated at the bottom in metallic tubes, as before. It was with the electric candle in this form that the hall at the Magasins du Louvre was illuminated, as previously stated. In either case only one electrical machine is needed to produce a number of lights. The positive and negative wires are led from the machine, and branch wires are simply conducted from them at the necessary points to the candles. In this way M. Jablochkoff succeeded in getting as many as eight candles to burn at the same time in the circuit of a single machine of the ordinary kind, with alternating currents.

Arrangements are being made in England to light up one of the East and West India Dock Company's docks in London upon M. Jablochkoff's system, so that the loading and unloading of ships may be carried on by night as well as by day when desirable. Experiments were to have been primarily made in order to test the system, but since the exhibition of the electric candle at the Louvre, M. Jablochkoff has still further improved his system, so that the experiments have been postponed for the completion of the details of the improvement. In the new form of candle the inventor dispenses with the carbon points which constituted the wick, and uses only the outer surrounding material answering to the tallow of an ordinary candle. We have already seen that this compound—to which M. Jablochkoff has given the name of "kaolin," which substance enters largely into its composition—consumes at the same rate as the carbon points. From this material alone M. Jablochkoff now produces results superior in many respects to those which he previously obtained. One point of superiority consists in the fact that he is now enabled to produce as many as fifty constant and uniform lights from a single machine of the ordinary kind, as was recently stated in a paper brought before the Academy of Sciences, in Paris, by M. Dumas. In short, M. Jablochkoff appears to have satisfactorily solved the question of dividing up the electric light by a method capable of practical application, of insuring perfect steadiness in the light so divided, and of distributing throughout a building lights of varying degrees of intensity. The results point to a very wide application of the system, which appears to possess special advantages for the lighting up of theatres and other large buildings.—*London Times.*

A new pocket photometer has lately been described to the French Society of Photography, by M. Schutte. The instrument has exteriorly the form of a small telescope. Putting your eye to the narrow end, and, looking through at a luminous source, you see a small luminous circle, on which is detached some figure in black. On turning the wider part of the instrument, the more you advance in the series of numbers, the weaker is the light perceived; and, at length, it quite disappears. This effect is obtained by means of leaves of waxed paper, the number of which increases with the figures. Thus, it will be understood, that a weak luminous source does not allow one to see the same number as a strong one, and the variation between the figures is greater, the more difference there is in intensity. Thus one may be enabled to determine the proper time of exposure. Jan 7

[20135.]—Torpedoes.—I forward a sketch of the Whitehead or fish torpedo. It is made of the same specific gravity as water, or nearly. It is constructed with four feathers along the side, and

May 77



terminates with a hoop or zone, which answers several purposes—viz., steers it, adds strength to the feathers, shields the screw, and concentrates the power for propulsion. If charged with compresse

air from 3,000lb. to 3,500lb. per square inch, it has a range of 2,000 yards. It is passed through a tube in the bow of a vessel fitted up for the purpose. It can be set to any range, and taken alongside of a boat and liberated. A is the zone or hoop, A end view showing the three-bladed screw, B; the body is taper, B, showing section with feathers; the holes at Q are where the air escapes after it has done its work on the turbine to drive the propeller; D are two lugs to support it in the tube and upon the guides from which it is passed; E is the shell for explosive material. If the ship is well trimmed that the torpedo passes out perfectly level it varies very little in its transit; but when the propelling power is exhausted it rises to the surface, and just shows a margin above water.—Jack of All Trades.

29

Comme on le voit par ce court exposé, Duchesne, de Boulogne, est peut-être de tous les médecins de cette époque, celui qui a le plus contribué aux progrès des sciences médicales. C'est par sa persévérance, par son admirable talent d'observateur, par son esprit patient et ingénieux, qu'il est arrivé à réaliser tous ces travaux. C'est également, grâce aux moyens d'investigation que lui ont fourni les courants électriques, qu'il a pu enrichir la médecine de ces nombreuses découvertes, et mieux que tous les autres faits, l'histoire de ces recherches montrent l'importance de l'application des sciences physiques dans les sciences biologiques. Sans ce petit instrument qui donne des secousses musculaires, et qui n'est qu'une des formes les plus ordinaires de l'électricité, bien des points de la médecine seraient encore ignorés et obscurs. Ajoutons encore, que Duchesne était un homme plein d'aménité, travailleur, il encourageait avec plaisir tous ceux qui voulaient suivre la même voie scientifique, et les aidait de ses conseils. Malgré la valeur incontestable de ses travaux, ni la Faculté, ni les Hôpitaux, ni l'Académie de Médecine, ne lui ont donné la moindre position officielle : Duchesne, de Boulogne, ne faisait partie que de la Société de médecine de Paris. Cet exemple est bien la meilleure critique de l'organisation officielle de notre enseignement supérieur.

Dr Onimus.

STATISTIQUE

DES DIVERSES APPLICATIONS DE L'ÉLECTRICITÉ D'APRÈS LES BREVETS D'INVENTION

La loi qui régit les brevets d'invention en France, comme les lois correspondantes des autres pays, en protégeant les inventeurs, les oblige, en retour de cette protection, à faire connaître loyalement et sans restrictions les découvertes qui sont le fruit de leur intelligence ou le résultat de leurs recherches. Les brevets d'invention ne sont donc pas seulement des titres légaux d'une durée temporaire, ils constituent en outre des documents servant à enregistrer à perpétuité et à divulguer les innovations et les perfectionnements enfantés par le génie humain, et que souvent la tradition serait impuissante à sauver de l'oubli. On peut dire des brevets qu'ils sont les archives de la civilisation industrielle.

Sans doute, on ne doit pas s'attendre à trouver dans chaque brevet la trace d'une idée neuve, voire même d'une amélioration. Mais il est certain que les brevets envisagés dans leur ensemble peuvent fournir les indications les plus précieuses pour étudier la marche du progrès dans chaque branche de l'industrie. Rien ne semble donc plus naturel que de soumettre les brevets à un dénombrement pour les classer par catégories, et former ainsi les éléments d'une statistique utile et même nécessaire, si l'on veut apprécier le rôle et l'influence des inventions industrielles dans le développement des besoins sociaux.

C'est à ce point de vue qu'il nous a paru intéressant de faire le relevé de tous les brevets qui ont été pris jusqu'à ce jour concernant l'électricité.

Le nombre de ces brevets s'élevait au 1er mai de cette année à un millier, chiffre rond. Mais dans ce chiffre ne sont compris que ceux qui se rapportent directement à l'électricité ou à ses applications; et il existe évidemment plusieurs autres brevets où l'électricité joue un rôle important, bien qu'elle ne figure pas dans la désignation de l'invention.

Les premiers brevets commencent à apparaître seulement dans l'année 1829. A cette époque on commençait à peine à connaître les découvertes d'Œrsted qui datent de 1819; celles d'Arago et d'Ampère, qui ont fondé l'électro-magnétisme, base des applications mécaniques de l'électricité, et notamment de la télégraphie électrique. Jusque-là, l'électricité statique et la pile de Volta avaient été peu utilisées industriellement, et par conséquent n'avaient pas donné lieu à la prise de brevets.

En suivant la marche des brevets concernant l'électricité, par année, on constate qu'elle progresse très-lentement jusqu'en 1852. Avant cette époque, le nombre annuel des brevets ne s'était jamais élevé à plus d'une douzaine, et, brusquement, il fait plus que doubler et atteint le chiffre vingt-sept. Si, dans les années précédentes, le nombre des brevets demeurait très-restreint, il est à remarquer pourtant que la liste emprunte un éclat tout particulier au nom des illustres inventeurs, tels que Morse, Bréguet, Caselli, etc., qui ont fait faire de si grands et si rapides progrès à la science électrique, si nouvelle encore.

A partir de 1860, le nombre des brevets s'augmente encore, et atteint son maximum en 1867. En cette dernière année, on en compte soixante-huit, et ce chiffre n'a pas été dépassé depuis, ni même atteint. Pourtant la différence, quant aux années suivantes, n'est pas considérable; elle est même presque insignifiante. Les deux années fatales 1870 et 1871, elles-mêmes, quoiqu'à moitié perdues par suite de tant de cruels événements, ne voient pas s'abaisser sensiblement le chiffre des brevets qui ont pour moyen ou pour but l'électricité. Tout au contraire, dans les trois années qui suivirent il y eut une certaine décroissance, puisque les brevets pris en 1872 sont au nombre de soixante-six, et ne sont plus que de quarante-sept en 1873. Néanmoins, depuis ce temps, la tendance à l'accroissement, lent mais régulier, n'a cessé de se manifester, et on peut prévoir que la présente année comptera environ soixante brevets.

Le rapport du nombre des brevets d'électricité au nombre total de tous les brevets pris annuellement, demeure à peu près constant, et dans les six dernières années il y a eu environ un brevet d'invention électrique pour cent brevets touchant toutes les autres formes de l'activité humaine. Cette proportionnalité indique la part relativement très-grande que prend l'électricité dans les inventions et les perfectionnements modernes.

Plus d'un tiers de tous ces brevets ont pour objet la télégraphie, ce qui prouve, sans qu'on ait d'ailleurs à s'en étonner, combien cette application de l'électricité, la plus merveilleuse, la plus utile, a engendré

Any 40

Blasting by Electricity. 77

Blasting by electricity, one of the latest practical developments of science, is being generally utilized. The advantages are great saving of explosives, safety, and protection of life, economy of capital and time, and overcoming obstacles that nothing else will, such as firing under any quantity of water, sinking or driving in soft sandstone, granite splitting, rooting up trees, blasting slag, etc.

On Saturday, June 10, a gigantic explosion was arranged in the granite quarries of Messrs. Ellis and Evrard at Bardon Hill, near Leicester, by Messrs. Atkin and John Harris, of Nobel's Explosive Company; six holes being put in, averaging a depth of 20 feet, each hole being charged with 15 lbs. of dynamite, and exploded with Capt. Brain's electric fuses. The machine used to fire them was Capt. Brain's American Improved, a most compact and simple article, being only some 14 lbs. in weight, which may be used by the ordinary working men, giving an electric spark 2 inches in length. The firing of these six holes had a most marvelous effect, the whole quarry having the appearance of being rent as by an earthquake. Huge blocks of granite were tumbled out, and upon careful examination and measurement it was computed that 14,500 tons had been dislodged and thrown into the bottom of the quarry. This practical demonstration of the effect of simultaneous blasting with a powerful explosive in connection with quarry works was most satisfactory to the proprietors and other gentlemen present, it being generally acknowledged that such successful results had never been known in the district before.

The Electric Blasting Apparatus Company, Cinderford, Gloucestershire, have also just very successfully laid down a set of blasting apparatus at South Kirkby Colliery, near Pontefract, where shafts are being sunk to a depth of 700 yards. The advantages of the system are so apparent in collieries already using this apparatus in the district that its use is becoming more general. At the Houghton Main Colliery, near Barnsley, two 15 feet shafts are each firing 16 holes at once, and raising 70 tons of *débris* from a shot, an increase of 50 tons a blast on the old system—a practical demonstration of the great advantages of simultaneous blasting.—*Mining Journal.*

WANTED—TORPEDO DEFENCES.

Mr. E. J. Reed, late Chief Naval Constructor of the British Navy, in a recent lecture before the Society of Arts, took occasion to express an opinion which, we think, every one who has given any thought to the method of waging future maritime wars has already more or less definitely reached. Coming from an engineer who has been so closely identified with the building of the ironclad navy of Great Britain, the views enunciated will assume greater force. They could not be more radical or more direct. Mr. Reed says, in substance, simply that, until a way of protecting vessels from the effects of torpedoes is invented, ironclad ships, notwithstanding their 24 inch armor and 100 ton guns, are anachronisms, and that their construction is waste of time and money. "Neither the suspension of chain nets, nor additional bulkhead divisions in ordinary forms of ships, will be a sufficient, nor anything like a sufficient, defence against this deadly submarine instrument of attack. The naval Whitehead torpedo delivers a most terrible blow; it moves for the space of some hundreds of yards with a speed double that of the fastest ironclads; its path is so sure and true that at that distance a second torpedo can be made to pass through the hole which the first has made; and whereas it has been assumed that, in ordinary conditions of weather and naval warfare under steam, a ship could not have more than a few feet of her depth below water attacked, the torpedo has the whole immersed bottom of the ship exposed to its assaults." Mr. Reed goes on to say that the days of war ships, more or less long and narrow, and with deep bottoms of thin iron containing the steam boilers and powder magazines, are numbered. He advises his government to reconsider its intention of beginning the building of a vessel of the Agamemnon class; and finally he concludes that modern naval necessities are "first, the construction of our large ships on principles which make them as little destructible by torpedoes as by guns, which I believe to be quite possible; and secondly, the building of all our other war ships of small and handy types." By the latter he means small vessels which can be manœuvred with sufficient rapidity to avoid torpedoes.

Mr. Reed unfortunately fails to mention the plan for protecting ships against torpedoes, the knowledge of which he implies that he possesses. It will be seen, however, that in his opinion a total reconstruction of the English navy is necessary, and that consequently the enormous sums of money which have been expended on its development are entirely thrown away. This is not cheering intelligence to the British taxpayer; and we doubt whether its purport will be acquiesced in until inventors, the world over, confess themselves vanquished by the problem of devising an efficient system of torpedo guard. So long as enormously heavy artillery is to be used, vessels must be built both capable of carrying the guns and likewise capable of resisting them. Already it is contemplated to build cannon which will dwarf the 100 ton gun; and the English iron founders, on the other hand, promise 40 inch rolled plates. If war ships must carry such loads of metal as these, it is difficult to see how they can be built light enough to dodge torpedoes. There is certainly little to be gained by building vessels possessing the latter advantage, if at the same time they are to be rendered easily vulnerable by heavy guns.

We agree with Mr. Reed in the belief that it is possible to protect large vessels against torpedoes, although we have no especial project to propose. The subject is one which we would particularly commend to the attention of inventors. It is obvious that the necessary protections can be obtained in two ways: first, by devices outside or extraneous to the vessel, and second, by modification of the construction of the ship itself. The simplest outside device is the torpedo netting constantly used by our vessels during the war. This is simply a network of chain or rope supported on booms at some distance around the ship and extending down into the water deep enough to guard the entire bottom. To prevent the access of torpedo launches, the ship may be surrounded by heavy spars also attached to the booms, and from these chain nets, as already described, may depend. These devices are obviously of little use or altogether impracticable when the vessel is in motion. To avoid stationary torpedoes anchored in channels, ships have used forked catchers protruding from the cutwater, to grasp and cause the explosion of the obstruction. Rafts pushed in front of ordinary vessels likewise serve a similar end. Under the second plan, war ships are built in watertight compartments. The Inflexible, for example, has 127 such sections. Or, as in the case of Admiral Porter's boat, the Alarm, there is a double hull with the space between divided up, while the entire hold of the ship may, through the watertight bulkheads which cross it, likewise be converted into separate sections. A torpedo, it is supposed, might injure a few compartments, while those still staunch would perhaps float the vessel. With iron ships there is not much surplus of buoyancy, however, and the racking effect of a blast might cause results much worse than the direct injury to the compartments immediately adjacent. Probably the means of defence nearest to security, lie first in keeping the vessel constant'

under steam and under control, and second in the electric light which reveals the approach of an enemy by night. But the circumstances of weather or of locality may prevent the rapid manœuvring of the ship, and a fog may render the electric beam useless: while there is no safeguard against the unseen approach of the submarine torpedo of the Ericsson, Lay, or Whitehead type.

The conditions of the problem need no especial explanation. It is simply a question of how to render a ship's bottom invulnerable, not merely to the explosion of the torpedo itself but to that shock *plus* the energy of the running blow delivered by the sharp bow of a heavy torpedo boat. An invention of this kind would be immensely valuable to every naval power, and would insure fame and fortune for its originator.

TORPEDOES.

BY G. OAKUMA.

The development of submarine warfare has been so rapid of late that it is hardly possible to foretell what potent influence it may have on the war now being waged in Eastern Europe. While England, France, Italy, and in fact nearly all the European naval powers, have been building huge engines of war, of a tonnage, armor, and artillery never heard of before, the torpedo has been gradually perfected, and threatens, at least under many circumstances, to neutralize them. A torpedo may be regarded as a gun which dispenses with a gun carriage, and which, without the vast and expensive agency of a great ship, inflicts as formidable a blow as that of the heaviest artillery.

The original inventor was David Bushnell, born at Westbrook, Connecticut, 1742. He not only devised a torpedo, but also a submarine rowing boat, intended to convey it to the bottom of the vessel to be attacked. His practical experiments, however, which he was enabled to carry out with the assistance of the private purse of George Washington, did not prove successful; and the invention sank into oblivion until the commencement of the present century, when Robert Fulton, an American sojourning in France, offered a similar one to the French Government. After considerable parleying, it was rejected, and Fulton sold his secret to the British Admiralty for $75,000. The so-called Catamaran Expedition, an attempt to destroy the French line-of-battle ships and transports off Boulogne, turning out a failure, Fulton returned to the United States, and, during the war of 1812, tried in vain to blow up several of the English blockaders. The rage of the British commanders knew no bounds and the proceedings were termed "unchristian," "the invention of a fiend," etc. Cousin John Bull has a frightfully short memory at times!

In 1829, Colonel Samuel Colt commenced experiments with a submarine torpedo exploded by a galvano-electric battery; and after many disappointments, he succeeded on October 18, 1842, in destroying the brig Volta in New York harbor, in the presence of 40,000 excited spectators. So far only vessels at anchor had been attacked; but on April 13, 1843, Colt blew up a brig of 500 tons under sail on the Potomac river, he himself being the operator, and at the time at Alexandria, five miles distant from the explosion.

The first European government to adopt the invention was Austria, who laid down a perfect electric torpedo net for the defence of Venice. Russia followed suit, and during the Crimean war protected the entrance of Cronstadt as well as that of Sebastopol harbor by an improved system of ground torpedoes, which kept the English fleet at a respectful distance. The American civil war for the first time clearly demonstrated the tremendous effect of the invention, and at the same time changed its character from a purely defensive to an offensive weapon. Galled by the soon-established superiority of the United States navy, which gradually sealed up all the important Southern ports, the Confederate Government organized a special torpedo service corps; and after sinking torpedoes in every available approach, they proceeded to build small steamers constructed to carry spar torpedoes. These torpedo boats, with an easily comprehensible Biblical allusion, were called "Davids," and were in several instances used with as much pluck and perseverance as terrible effect. The United States soon imitated the David, and in 1864 the late Commander Cushing, U.S.N., succeeded in destroying the Confederate ram Albemarle, lying at anchor in the James river. Since then the electric apparatus for torpedoes and the torpedo itself have been vastly improved; and numerous new inventions have been introduced, all of which, however, may be classed under the following five heads: Ground torpedoes, spar torpedoes, Harvey (towing) torpedoes, Whitehead (fish) torpedoes, and the Lay torpedo.

GROUND TORPEDOES.

The ground torpedo is a sort of sunken mine, exploding either by contact or by electricity. If these are judiciously laid down around a harbor or anchorage, the approach of hostile ships may be rendered impracticable, provided always they are protected by shore batteries or armed ships to prevent removal. Every channel may be barred by these hidden mines; and they may be made so powerful that any ship under which they explode is sure to become hopelessly disabled. They are fastened to and hold in their positions either by anchors or by stockades. The bursting charge consists of gunpowder, gun cotton, or dynamite; and the case or shell is either made of iron or wood; in Charleston harbor, old steam boilers were frequently used.

SPAR TORPEDOES.

The spar torpedo is fastened to the end of a spar from 15 to 38 feet long, carried in a boat, no matter how small, and explodes also either by electricity or contact. A most remarkable experiment was recently made at Cherbourg, France, with spar torpedoes, carried by a little vessel called the Thorneycroft, which was almost submarine. We illustrated this invention on pp. 239 and 246 of our current volume. A very small part of it was above water, but it was of sufficient strength to carry engines and two lateen sails, and it was worked by a lieutenant, two engineers, and a pilot. The French Admiral had two disabled ships in succession towed out to sea at a speed of 14 knots an hour. The Thorneycroft, however, was able to go at the rate of 19 knots an hour, a rate not attained by any vessel in the squadron. She very soon caught up with her prey, delivered her blow with a spar torpedo, which projected from her bow, and rebounded. A rent as big as a house was made in the side of the ship attacked, and she sank at once. The Thorneycroft only spun round and round for a few moments, and then returned uninjured to the squadron, from which she had started. A vessel of this kind is scarcely discernible in the water; even if she were detected, she is so small that it would be difficult to hit her; and half a dozen Thorneycrofts attacking a large vessel would be a most dangerous foe. Their expense is quite trifling compared with that of great ships of war; they can be multiplied indefinitely, and they can be carried on board other ships and be launched from them as occasion may require. The Italian Government has already carried out this idea in the construction of her formidable new ironclads Dandolo and Duilio. These vessels are fitted in their sterns with a sort of armored dry dock, harboring a small torpedo steamer. As soon as the services of the latter are required, the dry dock is filled with water and opened, and the little craft rushes out at the enemy, returning to her safe berth after her mission has been fulfilled. Admiral Porter's torpedo vessel Alarm, also recently illustrated by us, is fitted with spar torpedoes, both for bow and beam; but the torpedo generally supplied to all the cruisers of the United States is the

HARVEY (TOWING) TORPEDO.

Invented by an English officer in 1862, it was soon adopted by nearly all the other navies, and probably will be exclusively used in general actions at sea as least liable to injure a friendly vessel in the *mêlée*. The Harvey torpedo is towed upon the surface of the water by a wire rope towline from a derrick end of the yard arm over or against the enemy; and just before reaching the ship to be destroyed this towline is slackened, and the torpedo, being heavier than water, dives under it. When in this position the explosion is effected by means of a mechanical firing bolt striking down upon a pin as soon as certain levers of the torpedo come into contact with the bottom of the target. This torpedo can also be made to explode by electricity. Two different forms are used for starboard and port.

WHITEHEAD (FISH) TORPEDOES.

This invention is the secret and the property of the British Admiralty, but the following details have leaked out: These torpedoes resemble in shape a cigar, pointed at both ends, and are 18 feet long by two feet in diameter. The inside is divided in three different compartments: First, the head, which contains a charge of 350 lbs. of gun cotton and the pistol or detonator to explode it; secondly, the balance chamber, which contains a contrivance for setting it so as to remain at any depth at which it is wished to travel under the water line; and lastly, the air chamber, which contains the engines and the compressed air to drive them. The after end supports the screws—a right and a left handed—which propel the torpedo and are made of the finest steel. The air chamber is tested to the pressure of 1,200 lbs. on the square inch, although for service it is only loaded to 800 lbs. The Whitehead torpedo can be made to go at the rate of 20 knots for 1,000 yards, and at any depth that is desired from 1 foot to 30 feet. It can be set to explode either on striking an object or at any particular distance under 1,000 yards—in artillery language, either by a percussion or a time fuse. It can also be set so that, if it misses the object aimed at, it will go to the bottom and explode at half cock or come to the top on half cock so as to be recovered, as it has buoyancy enough just to float on the surface of the water when not in motion. It is fired from what is called an impulse tube, which, out of a frame fitted to a port, discharges the torpedo into the water. It can be fired above the water, but will at once go to the depth it is set for, and then go straight to the object, no matter how fast the ship from which it is discharged is going, or how fast the object aimed at may be sailing or steaming. It fact, it seems that it can do anything but speak. It is calculated to make a hole on bursting of 70 feet area, and there is no doubt that, if one of them hits a ship of any sort or description at present on the water, she must at once proceed to the bottom. It is evident that by this means a comparatively feeble ship, if only able to approach within 1,000 yards of a large one, can discharge a deadly flight of unseen projectiles at her, and at night such an attack will probably be wholly unsuspected and scarcely open to resistance, as the vessel fired against will be positively unaware of the attack until she is blown up. The newly invented electric light from the tops is a great help to the party attacked; but if three or four boats of great speed attack a vessel from different points of the compass, and if they are commanded by smart officers, nothing that she can do will save her from being hit by one or more of them. There is no doubt whatever that this torpedo is the most formidable weapon of modern naval warfare.

THE LAY TORPEDO.

Properly speaking, the invention of Mr. Lay, purchased by the United States Government, is not a torpedo, but a very ingeniously devised submarine torpedo boat fitted with a spar torpedo. This boat has the advantage of not requiring any crew on board, but in other particulars is capable of great improvements. The motive power consists of an engine driven by carbonic acid gas and a screw propeller. The boat is entirely submerged, and is steered and in all other respects controlled by means of an electric battery on shore, connected with her by a cable which is coiled up in her hold and pays out as she moves away. Her location is indicated above the surface of the water by a flag, so as to enable the operator to direct her course. The greatest defect of the Lay torpedo is want of speed. The United States Government stipulated for a speed of 9 statute miles per hour, but the maximum speed actually attained at the late trial trip, when it was steered by Lieutenant R. B. Bradford, U.S.N., showed only an average of 6·60 miles per hour, so that a ship attacked would only have to lower her boats and let them row between the approaching torpedo and the shore, and cut the cable, which would leave the torpedo at their mercy. The defence of ships against torpedo attacks of all kinds is at present very imperfectly developed, principally owing to the fact that the offensive qualities of any weapon must first be learned before effectual means of defence can be devised; and as actual warfare only can give a correct idea of the former, we are, no doubt, on the eve of very startling events, which may entirely revolutionize and change every recognized principle of naval tactics.

The great anxiety felt in England for the future safety and efficiency of the British navy, on account of torpedoes, is shown by the attempted formation of an International Torpedo Association, which Lieutenant Colonel Martin, of Boxgrove, Guildford, late commanding 4th (the King's own) Royals, is about to set on foot. He says in his programme: "When explosive bullets and chain shot were invented and actually used in war, nations unanimously agreed to discontinue their use and prohibit their manufacture; yet explosive bullets and chain shot, it must be admitted, are harmless as compared with torpedoes. Poisoning is prohibited in war. Why not prohibit torpedoes, which are actually more subtle and deadly than poison, there being no antidote to escape from them? For instance, were I allowed to fire (from a mortar) gutta percha bags filled with strychnine and charged with a [illegible] and time fuse to cause the bag to burst and scatter its diabolical contents over some obstinate city or fort which would not capitulate, this visitation would be far more merciful in its way towards the people of that city or fort than torpedoes would be against crews of ships, because the strychnine could be seen and avoided by flight; whereas, on the other hand, torpedoes secretly moored, or even fish torpedoes, insure complete, sudden, unexpected, and unavoidable destruction. Several clever artisans have already been killed by merely pumping compressed air into the tails of unloaded fish torpedoes. Had these torpedoes been loaded with gun cotton for service on board ship, and even if one of them exploded from careless handling during action while compressed air was being supplied to start it, or if by chance a shot or shell struck the ship at the time of starting a fish torpedo on its death track, the fearful consequences may be easily imagined. As a proof that governments appreciate the danger they incur by the use of torpedoes, I may here state that it is well known that, after the Austro-Italian war, all the picked-up torpedoes proved to be dummies. It is our bounden duty to keep pace with other countries, but every one will admit that the sooner the "International Anti-Torpedo Association has accomplished its task, the better for the cause of humanity!"

It is much to be feared that other nations will prefer to take a different view of the case, and continue to consider torpedoes a cheap and effective counterpoise to the costly and powerful English ironclads.

3. 42 32

77 **Application of Electricity in Dyeing.**

According to the *Bulletin de la Société Industrielle de Mulhouse*, Goppelsroeder has observed that if an electric current is passed through aniline dye becks decoloration ensues, with formation of colorless salts of leukaniline. If yarns or cloths are steeped in the liquid they absorb it, and on subsequent exposure to the air they become colored, just like the goods drawn out of an indigo vat and exposed to the air. The colors thus obtained are said to be faster than those produced by the ordinary method. Whether this principle of dyeing will prove practically useful remains to be seen.

NAVAL ARCHITECTURE.

June

TORPEDO PRACTICE.

77

THE actual use of torpedoes as engines of war, though theoretically most valuable both for attack and defence, has drawbacks which are worth considering. We may refer, by way of evidence, to Captain Scott's remark on Mr. Donaldson's paper in regard to the Whitehead torpedoes (see IRON, p. 654)—that every ship of war carrying a supply of these missiles, carries a terrible and novel source of danger to herself. Again, in the present war, it is reported that, with the aid of skilled divers, torpedoes can be successfully disarmed. It is not difficult, therefore, to understand that the manufacture of torpedoes is one thing, but that their successful use is totally different. For coast protection there are two classes of torpedoes, the mechanical and the electric. At the present time, except in peculiar circumstances, the mechanical torpedo presents so many disadvantages—not the least of which is that its success depends a great deal on accident, and is, consequently, very problematical—that it may almost be excluded from consideration. Yet, when mention is made of the use of torpedoes during the present war on the Danube or elsewhere, it would not do to assume that the mechanical torpedo is discarded. This weapon is useful enough if it is properly planted, if it is properly made, if a great many other considerations have been carefully noted, and if, finally, luck is on its side. But, once laid down, it cannot be tested, nor can it be manœuvred in any way. It is as likely to injure friend as foe, and is not unlikely to be found perfectly harmless to both. In fact, it is a two-edged weapon, which is as dangerous as it is useful, and it proved its terrible unsteadfastness in a variety of ways during the American War. Now, when it is reported that the Turks are prepared to render Russian torpedoes inoperative, reference is evidently made to this class of weapon, which can easily be ruined without risk of serious danger. The electric torpedo is, however, a more formidable weapon, and can hardly be destroyed or ruined, except by accident, or by taking advantage of extraordinary carelessness on the part of those who are interested in its safety. The deadly nature of this weapon may be realised by remembering that the operator is on shore, undisturbed, with plenty of time for quiet and accurate calculation, and dependent only on nerve for the success of his torpedo. But, and this "but" is very large, the use of electricity, especially in a case like this, where the results are so serious, requires a large exercise of dexterity and delicacy. The smallest deviation from the prescribed course may lead to an awful disaster, and a slight want of nerve may send a friend instead of an enemy to the bottom. In fact, the position of the operator is not unlike that of a pointsman or signalman on a railway. Captain Fisher places this in a strong but intelligible light in his remark that "when that most trying time comes in which the utter destruction of an enemy's ship may rest solely on the operator, he will be able to act instantaneously, without hesitation. There is no time to think then. The enemy, if he is wise, will be forcing his passage at his utmost speed—one instant he is in danger from the torpedo, the next he may be safe—with the exception perhaps of a good shaking." His subsequent remark is worthy of being inscribed in letters of gold in every battery and every man-of-war:—"The great secret of the successful management of torpedoes will be found to consist in paying the utmost attention to apparently trifling precautions, and in trusting no one."

In the use of torpedoes, or in their actual application in time of war, one of the most important lessons to be learnt is their planting. Great judgment and care are essential here, and it forms naturally an important feature in all courses of torpedo instruction. In referring to the difficulties of this operation, Captain Fisher has pointed out that it is of the utmost importance in laying down a torpedo to insure the preservation of its exact position; to avoid any chance of a fracture of the insulated wire through twisting; to calculate accurately the exact height and force of the tide, so as not to expose the torpedo at low water, nor make it inoperative at high; and to consider carefully currents, winds, the action of spring tides, and any other exceptional points in the channel under protection. Position also requires great consideration and experience; for it is quite possible to lay down scores of torpedoes which would be perfectly useless. For instance, it is essential to plant them at such a distance from the line of coast under protection as to prevent ships from coming sufficiently near to use their guns effectively. It is also important to plant them like lettuces or cabbages, sufficiently far apart from one another not to interfere with independent action. Reference has been made recently to the valuable aid to be derived from the *camera obscura*; but this instrument, useful as it is, has been rather overrated, for its accuracy in daytime is difficult to insure except in peculiar circumstances, and at night it would naturally be useless.

But while the difficulty in using the electrical torpedo is chiefly technical or mechanical, and can be overcome by practice, the treatment of torpedoes to be used at sea, whether in the "spur" or "Whitehead" form, calls not only for technical skill and dexterity, but for personal qualities of the highest order. The "spur" torpedo is intended to be used in the new Thorneycroft boats, such as the *Lightning*. The object of these boats is, by the attainment of a speed of twenty or twenty-five miles an hour, to attack any man-of-war by coming up with it, launching against it a torpedo, and then running away again. Simple as this operation may seem, it is attended with such manifest danger as to prove that special qualities of nerve and readiness are requisite. To use a torpedo in this way efficiently, it is important to be very careful both as to the place and mode of using it. As failure will, almost inevitably, prove fatal, constant practice is necessary to attain the necessary proficiency. In fact, to be successful demands on the part of the officer chosen for this work an amount of nerve and of delicate judgment not exceeded in any other warlike operation. The great recommendation about this mode of using torpedoes is that, if successful, its success is undoubted. The case of the *Housatonic*, mentioned by Mr. Donaldson at the United Service Institution, is a case in point. But precision in attack is absolutely essential. It is quite possible, as has been proved by experiment, to explode a torpedo harmlessly, although in actual contact with a ship's side. In one case the charge was submerged only six feet, and although the charge consisted of 50lb. of powder, no vital injury was done. To quote Captain Fisher on this point—"The vertical effect of a submarine charge, no matter at what depth, is much greater than that in any other direction; this is but natural. The explosion is dammed up laterally, stopped by the bottom, reacted upon laterally, reacted upon by the bottom; so it is evident the greatest effect must take place in a vertical direction. This principle should always be borne in mind when endeavouring to attack an enemy's vessel with outrigger torpedo boats." He quotes an instance, the case of the *Albemarle*, where "the torpedo was submerged ten feet, and exploded under an overhanging portion of her stern, which, though several feet from, yet was virtually over, the torpedo."

Although this subject admits of much elaboration, and a great deal remains to be said about the special danger of the Whitehead torpedo, not only in its actual use, but in the mere fact of carrying such a destructive weapon in a man-of-war, we have said enough to show that there are two sides to the torpedo question. The torpedo is a very double-edged tool, and, valuable as its powers are for attack, its value depends mainly on the exercise of exceptional and high qualities.—*The Times*.

Captain Morgan Singer, of the *Vesuvius*, torpedo ship, has been carrying out a series of experiments in the capacious repairing basin at Portsmouth, with the object of discovering the best means of defending ships against the attack of the Whitehead torpedo. Up to the present time the ingenuity of the naval architect has been mainly exercised to protect ships against the entrance of shot and shell; and while for this purpose he has gone on increasing the thickness of the side armour, the bottom of the ship, against which the attack of the torpedo is directed, remains in almost its original weakness. How to protect the hull against both the gun and the torpedo and at the same time preserve the seaworthiness of the ship is one of the many problems in naval construction which have yet to be solved. In the meantime two methods of protection against torpedoes are proposed—*viz.*, the employment of fast "satellites" to ward off and attack the torpedo boats before they can get within range, and the erection of crinoline frames around the ships themselves, by means of which the rush of the projectile would be arrested before striking the hull. Both devices have their disadvantages. The general use of patrolling craft would immensely complicate the exigencies of an engagement by provoking a number of subsidiary battles around the main action; besides, the champions of these small craft seem to forget the all-important fact that in the next naval engagement the principal antagonists would themselves use the torpedo. Hence, even with the adoption of an auxiliary fleet, it is essential that our ships of war should be fitted with some defence against this terrible submarine engine. The torpedo net will necessarily impede the way and obstruct the manœuvring of an ironclad, and, such being the case, the object of Captain Singer has been to ascertain the form of crinoline which would oppose the least resistance to the water and the most resistance to the torpedo. Various forms of nets, composed of alternate lines of bars and chains, have been tried, but the size and power of the missile have been so increased of late that it has been found that the torpedo nets of the *Thunderer* afford little or no protection. Last week a chain net, formed of chains 5-16ths of an inch thick, was easily perforated by the Whitehead. The great fault of the nets is their extreme rigidity, which opposes a solid wall to the impact of the torpedo, and the bars are consequently snapped. After many trials, however, very successful results have been obtained from a wire grummet, matting, composed of wire strands about half an inch in thickness rove into open meshes. It possesses considerable flexibility, and, as it yields when struck, the force of the torpedo is not suddenly, but gradually, arrested, and as it loses its momentum it is thrown back by the recoil of the mat. During the experiments a torpedo thus forced back twirled its tail off without inflicting any injury to the matting. This is the nearest approach to perfection which has yet been attained.

June 77

Some New Uses of Electricity. 77

1st. The galvanic chair, to prevent joggling in schools.

2d. The torpedo battery, to prevent fainting fits among girls, and shock at once any fainted female (for which all other remedies fail) into perfect consciousness.

3d. Electric whips, to tickle horses by slight shocks, and thus cause them to run, or stop them at once by the parlyzing effect of a strong discharge.

4th. Electric hair-dressing machine, causing the hair to stand up perpendicularly. The ladies liked it at first, but found out that when any young man came in contact with their electrified hair, a crackling explosion followed, and was the means of frightening away some timid young fellows, one of whom said that he "didn't want any girl of his who put nitro-glycerin in her hair."

5th. The latest is the electric dining machine, invented by a French physician for the benefit of a patient who could not swallow. He filled his mouth with food and then gave a downward shock through his jaws and throat, when all went down with the velocity of the electric current—that is, at the rate of 4,000 miles per second. This man, it is reported, has since dined daily by help of electricity, going through the whole bill of fare of an exquisite French dinner, including the delicacies of the season—wine, coffee, ice-cream, Charlotte-Russe, etc., in 1 minute and 14 seconds.

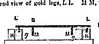
The *New York Times* recommends this system highly to the American business men who have no time to spare, and now waste as much as 12 or 15 minutes between soup and toothpicks. The time so wasted while eating is estimated to be worth $300 per year for each, and for a city like New York, alone would amount to some hundred millions of dollars per year. If the whole country coöperated, estimating the money-making population at ten millions, we could pay the whole national debt in a very few years, if men would only agree to follow the advice and swallow their food by the help of electricity.

 33 43

FACTORY NOTES.

ELECTRIC CLOCKS FOR GLASGOW.—The corporation of Glasgow have agreed to fit up thirteen electric clocks, in order to remove a grievance regarding the disparity of time indicated by the present public clocks. The clocks, which are to have large white faces with distinct black figures, will be pretty equally distributed over the city in prominent places, where they are likely to be readily seen during the day, and where there is sufficient light to render them visible at night.

[3020.]—**Electric Clock Pendulum (Bain's).**—As an accompaniment to my sketch of electric pendulum, page 611, No. 650, Vol. XXV., I inclose sketch of the break, which is a very important part of the clock. A, a square-shaped ivory bar, about 4in. long; *g g*, two small strips of gold plate, thickness of threepenny piece; platinum might do nearly as well. H H, two brass plates exactly similar to the gold ones, and fixed in the ivory bar close as possible to the gold strips without touching them. S, sliding rod of light wire, having two leg-pieces, L L, of gold to slide freely over the gold and brass plates. L a, end view of gold legs, L L. M M, two brass



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pins on slider; these pins being struck with the pin, P, on pendulum staff by each vibration, when the pendulum swings to the left it will shunt the slider's legs so that both cover the gold strips which are shown shaded, and the circuit is then complete; the pendulum, on its return journey to the right, will again cut off the current by throwing the right-hand leg, L, on to the brass plate again, so that it only obtains its power whilst journeying from left to right until the slider is struck, when the current is disestablished. Should the pendulum by increased activity of the battery swing too far to the left, it will carry the slider off the left-hand gold strip, consequently deriving no impulse for the next swing. It will, therefore, be seen that to a very great extent the pendulum is its own regulator. If great care is used in the construction of such an electric pendulum, it will go for years by a plate of zinc about 2ft. square, with a little rough carbon embedded in the damp soil.—ALFRED CROFTS, Dover.

THURSDAY, AUGUST 9, 1877

ELECTRICITY IN WAR

THE important *rôle* played by electricity in modern warfare affords an excellent example of the influence which science has of late exerted in naval and military affairs. It is no isolated example of scientific warfare that we have here to deal with, for the electric fluid has in a great measure changed our whole practice of war, and bids fair to revolutionise it still more in the future. Every soldier or sailor, if he desires to make his mark, must be something of an electrician, for there seems to be no limit to the useful applications of the galvanic spark in battle. Broadly, we may divide these applications under three heads; namely, the employment of electricity for signalling, for the explosion of charges, and lastly, for illumination, both for the purposes of attack or defence, it being a difficult matter to decide in which connection the electric spark fulfils the most important duty.

To begin with the telegraph. All will agree that it is well-nigh impossible to overrate the advantages which this rapid means of communication gives to the general, in these days, when the line of battle sometimes extends for a dozen miles. Let the commander occupy the most central position, a long time must elapse before his aides-de-camp can communicate with one wing or the other. Assisted by the electric telegraph, however, the general is as close to his subordinates as if he were within shouting distance. Even a brigade of horse artillery, or a cavalry division advancing at a gallop, can carry its telegraph equipment with it, the operators accompanying a flying column of this nature with but very little difficulty. The wire drums are started off at a gallop, the cable being unwound as the carts proceed, and a sergeant on horseback with a "sounder" to his ear, in connection with one end of the wire, receives the general's commands as soon almost as they are spoken. The movement countermanded or a retreat ordered, the cable is again wound up as readily as it was laid down, and the telegraphers make good their return with the rest of the troops. Where ordinary movements are executed, use is of course made of the telegraph wagon, a comfortable little office on wheels, furnished with all things necessary for the receipt and despatch of messages, but this convenience is naturally out of place where a rapid change of front, or some speedy flank movement has to be executed.

Coming next to the explosion of charges by means of the electric spark, we enter upon a phase of war-science which bids fair to grow to infinite proportions. Both Franklin and Priestley suggested the employment of electricity in this connection more than a hundred years ago, but it is very recently indeed that we have been in a position to make proper use of this valuable agent as a means of firing charges at a distance. In fact, at the present moment we have by no means exhausted research in this direction, and we find scientific soldiers and sailors still at variance with one another as to the best plan of using the electric current for firing purposes. One of the first applications made of the subtle fluid was in the removal of the wreck of the *Royal George*, at Spithead, nearly fifty years ago, when the explosion of the charges was brought about by what is termed a wire-fuse, or in other words a short piece of platinum thread stretched between two copper wires. The platinum bridge having less conducting power than the copper wires, presents a considerable amount of resistance to any current of electricity that passes, and, in doing this, becomes so heated, as to be capable of igniting any particles of gunpowder in contact with it. A wire-fuse of this description has simply to be placed in the middle of a charge, and if then a current of electricity is passed from a battery along the wire in connection with the fuse, instantaneous ignition is the result. This simple method of firing charges under water was a vast improvement over the old one in use by our engineers, which consisted in leading up a metal pipe from the charge to the surface of the water; the outlet of the pipe was placed as far as possible from the charge beneath the water, and then a ladle full of red hot shot was emptied down it, and so reached the gunpowder below, which thereupon exploded if the iron fragments had not become too cool in transit.

But for many purposes the wire-fuse is ill-adapted to the military and naval services. A voltaic battery is necessary to evolve the low-tension electricity required to yield sufficient resistance and heat, and such a battery made up of metal plates, and involving the use of acids, is an awkward apparatus to carry in the field. Already in 1853, this fact seems to have occurred to a Spanish officer, Col. Verdu, who determined to see what could be done in the way of exploding gunpowder by a spark, or in other words, by high tension electricity. Aided by a Ruhmkorff coil he succeeded in firing half-a-dozen charges simultaneously, and although the discharge was sometimes a matter of considerable uncertainty, to Verdu certainly belongs the credit of having been the first soldier to apply electricity in this way to the firing of one or more mines. Wheatstone and Abel followed in Verdu's footsteps, and while the former directed his attention to the construction of a frictional apparatus of a portable nature, which should be suitable for military use, the latter busied himself in the preparation of a fuse inclosing a compound more delicately explosive than gunpowder, a fuse, by the way, which still retains an important place among our warlike stores.

It was in the China war of 1860 that we first find an electric firing apparatus forming part of an army equipment. In this case the outfit was of a somewhat clumsy nature. A conveyance, in shape and size much resembling a baker's barrow, contained a monster horse-shoe magnet, and it was the sudden disruption of its armature from this magnet which generated the spark to fire the fuse. A few years afterwards, this ponderous conveyance gave place to a neat little mahogany box about a foot cube, which contained half a dozen small but powerful magnets, in the field of which the armatures were made to revolve with exceeding celerity; and it is by means of such an apparatus that to day we are enabled to fire a score of charges at a time, the wires branching off from the instrument to a distance of a hundred yards or more. But, nevertheless, we have yet to devise, it seems, an efficient exploding apparatus capable of igniting both low and high tension electric fuses.

As everybody knows, it is by reason of electricity being employed to fire explosive charges that torpedo warfare has

415

INTESTINAL OBSTRUCTION TREATED BY ELECTRICITY.

Sept 77

M. GIOMMI (*Centralblatt*) gives an instance of the benefits of electricity in intestinal obstruction in the case of a man, aged fifty-one, who, up to the time of his illness, had always been strong and well. He had had complete obstruction for some weeks, and was almost moribund when the idea struck M. Giommi that the cause of the evil lay in atony of the walls of the bowel. He accordingly applied a strong induced current several times during two days, each time for ten or fifteen minutes. One electrode was introduced into the rectum and the other applied to the abdominal wall, in the course of the transverse colon. The result was marvelous; copious stools followed the free escape of gas, and after a few days the patient left, quite well.

METALS AS PHOTOMETERS.—The discovery of Siemens that light influences the capacity of selenium to conduct electricity, and which we have mentioned before, has now been applied to the construction of a new photometer, or instrument to measure the intensity of light. It has also been discovered that tellurium (a semi-metallic substance similar to selenium) partakes of the same capacity; while, finally, M. Boernstein, of Heidelberg, announces that he has discovered that it is the same with platinum, gold, and silver, and probably all the metals in some small degree. 78

Sept 13/77

SOME extraordinary statements have been going the round of the papers relating to an instrument called the telegastrograph, by which, through the aid of electric currents, the flavour of any food or liquor can be transmitted by wire to any distance, and the sensation of eating or drinking conveyed by merely placing the end of the wire between the teeth. This wonderful device is the invention of a member of the staff of the *Melbourne Age*, and that paper contains an account of certain experiments in which several scientific men in the colony are alleged to have taken part. Our contemporary does not supply any details of the machine, perhaps wisely, but we learn that it has a receiver, and there is an electro-magnetic battery capable of being turned on. We are gravely informed by our contemporary that the observers at the different stations having taken the wires between their teeth, the alcoholic essence of a large quantity of sherry was "sent along the wires," and the thirty-six "observers" received the impression of having each consumed a bottle of sherry and bitters. It should be noted that only one bottle of sherry with a wineglassful of bitters was poured into the receiver, and yet every sign of incipient intoxication was produced. The flavour of various articles of food was transmitted in this manner, and on one occasion, when the soup was too hot, the wires were very rapidly drawn from the mouths of the guests at Government House. "Every bubble on every glass of champagne poured into the receiver was faithfully imprinted on the palates of the observers." We suppose that our Australian contemporary considers it has done a very clever thing, but it is doubtful whether Mr. Ellery and Baron von Mueller will feel gratified in finding themselves made partly responsible for the statements of a writer who is a very second-rate Gulliver indeed.

FRENCH TORPEDO EXPERIMENTS.

WE publish engravings, showing the effect of a torpedo explosion directed against the Bayonnaise, an old wooden French frigate of about 2,000 tons. The experiments, which terminated in the practical destruction of the vessel, took place during February and March last off Cherbourg. On the 3d of March a torpedo charged with 33 lb. of damp gun-cotton, and carried at the end of a steel spar about 40 ft. in length, was exploded against the side of the ship at a depth of about 8½ ft. below the surface of the water. The launch carrying the spar was, as will be remembered, one supplied to the French Government by Messrs. Thornycroft & Co., and it attacked the Bayonnaise at a speed of about 14 knots per hour, the frigate itself being towed by a steamer at a rate of about 6 knots per hour. Just before the moment of striking it was found necessary to reduce the speed of the launch. The explosion was followed by a shock, and a large wave, which flooded the launch and drove it back for a considerable distance. The damage done to the Bayonnaise was, as will be seen from the engravings, of such a nature as to have sent her to the bottom immediately, had not the precaution been previously taken of loading her with empty casks. She was shortly after towed into dock for inspection.—*Engineering.*

Engraving on Glass by Electricity.

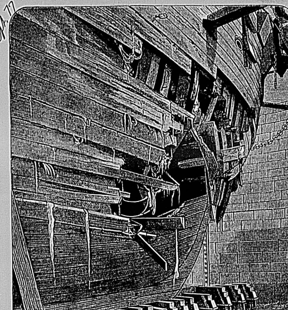
March 78

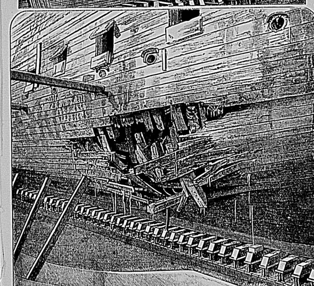
M. Planté, the inventor of secondary batteries by means of which a large quantity of electricity may be accumulated, has just discovered an excellent means of engraving on glass. Having remarked that a glass tube traversed by a platinum wire serving as electrode to a powerful voltaic current was instantaneously spread out in the form of a cone or funnel, in the midst of an alkaline solution contained in a voltameter, he made a series of experiments to determine what alkaline solution required the least electric force for devitrification. He therefore thought out the following process, which has given some remarkable results:

The surface of a plate of glass is covered with a concentrated solution of nitrate of potash, by simply pouring the liquid over the plate laid horizontally in a shallow saucer. Then into the liquid which covers the plate of glass is introduced a horizontal platinum wire, connected at one end with the edge of the glass plate and at the other with the poles of a secondary battery of 50 or 60 elements. Now taking in the hand the other electrode, (formed of a platinum wire surrounded everywhere except at its extremity with an insulating sheath), the surface of the immersed glass is touched with it at the points where it is wished to engrave. Wherever the electrode touches, a luminous furrow is produced; and, whatever be the rapidity with which the writing or drawing is done, the traces made are found clearly engraved on the glass. If the writing or drawing be done slowly, the traces are deeply engraved; as to their width, that depends on the diameter of the wire serving as electrode; if it be sharply pointed the traces may be made of exceeding fineness. Either electrode may be engraved with, but the negative requires a weaker current.

Sept 77

347



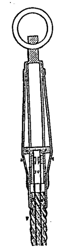


EFFECTS OF TORPEDOES ON THE HULLS OF VESSELS.

ELECTRIC SIGNAL FOR DIVERS. 77

We subjoin an illustration of a neat arrangement of electric signalling apparatus, designed by Mr. Protheroe, for the use of divers, and patented by him. The invention relates to the means provided to enable the diver to transmit signals through insulated wires imbedded in the ordinary "life line" to a telegraph instrument at the surface, this instrument being of any kind which may be considered most suitable. The fact of the insulated wires being imbedded in the life line dispenses with any extra ropes, while it also leaves the life line free to be used for signalling in the ordinary way if by way of any mischance anything should go wrong with the electrical apparatus.

Referring to our engraving, A is a portion of the diver's life line extending to the vessel above, having enclosed in it, or entwined with it, two insulating conducting wires B and C. These wires terminate in springs D and E, having on them contact faces *d* and *e*, which may be platinized in the usual manner. The ends of the springs D and E engage in a recess in a sliding piece of vulcanite or other non-conducting material F, both ends of which project through the sides of a tube G, in which the spring contacts are enclosed.



Over the tube G is fixed an external tube H of caoutchouc or other flexible waterproof fabric, which covers the ends of the sliding piece F. In the ordinary or normal position of the springs the two contact faces *d* and *e* remain apart, so that no electricity can pass from one of the two wires B and C to the other. But when the diver, by pressing with his thumb on either of the projecting ends of the slide F, pushes either of the springs D and E toward the other, then the two faces *d* and *e* are brought into contact, and an electrical circuit through the wires B and C is completed. By the pressure of the water the outer tube H will be more or less collapsed, but as the pressure acts equally on both ends of the slide F no contact will be made except when it is pressed in either direction by hand. By maintaining contact for a shorter or longer time signals of the ordinary Morse character can be readily transmitted. The ring at the lower end of the apparatus is secured to the diver's waist by a belt or cord. Intelligent communication from an unencumbered diver necessarily facilitates any submarine undertaking, as in most cases where force is required it can be applied from above under the direction of the diver from below. The safety of the diver is also more assured in intricate positions, where by the old method his signals would be indistinct.—*Engineering.*

9

Use of Electricity in War. 78

In the art of war many scientific discoveries have been utilized, originally expected to extend the blessings of peace. Steam-power, the servant of trade, by diminishing distance and multiplying carrying power, also accelerates the speed of armies and augments the number and the force of destructive weapons, missiles, and engines. In like manner electricity, which annihilates space, not only gives wings to messages and counsels of peace, but brings into instantaneous communication the field of battle, the commander's tent, and the council-chamber where sovereign and ministers debate on policy, and condenses into weeks the consultations and the operations that, without this aid, would be the work of years. But this is only a small part of the duty which electricity seems destined to discharge in the wars of the future. Its most effective work will be the firing of submerged and invisible torpedoes, as far removed from the actual touch of those who use them as from the knowledge of those for whose destruction they are to be employed.

Electricity is as Protean as life itself; its benificent form of to-day is constantly found to neutralize its noxious form of yesterday. The fitness of the electric light to circumvent the torpedo has engaged the experimental efforts of military scientists for some time past; and, judging from what is known of the recent practice in Europe, those efforts have led to a very appreciable success. The electric light apparatus which has been fitted up on board the new French war-ship Temeraire was brought into play, and the effect was such that no hostile vessel could have approached the illuminated ship within two miles without being seen. The results of the general adoption of this light, supposing it can be continuously relied upon, must go far to destroy the mysterious terror which at present surrounds the torpedo. Had the Temeraire been in the midst of foes on the occasion of the experiment, it would not have been possible for a torpedo-boat or ship to come near enough to discharge a moving torpedo without herself becoming a conspicuous mark for the Temeraire's guns. Add to this the use of the light in revealing stationary torpedoes planted under the sea, and we may safely congratulate ourselves upon our command over this manifestation of the electric force, and in regard to which our knowledge is daily increasing.

[Franklin Journal.]

THE ELECTRIC REGISTER AND KOENIG'S TUNING FORKS. 77

By LeR. C. Cooley, Ph. D.

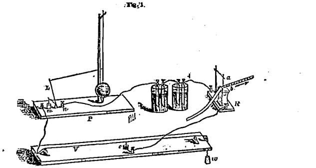
The application of electricity to register rapid vibrations was first made in 1868.* In that year I succeeded in obtaining a direct registry of the vibrations for all the intervals of of three successive octaves on a piano.† The wire was made to open and close a battery circuit in which an electro-magnet was placed, whose armature carried a stile, and, responding to the alternate efforts of the electric pulses and an opposing spring, flew back and forth in unison with the vibrating wire, and left a dot for each vibration on a strip of moving paper.

But the motions of an armature are too sluggish to keep pace with vibrations beyond a certain degree of rapidity; hence, the electro-magnetic method was speedily abandoned, and an electro-chemical registry substituted. "The requirements are: first, a steady stream of electricity from a powerful battery; second, means by which the vibrating body may open and close this electric circuit; and third, a rapid motion of chemically-prepared paper, through which the electricity is passing."‡

In the instrument first constructed, a fine copper wire, forming one electrode of the battery, was rapidly drawn along over the surface of a strip of tin-foil forming the other. A strip of tissue paper moistened with acidulated water, lay upon the tin-foil; upon it the moving wire constantly pressed, and every electric pulse traversing the paper left a velvety black stain upon the foil beneath. The vibrations in any measured period of time were thus revealed in a series of dots easily counted and permanent in the highest degree; records made then are as distinct to-day.

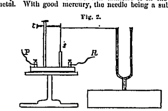
With this instrument the laws of vibration were demonstrated by an almost unerring registry in several courses of lectures, yet certain difficulties in manipulation forbade the expectation that it would become generally useful. By changing the form of the apparatus and perfecting the method, however, the electro-chemical registry became, it seems to me, a matter of comparative ease, enabling one to study phenomena depending on rapidity of vibration, with the precision attained by actual count. Whenever the vibration is of amplitude sufficient to open and close an electric circuit, an *autograph* of vibrating body will be the given in dots to be counted at leisure, and representing its rate within very narrow limits of error.

Fig. 1.



The accompanying cut represents the apparatus, arranged for the study of vibrating wires. The wire, *V*, a time measurer, *P*, and the register, *R*, are included in the same battery circuit. The wire is enabled to open and close the circuit by means of a fine steel needle, fixed to its middle point, beneath which is a cup of mercury, *c*, the surface of which is so nearly in contact with the point at rest that every vibration of the wire will immerse it in the liquid metal. With good mercury, the needle being a substance

Fig. 2.



not easily amalgamated and the surface of the mercury covered with alcohol to prevent oxidation, when once adjusted, little attention is needed afterward. Clean mercury may be substituted from time to time, and the needle may, if necessary, be cleaned by nitric acid.

For the measurement of time a pendulum is employed, which holds the circuit during the time of one beat. The arrangement for this purpose is represented at *P*. A slender fibre is fastened to the pendulum-rod, and thence reaches over to the upper end of a light bent lever, *L*. This lever moves freely, and is in conducting communication with a binding post, *n*. Beneath the lower end of the lever is a mercury cup, *m*, in metallic connection with another binding post. When the heavy pendulum is at rest, the weight of the lever keeps the fibre tense, and the mercury surface is so adjusted as to be exactly in contact with the point of the lever, a most vital adjustment, but one very easily made. It will be seen that the pendulum, when vibrating, must compel the lower end of the lever to be alternately in and out of the mercury during the exact time of one vibration.

The record of the vibrating wire is made in the register, *R*. A metallic point, *a*, presses upon a strip of chemically prepared paper, which runs over a platinum surface *b*. The pen and the platinum beneath are each provided with a binding post, by which it can be made a part of the circuit. The paper may be drawn through by the hand of the operator, the more swiftly as the vibrations are more rapid.

Let the circuit be continuously closed while the paper is in motion, and a continuous colored line will be traced by the pen, *a*; but let the wire vibrate, and electric pulses in unison with it will traverse the paper, leaving a series of dots instead. If the pendulum be at the same time in motion, the pulses can traverse the paper only while the lever, *L*, is in the mercury, and hence a *group* of dots on the paper will represent the vibrations of the wire in the unit of time.

Various electrolytes may be used in the preparation of the paper. A strong solution of potassic iodide, mixed with a small proportion of starch, is very sensitive and easily managed. A strip of paper, strong, thin, with a smooth surface—strips cut from a sheet of book-paper of good quality, not over thick, are excellent—is *moistened* with this mixture. If too wet the dots will run together, if too dry the electricity will not traverse the paper; the strip should be moistened uniformly, but not wet. The record is written by a platinum pen, *a*, in dots of a reddish-brown color. Let it be at once washed in a stream of water, and the expected blue color takes the place of the brown; the fluid is at the same time washed from the paper, leaving the record in a condition to be more permanent.

Or, saturate the paper with a mixture of potassic ferrocyanide and nitric acid, made as follows: To four parts of a saturated cold solution of ferrocyanide, add one part of dilute nitric acid—one ounce acid to five of water. If the color of the mixture is decidedly blue, too much acid has been used; if no hint of blue appears, too little. With this fluid the pen, *a*, should be of copper, and the record consists of brownish-red dots of cupric ferrocyanide. Let the paper be washed to remove the excess of fluid, and the record may be preserved. This substance is less sensitive than the iodide, and not so pleasant to work with, but the dots are more permanent. Records made a year ago can be counted still.

In experiments with tuning forks, the vibrations may open and close the circuit by means of a solid break-circuit represented in Fig. 2. From the prong of the fork a silk fibre stretches across to a slender vertical spring, *s*, fixed at the lower end, while its upper end rests against the end of a set screw, *t*. The two surfaces in contact are platinized. The spring is slightly bent, and the set screw, pressing against its upper end, holds it in constant tension, and thus forbids it vibrating, except in unison with the fork. Every vibration of the prong is transmitted by the fibre, and compels the spring away from contact with the screw. Putting this break-circuit in place of the monocord, represented in Fig. 1, between the pendulum, *P*, and the register, *R*, the vibrations of the fork record themselves upon the moving paper.

Noticing that the accuracy of Koenig's tuning forks is questioned by Mr. Ellis (*Nature*, xvi. p. 85), I fancied that the testimony of this method would not be without interest. Seizing the earliest opportunity, therefore, I submitted the *Ut₃* fork, bearing Koenig's monogram, to careful examination. The pendulum was accurately adjusted to hold the circuit one-half a second. The iodide-starch solution, with a battery of ten Bunsen's immersion cells, was used. Fifteen perfectly distinct and easily counted records were taken. Every one of these autographs was found to consist of 128 dots, representing 128 complete vibrations per half second, 256 per second, or 512 according to the French notation.

But the instrument cannot record fractions of a vibration; on the other hand, no complete vibration can escape its registry. Evidently when the rate of the fork is any whole number of complete vibrations, that number must be recorded. Exactly 128 vibrations, for example, would yield invariably 128 dots; 129 would yield 129 dots invariably; but 128 and a fraction vibrations would yield 128 dots in some experiments, and 129 in others, and in this case the mean experiments would be a close approximation to the exact value of the fraction.

Now in the experiments with the *Ut₃* fork the autograph *invariably* consisted of 128 dots, declaring the rate of the fork to be 256 complete vibrations per second, testifying to the exactness of Koenig's stamp.

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* Proceedings of the Albany Institute, Vol. I, p. 80. Journal of the Franklin Institute Vol. lvii, p 41.

† Journal of the Franklin Institute, Vol. lvii, "Annual of Scientific Discovery," 1870, p. 162.

‡ Cooley's "Text-Book of Natural Philosophy," p. 299.

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ON ELECTRICITY IN DYEING.

March 78

By M. L'Abbe Vassart.

In dyeworks, the electric light is likely to render particular services as a light enabling the dyer by night, or in cloudy weather, to continue work which requires an exact appreciation of shades.

In the first attempts made at Roubaix, in the dyeworks of MM. Motte and Meillassoux, the same gradations of color and varieties of tone were recognized as in the daylight. All the dyers present agreed that matching off shades was perfectly practicable. A machine was fitted up at the works of Hannart Brothers, at Wasquehal, and has been in use every evening during the last winter.

It has been found practicable to dye by the electric light, greens, blues, and pearl grays, the quantity of the latter shade turned out having greatly increased since the introduction of the Gramme machine.

Another 100-burner Gramme machine has been fitted up at M. Gaydet's, at Roubaix, and has been in use most of the winter. It has been found that the electric light enables them to dye all shades to pattern except grays obtained by different methods, that is, when the red, the blue, and the yellow serving to produce them are not of the same nature.

But the electro-dynamic machine, so particularly advantageous in dyeing as a substitute for daylight, may also be capable of other applications in this branch of industry.

If we seek to explain the phenomena which occur in the bleaching of vegetable fibers, we cannot fail to perceive that at the foundation of all these procedures, however different in appearance, such as exposure on grass, bleaching with chlorine, with the hypochlorites, the manganates and permanganates, bichrome, and sulphuric acid, etc., there is one action in common, that of ozone.

Further, a great number of the artificial coloring matters are obtained by the oxidation of aniline, or its derivatives, by means of bichrome, chlorate of potash, arsenic acid, etc., and aniline black has been already produced directly by passing an electric current through the solution of a salt of aniline.

As the dynamo-electric machines have become economical sources of electricity, could they not produce ozone, or active oxygen, under conditions available in the arts?

Would it not be possible to regulate its action for bleaching fibers, and to take advantage of its remarkable properties in the preparation of some of these colors?—*Soc. Industr. du Nord de la France.*

Last year M. Grandeau made some interesting experiments with regard to the influence of electricity of the atmosphere on the nutrition of plants. He has more recently shown that atmospheric electricity affects very distinctly the the phenomena of flowering and fructification. He worked with tobacco plants. The influence revealed itself in retardation of the flowering, and in the number of flowers formed about 50 per cent. more in the one case than in the other; also in the increase of the number of capsules of the fruit, and of the weight of the seed. Jan 77

sunk from 18,100 tons in 18..

Torpedo Telegraph Posts.—This term is applied to certain posts in Australia, which, we are informed, are "by an arrangement of supplementary currents" caused to communicate a severe shock to any one meddling with them. The unexpected punishment, attributed to supernatural power, which fell upon certain natives in the vicinity of McDonald Peak, when they attempted to cut the wire, had the effect of deterring other tribes from in any way damaging the Australian trans-continental line, the total length of which is about 2100 miles. Aug 23.78

TORPEDO DEFENCE.

.. 1 represents an imaginary harbor defended by torpe- .., the presumed width of the navigable channel being about one mile, and the mouth of the harbor itself, say, two miles. The line of torpedoes marked 1, 2, 3, are placed across the entrance at a distance of from two to three miles from the town; each line consists of seven torpedoes, each of which should contain a charge of 500 lb. of compressed gun-cotton, and be placed so as to converge on one signalling or converging station; of course this station only becomes a necessity when it is desired that the torpedoes in question be so arranged as to allow of their being exploded either by contact or from the shore by observation. The firing and converging stations are connected by a four-core electric cable, one conductor for each line of charges, and the other for telegraphing. The telescopic arcs A A A, shown at the converging station, are each provided with a single fixed telescope which commands one of the lines of mines; while those shown at the firing station, and marked B B B, are provided with telescopes that are capable of being provided with telescopes that are capable of being revolved on their axis by means of a wheel and pinion arrangement, operated by a small mill-headed screw; each of these arcs are provided with seven sighting pieces—as described in a previous article—one sighting piece to each torpedo, fixed in a position corresponding to the position of the said torpedo as indicated by the telescope during the operation of mooring, and are connected so that one arc commands one particular line, and is in connexion with that line only; each arc at the firing station marked respectively 1, 2, and 3, being connected electrically with the arc at the converging station bearing that particular number, so as to include each individual line in a separate circuit, and thereby render firing by observation practicable. Each arc, both at the firing and converging station, is provided with keys for closing at will any particular circuit.

A signalling and shutter apparatus c with seven indicators—also described in a previous article—is attached to each telescopic arc at the firing station, and in connexion with the same individual line of torpedoes.

One battery of a hundred cells—modified Leclanché—is placed at the firing station, and is connected one pole to earth and the other to the firing terminal on the shutter and signalling and apparatus; but although attached to the apparatus it has no connection with the torpedo wires until one of the indicators fall. The dropping of the indicator arm may be effected either by the simultaneous action of the observers at the two stations, or by a vessel striking the circuit-closer in connexion with and floating above the torpedo. A signalling battery of two cells is also connected with the shutter and signalling apparatus, the mechanism of which is so arranged as to permit of the current charging all the conductors connected with it, yet no perceptible part must pass to earth without the circuit-closer being struck, when the full force of the current would instantly circulate, and trip the indicator arm belonging to the circuit closer struck, thereby switching in the firing battery current, and so explode the annexed charge. This system of firing may be in operation both night and day, but firing by observation can only be carried out in clear weather, when the approaching vessel could be clearly discernible with the telescopes of the firing and converging stations. Supposing an enemy's vessel were seen advancing in the line of torpedoes, but still outside the furthest line; the moment she covers one of the torpedoes, as observed through the telescope at the firing station, which must be moved rapidly from one to the other of the fixed sights that indicate the position of several of the mines, as often as the vessel changes its course, closing at the same time the key corresponding to the sight on which the telescope rests, and keeping them closed so long as she

451

remains covering them. But the observer at the converging station would wait until the vessel came on his line, closing his key only when she was crossing; and if she did not cover any torpedo in passing, the operator at the firing station watching would have no key down, and consequently no torpedo would be fired. As in this case she would be passing through the space between two torpedoes, and advancing on the second line, the key of the second line would then be closed at the converging station, the effect of which would be the completion of the electrical circuit, providing the operator at the firing station had compressed the key corresponding to one of the charges situated in the second line, thereby tripping the indicator belonging to the torpedo named, switching in the firing battery, and so exploding the mine, the two observers simply acting the part of the circuit-closer when struck. Should the vessel, however, strike the circuit-closer before both keys are closed the explosion would be brought about independent of the operators, so that both systems of firing are in operation at one and the same time, each entirely independent of the other.

The channel is also guarded by a system of electro-contact torpedoes placed a mile or so in advance of the outer line of large torpedoes. In our diagram each of the two lines of torpedoes is shown connected with the firing station by means of two single-core cables, but it is also proposed to employ a four-cored cable running from the firing station, and terminating in a junction box, adjacent to the intended moorings, from which the branch cables, to which are connected the several short cables leading the charges, would extend; the remaining two cores being intended, one as a reserve in case it should be required at any time to throw out another line of torpedoes, and the other for establishing telegraphic communication between guard boats and the firing station during the night and in foggy weather. One great advantage in employing a vanguard of electro-contact torpedoes is that they save the necessity of expending so large a charge as 500 lb. of gun-cotton against minor vessels for the destruction of which a lesser charge would suffice.

A series of mechanical torpedoes are also shown guarding the flank of the electrical system, to which for this purpose they form valuable adjuncts. In the navigable channel, however, no torpedoes are employed save what are in connection with the shore, as it is absolutely imperative that they should be capable of being rendered safe for the passage of friendly vessels, and this can obviously only be effected by running the cables to the firing station and connecting or disconecting them at will with the firing battery.

Referring to the diagram under discussion, Y and Z are two strongly fortified positions from which the electrical torpedoes are controlled. At the converging station Z are three fixed telescopes A A A, one to each line of mines, and a Morse telegraphing instrument for sending and receiving messages to and from the firing station; while at the firing station Y are three telescopic firing arcs B B B, each provided with seven sights corresponding to the seven charges of one particular line, one arc, as at the converging station, serving for each line; three shutter signalling and firing apparatus C C C connected with the firing arcs and with the cablee in the manner shown on the diagram, four or seven strand copper wire insulated to five-sixteenths of an inch with india-rubber being usually employed for this purpose; a battery D of a hundred modified Leclanché cells; two cells E, Daniell's or medium size, ordinary Leclanché for signalling, one well-appointed "test table" with the necessary battery, five firing keys F F F F F, one test battery with galvanometer complete, one ordinary galvanometer, one frictional-electrical machine, one magnetic exploder, one magneto-electrical machine, one box of selected tools, two signalling lamps (Walker's patent), for each of which must be provided the following list of articles:

2 retorts.	1 oil lamp (reading).
1 wash bottle.	3 yards india-rubber tubing.
1 gas bag.	1 wrench.
1 pressure bag.	1 stove.
1 pair of lamp scissors.	1 case of potash.
1 box of lime pencils.	1 case of spirits.

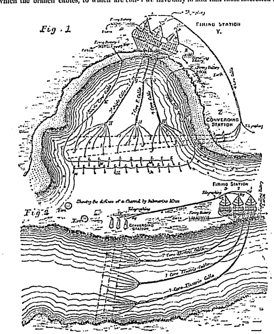
One portable tool chest containing the necessary tools for adjusting circuit-closers, etc., including one small plumber's stove, one soldering iron, one bottle of spirits of salts, a few sticks of solder, one small box of india-rubber solution, two rolls of india-rubber tape, one pair of pliers, and one hand knife, and, say, half a dozen military telegraph sounders. Referring again to our illustration, G G G are seven-core multiple cables, H H H are multiple junction boxes, I I I are single-core cables, J J J torpedoes, K K are also single-core cables, L L L T junction boxes, M M M electro-contact torpedoes, and N N N are mechanical torpedoes. The single-core cables K K may be connected to the large firing battery or to independent batteries according as the operator in charge may deem best. We doubt not but it will be more convenient to substitute for the two cables K K, one four-core cable and junction box, as before alluded to, especially if they are to be placed at any considerable distance from the firing station.

Fig. 2 illustrates the defence of a navigable channel, heavy ground charges only being employed, arranged to be fired either by contact or by observation; the general arrangement is precisely the same as in the diagram just described, and need not therefore be recapitulated.

The instruments, etc., represented in the diagrams have been drawn to an exaggerated scale for the purpose of rendering the explanation more lucid.

In concluding this article on moored or fixed torpedoes, we have only to add that those interested in the torpedo question will now be in a position to judge of the possible efficiency of the approved appliances of to-day, and to see how needless are the fears expressed by sensational alarmists as to the presumable fate of our ironclad fleet in the maritime wars of the future. We do not, be it understood, wish to deteriorate in any degree from the merits of torpedo defence, or to underrate their value as obstructive agents; indeed we can unhesitatingly assert our belief that even should an enemy succeed in clearing a passage through them without any considerable loss to themselves—and we should certainly dissemble if we pretended to think that anything but the grossest carelessness on the part of the invaders could lose them a single vessel—the delay necessarily caused would more than compensate for the outlay expended on them.

There are doubtless many ways by which an intelligent commander could force a passage through even the most formidable lines of these submarine obstructions, without any very considerable danger to his ship. It will be sufficient, however, for our present purpose to call attention to three methods, which are as follows: First, the sending down of divers to search for and sever the connecting cables; secondly, the sending out of small craft, under cover of darkness, to grapple for and raise the torpedoes bodily from their anchorage; and, thirdly, the projecting of a guard of Bessemer steel wire, or other material, some 40 ft. or 50 ft. in front of the vessel's prow, supporting it, if necessary, with buoys; by this means the circuit-closer would be struck, the circuit closed, and the mine exploded, before the vessel was near enough to be anything more than severely shaken.—*Engineering.*



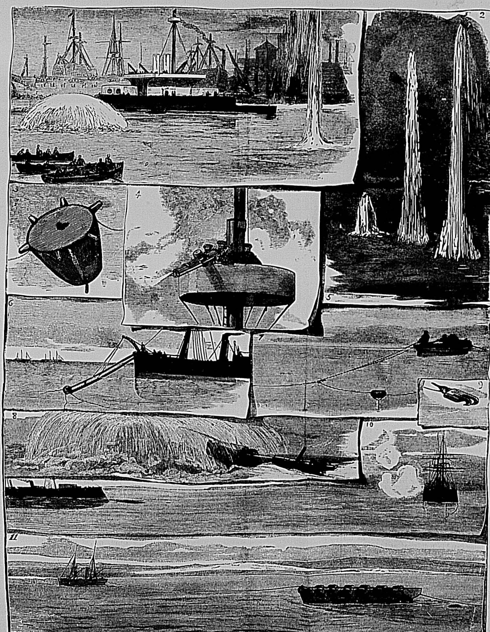
TORPEDO DEFENCE.

52

RECENT TORPEDO EXPERIMENTS IN ENGLAND.

In England at the present moment the most active preparations for a prospective war with Russia are going on, and so far as naval operations are concerned the torpedo system is likely to be brought into more extensive use than ever before.

Recently a visit was made to Portsmouth Dockyard by the Speaker and some hundred other members of Parliament, entirely unofficial, the visitors having been invited by Lord Charles Beresford, M.P., Commander of H. M. S. Thunderer. Our cut and these particulars are from the London *Graphic*. Traveling from Victoria Station by special train, the party were received at Watering Island Jetty by Admiral Foley, Chief Constructor Robinson, and other officials. After crossing the dockyard in some open railway trucks drawn by a dockyard locomotive, they went successively on board the Inflexible, the Dreadnought, and the Thunderer, all turret ships of the latest type. The first-named of these vessels, about the stability of which there has been so much controversy, will probably be completed within the year. Her tonnage is 11,406, her horse-power 8,000, and she will throw about twice the weight of metal of any other English ship. The Dreadnought is much nearer to completion than the Inflexible, and, as her turrets are finished and armed, the visitors had an opportunity of seeing how easily heavy guns can be worked by machinery. On the quay alongside the Thunderer 650 lads from the St. Vincent training ship and 300 seamen gunners from the Excellent were drawn up for inspection. The visitors then went on board the Iris, a steel clipper, and the Glatton, a ship of the enlarged monitor class, after which the Speaker and about a score of guests were led off to the residence of Admiral Foley to luncheon, while the remainder of the company was received on board the Thunderer by Lord Charles Beresford and Captain Wilson, his commanding officer. After luncheon the Thunderer was eagerly inspected, and visitors ascended the flying deck and breastwork deck to witness the evolutions of the crew, who, under the orders of Captain Wilson and Lord Charles Beresford, evinced remarkable smartness in clearing the impediments, such as stanchions, catheads, boats, davits, etc., removing the glass illuminators from the deck and substituting armor coverings, and beating to quarters in readiness for an engagement, all being completed in three or four minutes. A Gatling gun was hoisted in the tops, whence it would sweep an enemy's decks. The turrets were revolved and the guns worked, all being done in a manner that elicited the warm encomiums of the visitors. Attention was next directed to the Vesuvius torpedo vessel, Captain Morgan, lying just astern, beside which was a dingy, from which a Whitehead torpedo was dispatched in the direction of a boat some distance out in the basin. Next, a launch, with no one on board, and steered by electricity, left the Vesuvius, and dropped two counter-mines, which were exploded from the Vesuvius. Illustration was also given of the method of clearing channels of torpedoes and other obstructions. On leaving the Thunderer the visitors went in steam launches to the Vernon torpedo school-ship, Captain W. Arthur, where a lecture on torpedo warfare was delivered by Commander Wilson, experiments were made to show the effect of gun-cotton in various states, and a boat was sent from the ship with spar torpedoes, which were fired by electricity.



RECENT TORPEDO EXPERIMENTS IN ENGLAND.

1. Watching Experiments from H. M. S. Thunderer.—2. Mine Elploded, a Cask thrown to a height of 200 feet.—3. A Russian Torpedo captured by the Turks.—4. Gatling Gun on the Mast of H. M. S. Thunderer.—5. Exploding Sunken Mines.—6. Torpedo Fender Catching the Enemy's Mine.—7. "Creeping:" Fishing up the Electric Wire of Enemy's Torpedoes to blow them up. "I've got a bite; pull away, my lads."—8. Spar Torpedo Practice: a Ducking at Close Quarters.—9. Grappler Loaded for destroying Torpedo Connections.—10. H. M. S. Vesuvius discharging a Whitehead Torpedo.—11. Boat Steered by Electric Cables dropping Torpedoes to clear the Waterway of Enemy's Sunken Mines.

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The horse was running at his freedom in the ring, and charged with a wild fury at every person who ap-
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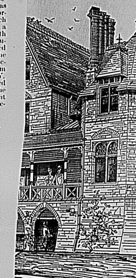

...ion of the Self-Coiling Venetian Shutters.

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During this process Cognac fought with his mouth and forefeet as best he could, but he did not show any disposition to use his hind feet. The Professor then took the reins, one in each hand; he kept the thumb of his left hand constantly on the button of the strap; his right thumb he held over the other button, but not in contact with it, except when he wanted to give the horse a dose of lightning. When all was ready, he dropped his right thumb on the positive button, giving at first but a light charge. Cognac started as if he had been struck by a bullet. As the shocks were increased in strength the animal plunged and reared as much as his strong fastenings would permit. At length the side rope was loosened, and he had the full circuit of the ring. Tapp let on the electric fluid, and Cognac reared high in the air, endeavoring to plunge at his tormentor, but the Professor kept his eye on him, and by the slightest movement of his thumb created a wall which the horse could not cross.

It was a magnificent sight—the horse, covered with foam, fretting, chafing and panting, reared and attempted to throw himself forward upon the Professor, but the brute strength and fierce... paled before the behest of science, and Cognac was powerless to do harm. The experiments continued about twenty minutes, when the Professor concluded to test the docility of the animal. He said that the principal thing to be overcome was Cognac's disposition to bite. Tapp approached him, stroked him ... the body, then on the head, and took hold of his ...ose. The horse having become convinced that he ...d found his master, permitted this, and even showe... ...e same docility toward the Professor's assistant.

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RECENT TORPEDO EXPERIM

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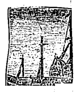

W. Elliott, of Chowbent, near Manchester, and of which Mr. Macdermott, of London, the patentee of the coal perforator, is the agent. It is a most effective instrument, and is known as the "Parallel Multiple Wedge Expander," and not only brings the coal down after it has been holed, but without the latter process, by forcing it toward a loose end. The wedge is made of the best quality of steel, while its power of expansion is almost unlimited, and as the work can be carried on without any break whatever, it brings the coal down in less time than is required in blasting. A short time since some interesting experiments were made with the wedge at the extensive collieries of Messrs. Wood & Son, Scot Lanes, Blackrod, and West Houghton, in the Wigan district, in the presence of a considerable number of practical men, who were much struck with the simplicity of the invention, its lightness, and moderate cost. Mr. Elliott, the patentee, conducted the experiments, along with whom was Mr. John Unsworth, the manager of Messrs. Wood & Son's pits. The first trial was made in what is known as the "Yard Mine," a seam of coal about 30 ins. in thickness, worked on the longwall principle. The place selected was where the roof was of a rough scaly nature, so that even powder could scarcely operate successfully on it. The coal was first holed or undercut to a depth of 3 ft. 6 ins. and 8 yards in length, and then a hole for the insertion of the wedge was drilled by Macdermott's patent "rock perforator" in a very short time near to the roof. The point of the wedge was then inserted in the tool, and two other parts were also put in and driven home alternately by a sledge hammer. The result was more than any of those present anticipated, for the coal came down very clean, and in a very large quantity, in marketable condition. A second wedge was at hand as a reserve in the event of the first one turning out to be unequal to the work required, but which it was stated was very seldom the case. The next trial was on the roof of the same pit, which is generally brought down with some difficulty. But here the wedge did what was required of it most effectually, for it brought down a vast quantity of stuff in a comparatively short time, much greater, indeed, than could have been obtained by blasting in the ordinary way. The apparatus was then taken to the well-known Arley seam, where operations were commenced in the "wide-work," the bed of coal being ... ness. The seam was holed ... yards in length ...

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The parts A, B, C,

The mode of working is as follows:—The portions of the wedge marke

and fully bore out all that the patentee had said could be effected by his invention. A few days afterward a third trial was made in the Arley seam at another pit belonging to the Messrs. Wood, where the coal was worked on the "pillar and stall" system. The wedge was put in operation in a pair of "down brows," and driven on the face of the coal. These places were 12 ft. wide, and the coal having been holed and cut on one side the wedge was put in on the opposite side of the "cutting," about 1 ft. from the roof and about the same distance from the side. The effect was very ...

Taming Malicious Horses by Electricity.

There is now in California a mottled gray thoroughbred stallion called Cognac, born in Normandy, France, of a most symmetrical and powerful mold. At his native home he was docile, and was worked at the plow. He was imported to the United States two years ago, being then five years old, and became the property of a man in Illinois. One day his owner put a halter on him, the style of which he took as a mortal affront, and he became refractory. All attempts to subdue him were in vain. He was so terribly beaten about the the head that for some weeks he was but little better than a dead horse. He recovered, and has ever since exhibited a deadly hostility toward man, and was therefore called the "man-eating horse," though perfectly harmless to animals of his own species.

The way of taming horses by electricity, of which we have before spoken, is now practiced in San Francisco by Prof. Tapp, and this gentleman undertook to tame Cognac in this way, and did it at a public exhibition of his method. Some two or three hundred spectators assembled to see how the animal would conduct himself under the electrifying effects of a galvanic battery. The novelty of the experiment and the fame of the tamer and of the horse attracted the spectators. The ring inclosure was about seven feet high, and the seats for spectators were elevated still over this, so that they were presumably out of the reach of Cognac. Notwithstanding this, he came very near making ... some citizen who was unwarily leaning over the temporary rail that surmounted the ring inclosure.

The horse was running at his freedom in the ring, and charged with a wild fury at every person who approached the railing, although they were above his head. He seized the gentleman in question by the coat lappel, taking also his vest, shirt, and undershirt in his teeth, and, being an immensely powerful animal, it was with the greatest difficulty that the man was kept from being dragged into the ring and killed. As it was, the horse got away with a large piece of broadcloth coat and a hearty mouthful of vest, shirt, and red flannel under-garment, and the man's breast was discolored as if he had received a very heavy blow. This was before the audience had assembled or the horse-tamer had come in.

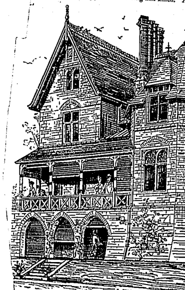

Fig. 1.—Application of the Self-Coiling Venetian Shutters.

At two o'clock the work of securing Cognac began, and by a little maneuvring two ropes were made fast to the headstall he wore. This was accomplished by the Professor and an assistant, who stood on the outside of the entrance door, which was opened sufficiently to admit a man's arm; Cognac keeping his nose thrust close to the opening in the apparent hope of getting a nip at somebody. One of the ropes was then passed along the corridor in front of the seats and made fast to an upright post. Then the trainer entered the ring and secured the other rope to the tent-pole. Thus Cognac found himself unable to follow the bent of his inclination any further.

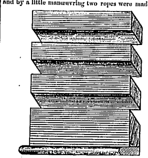

Fig. 2.—Section of Blind.

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Photo-Electricity of Fluorspar.

26/2/78

M. Hankel, at the Saxon Academy of Sciences, recently described the results of some experiments he had made on the electric action of light on crystals of fluorspar. After exposure to sunlight, the center of a face of the crystal is found to have a marked negative potential, while the potential of the sides of the face is much less strong and sometimes positive. On sifting the sunlight through colored glasses, a layer of water, or a solution of alum or sulphate of quinine, it was found that the chemical rays are the most active. A too strong concentration of light on the face of the crystal destroyed its sensibility to the further action of light. An exposure of the crystal to a temperature of 95° produced the lowest positive potentials at all points of the crystal while it was cooling.

[31961.]—**Electricity and Rheumatism.**—To "SIGMA."—I was not treated by electricity. In some cases I should say that electricity might be usefully employed, though my faith in its action in rheumatism is limited. I may say I have not been treated at all, but have been my own doctor, except during the acute stage, in which, of course, I could do nothing, and required medical attendance to keep watch against the disease attacking the heart. For some months I endured much pain because, besides every joint in the body being affected, the stomach was constantly attacked, and there was constant pain round about the heart apparently, but really, no doubt, in the muscles among the ribs. Happily, I have got rid of all these, and the pains in the joints seem to slowly diminish, and so give some hope of driving the enemy out in time. The treatment I have adopted is, in essence, that sketched in my letters referred to, using little medicine except when its use was indicated, and that little being—podophyllin, when the liver seemed sluggish; carbonate of potash more frequently, with small doses of iodide of potassium when pains sharpened, and bromide when they took the form of persistent headache. Local pains I met with wet bandages and flannel wrappings, followed by douches of gradually colder water and rubbing with good Turkish towels. The main point, however, is careful management of the general health; as much exercise as possible within the limit of fatigue; as much open air as possible when the weather is fine; nutritious diet of the simplest character; daily washing and rubbing of the whole body, with frequent Turkish baths of a simple character, such as one can manage at home easily enough. In fact, every care should be taken to give the internal organs fair play, and to get the skin into wholesome active condition; avoiding chills carefully, and wearing flannel by day, and sleeping on, or rather in, a blanket by night. This latter I believe to be most important, and to do much towards checking or preventing the sciatica, which usually accompanies rheumatism. The most effective way I have found of applying all these has been at the seaside in warm weather, selecting a bracing tonic location, and bathing regularly, not in the cold damp boxes provided for the purpose, but at some open part where, after a few minutes in the water, and the following rub down, I could lie peacefully on the warm sand, and let the sun and air do their work in bringing the skin back to a more natural condition than our civilised clothing gets it into. This of course implies either a companion or a perfect familiarity with the water; the latter is almost essential for such a case; and, for my own part, till the weakness and pain of rheumatism warned me that I must not trust to my own powers, I was as much at ease in the sea as on the land, and have, in fact, gone to sleep floating on a warm calm day. Possibly this may make sea bathing more useful to me than to others, who would not have the same sense of enjoyment in it.—SIGMA.

[32447.]—**Electrical Indicator.** 25 I think, with J. Jones, that electrical means are too complicated for "An Old Reader's" purpose. He says he wants it done by electricity, because laying the mile of pipe is out of the question. But if he will follow me I will try and show that the sounding apparatus which he mentions, and calls the "patent sounder," will act perfectly over a mile, or over two miles if necessary. The "patent sounder" is for the purpose of showing exactly how much a body of water is rising or falling—thus, water rising or falling in a cistern, or in a ship's hold, or in a tidal river—such as our friend wants to measure—and its action is simply this. If it is wanted to know how much water there is in a ship's hold, a metal box, about 6in. square, is secured to the bottom of the hold, and a hole having been made in the bottom of the box, so that the water can get into it, this part of the apparatus is ready; the box is, of course, full of air. And should the ship spring a leak, or, through any other cause, should water get into the hold, the water as it increased in depth, would enter through the hole into the box and compress the air in it, and the higher the water rose in the hold the more the air would be compressed. What the "patent sounder" does is to show on an indicator the amount of this compression, and this is done by having a small pipe from the box to the indicator, which is so marked that you see clearly what depth the water is in the hold. Now, if I understand "An Old Reader's" query, he wants nothing more than a "patent sounder," (which he appears to understand), rigged up with a mile of pipe from the box at the river to the indicator at the office. The pipe will have to be the smallest he can procure, and the box at the river as large as possible. Thus, if he uses the pipe that is sold for pneumatic bells, which is ⅛in. inside diameter, or ¼in. iron pipe, the box would have to be at least 12in. square. The best size, I believe, would be about 24 × 24 × 6in. deep, the object being always to have much more air space in the box than in the whole of the pipe. If he goes in for this plan, and wants economy, buy the pipe from the maker, and not from dealer, and a mile of this size won't amount to much money. There are two or three makers of the pneumatic tube in London. The indicator will have to be bought from the patentees. I have read "Draughtsman's" letter, and think his plan very ingenious, and will look out to see what our electrical friends say about it.—PNEUMATIC.

Henry County, Illinois, will build a new Court-

MOTEURS ET GÉNÉRATEURS

DE L'EMPLOI DE L'ÉLECTRICITÉ ET DE L'INFLUENCE DU ZINC DANS LES CHAUDIÈRES A VAPEUR POUR EMPÊCHER LES INCRUSTATIONS

Par M. Ferd. FISCHER, à Hanovre.

Déjà, en 1840, on avait cru observer des manifestations d'électricité dans les chaudières à vapeur. Armstrong, Faraday, Pattison, Schafhaull s'occupèrent de cette question. Les uns pensaient que l'évaporation produisait de grandes quantités d'électricité, d'autres attribuaient cette production à la chaleur devenant libre lorsque la vapeur se détend; d'autres enfin admettaient que l'électricité joue un rôle dans les explosions de chaudières.

Faraday montra que l'électricité est produite seulement lorsque la vapeur est chargée d'eau et par le frottement contre les parois.

Armstrong, Schäfer, Parry, Ramsbottom et quelques autres ingénieurs croyaient qu'il existait une relation entre le développement de l'électricité et la formation des incrustations, un certain nombre d'expériences furent faites à ce point de vue.

On pensait déjà en 1826 que le zinc, en contact avec le fer, empêchait, tant qu'il restait à l'état métallique, l'oxydation du fer. M. Fischer partageait cette opinion, ses expériences ont démontré que l'action du zinc était insignifiante.

M. Fischer n'a pas pu constater le plus faible courant électrique. Il décrit ses expériences de la manière suivante :

La question « le zinc a-t-il de l'influence sur la formation des incrustations dans les chaudières, et, s'il en a, quelle est la nature de son action? » ne peut être résolue que par l'expérience. Un industriel, M. Knovenagel, président de l'Association pour la surveillance des chaudières de Hanovre, a bien voulu me permettre d'installer une petite chaudière simple pour faire cette étude. Un morceau de tube de chaudière était fermé à une extrémité par une plaque qui portait la soupape de sûreté; le fond opposé portait le manomètre et un tube de verre, ce fond était fixé avec des boulons, le tout reposait sur un bâti en fer.

A travers le tube de verre, on introduisit un gros fil de fer dont une extrémité plongeait dans l'eau de la chaudière, et dont l'autre extrémité pouvait être mise en communication avec différents points de l'extérieur de la chaudière, que l'on remplissait d'eau jusqu'aux deux tiers environ et que l'on chauffait avec du gaz jusqu'à 2 kilogr. de pression, de manière à faire fortement souffler la soupape de sûreté.

La chaudière étant remplie soit d'eau distillée, soit de différentes dissolutions, je n'ai pu constater, avec un galvanomètre très-sensible, la moindre trace d'électricité.

On fixa alors, à l'extrémité du fil de fer qui plongeait dans la chaudière, un lingot de zinc pesant 90 grammes; ce lingot était placé de telle manière qu'il était en contact sur toute sa longueur avec le flanc de la chaudière. On remplissait alors la chaudière avec une dissolution saturée de gypse cristallisé, et on chauffa à la pression de 2 kilogr. L'extrémité extérieure du fil de fer était reliée à un fil de cuivre faisant deux fois le tour d'une boussole et dont l'extrémité opposée se reliait également à un fil de fer que l'on mettait à volonté en communication avec un point de l'extérieur de la chaudière. Cette disposition avait pour but d'éviter des courants thermiques possibles. Lorsque le circuit fut fermé, il s'établit bientôt un courant allant de l'extérieur de la chaudière au lingot de zinc, et l'aiguille magnétique fut déviée de 8 degrés. L'intérieur de la chaudière en contact avec le zinc était électrisé négativement, l'extérieur de la chaudière positivement. L'expérience dura quatre jours; chaque jour la chaudière était chauffée de quatre à six heures à 2 kilogr. de pression, l'eau évaporée était remplacée par la solution saturée de gypse. Le courant électrique observé au début diminua rapidement; le soir du quatrième jour on ne pouvait plus le constater qu'au moyen du multiplicateur. L'appareil étant disposé de la même manière, mais sans lingot de zinc, si l'on plaçait dans le circuit une batterie de six éléments Leclanché, la déviation de l'aiguille était de 25 degrés; cette batterie, appliquée à un appareil à décomposer l'eau, donnait en dix minutes 5,4 centimètres cubes d'hydrogène. Comme les courants électriques sont proportionnels aux tangentes des angles de déviation, le courant électrique produit au début aurait donné 1,64 centimètres cubes, soit $\frac{15}{100}$ milligrammes d'hydrogène, ce qui représente à peine 0,015 unités. Ce courant était donc faible même pendant les premières heures de l'expérience. Si l'on desserre les vis de pression qui assurent la communication entre le fil de fer et le fil de cuivre ou si le zinc n'est pas mis en communication avec l'extérieur de la chaudière par un circuit isolé, il y a sans doute encore des tensions électriques, on ne peut toutefois admettre que ces tensions soient les mêmes.

Lorsque l'on eut évaporé de la dissolution de gypse environ sept fois le contenu de la chaudière, on arrêta l'expérience et la chaudière fut ouverte. Le zinc avait perdu son éclat métallique, il était recouvert d'une couche mince de sulfate de chaux et d'oxyde de zinc, et aussi de sulfate de zinc basique ($4ZnO, SO^3$). La plaque de feu de la chaudière était recouverte d'une couche adhérente de sulfate de chaux de 2 millimètres d'épaisseur, le reste de la chaudière, baigné par l'eau, était recouvert d'une très-mince couche de sulfate de chaux. *L'intérieur de la chaudière, principalement dans la partie occupée par la vapeur, était oxydé.*

L'eau de la chaudière avait une réaction basique et ne contenait pas de traces de zinc, la boue qui se trouvait non adhérente dans la chaudière, en très-petite quantité, avait la composition suivante :

56

DE L'EMPLOI
DE L'ÉLECTRICITÉ ET DE L'INFLUENCE DU ZINC
DANS LES CHAUDIÈRES A VAPEUR POUR EMPÊCHER LES INCRUSTATIONS

Par M. Ferd. Fischer, à Hanovre.

(2e article[1].)

Si l'on fait bouillir dans une capsule de fer ouverte une dissolution de chlorure de calcium avec un lingot de zinc, un actif dégagement de gaz se produit. Pour étudier cette réaction, nous avons fait les expériences suivantes. Dans des fioles à réaction de 100 centimètres cubes de capacité, on plaçait seule une feuille de zinc pur de 13 centimètres de long, pesant 15 grammes et brisée en trois morceaux; dans d'autres fioles on plaçait des feuilles semblables, entourées d'un fil de fer décapé de 24 centimètres de long, pesant 1,8 gramme. Les fioles étaient alors remplies de dissolution bouillante et leur orifice fermé par des bouchons de caoutchouc, percés d'un orifice portant un tube de dégagement permettant de recueillir sur l'eau les gaz dégagés.

Essai nº 1. — Zinc et dissolution à 2 % de chlorure de calcium. Après vingt-quatre heures de repos, aucun changement. Si l'on chauffait pendant deux heures à 100°, quelques bulles de gaz se produisaient. Le zinc perdait son éclat métallique, le liquide se troublait un peu par suite de la production d'un précipité blanc.

Essai nº 2. — Même essai avec une solution à 2 % de chlorure de magnésium, mêmes résultats, quelques flocons de précipité.

Essai nº 3. — Zinc et fil de fer disposés de manière que les métaux ne soient pas en contact immédiat, dissolution de chlorure de magnésium. Après vingt-quatre heures de repos, quelques bulles de gaz s'étaient produites, le dépôt boueux qui s'était formé sur le zinc était coloré en jaune par l'oxyde de fer. Si l'on maintenait pendant deux heures la température entre 95 et 100 degrés, quelques bulles de gaz se produisaient au début, mais aussi bien sur le zinc que sur le fer. Les deux métaux perdaient rapidement leur éclat métallique, ce qui rendait impossible à apprécier toute action ultérieure. Le précipité qui se formait était assez coloré et se déposait en poussière. La solution était neutre et ne contenait pas de zinc.

Essai nº 4. — Même essai, les plaques de zinc entourées par le fil de fer bien serré. Au bout de vingt-quatre heures, 0,8 centimètre cube d'hydrogène s'était dégagé, le zinc était noyé dans un précipité volumineux que traversaient quelques bulles de gaz. On chauffait pendant deux heures entre 95 et 100°, et 12 centimètres cubes d'hydrogène se dégageaient. Le zinc perdait son éclat métallique, le fer devenait d'un noir gris et était presque complétement enveloppé d'une petite croûte blanche mince. Sur le zinc, aucun dépôt n'apparaissait. Le dégagement d'hydrogène diminuait rapidement, mais n'avait pas encore cessé au bout de vingt-quatre heures. La solution présentait une faible réaction alcaline et contenait des traces de zinc.

Essai nº 5. — Les plaques de zinc entourées par le fil de fer, solution de chlorure de calcium. Au bout de vingt-quatre heures, 1 centimètre cube d'hydrogène s'était dégagé. Le zinc était noyé dans un dépôt volumineux que traversaient quelques bulles de gaz. En chauffant entre 95 et 100°, on obtenait en deux heures et demie 24 centimètres cubes d'hydrogène. Le dégagement diminuait rapidement et était inappréciable à la fin de l'expérience. Zinc et fer perdaient leur éclat métallique; il se formait un précipité pulvérulent; la dissolution avait une réaction alcaline et ne contenait pas de zinc.

Essai nº 6. — Même expérience avec une dissolution saturée de gypse. Au bout de vingt-quatre heures, pas de changement. En deux heures de chauffage à 100°, on obtint 4,8 centimètres cubes d'hydrogène. Le zinc avait perdu son éclat métallique; le fer était en partie devenu gris noir. La dissolution était neutre et ne contenait pas de zinc.

Essai nº 7. — Même essai avec une solution à 5 % de sulfate de magnésie ($Mg.SO^4 7HO$). Au bout de vingt-quatre heures, quelques bulles de gaz seulement s'étaient produites; ces bulles adhéraient quelques-unes au zinc, mais la plupart au fer; un précipité assez volumineux se manifestait. Si l'on chauffait pendant deux heures de 95 à 100°, on constatait le dégagement de 5,8 centimètres cubes d'hydrogène. Dans ce cas encore, le dégagement de gaz diminuait jusqu'à devenir nul, bien que le zinc eût conservé sur une partie de sa surface l'aspect métallique. Le fer était recouvert entièrement d'un dépôt blanc. Ce dépôt ne se remarquait pas sur le zinc. La dissolution présentait une très-faible réaction alcaline et contenait un peu de zinc dissous.

1. Voir *Ann. Ind.* du 17 mars 1878, col. 349.

57

Essai nº 8. — Même expérience avec de l'eau distillée. Au bout de vingt-quatre heures, quelques bulles de gaz s'étaient montrées. Le zinc était enveloppé d'une couche mince d'un précipité jaunâtre de faible densité. Deux heures de chauffage à 100° donnaient 3,8 centimètres cubes d'hydrogène; un précipité ferrugineux et pulvérulent se déposait. Le zinc et le fer perdaient leur aspect métallique et le dégagement d'hydrogène cessait. L'eau ne contenait pas de zinc dissous.

Essai nº 9. — Pour étudier plus complétement l'action du fer sur la production de l'hydrogène, on se servit d'une lame de zinc de 6 centimètres de long enveloppée sur une longueur de 1 centimètre de fil de fer décapé, et on la plaça sous une cloche de verre graduée, dans une dissolution à 5 % de chlorure de calcium. Il se produisit sur le fer un dégagement d'hydrogène passablement actif, quelques bulles de gaz se formèrent aussi sur toute la longueur de la feuille de zinc. Après deux jours d'expérience, le dégagement du gaz cessait. Le zinc était devenu gris, le fer était resté complétement décapé. Il s'était formé un précipité assez abondant et volumineux, composé d'hydrate d'oxyde de zinc, d'oxychlorure de zinc et d'un peu de carbonate de chaux, la solution présentait une réaction alcaline.

Ces expériences démontrent suffisamment la solidité de l'hypothèse de Seidler, que des courants électriques passent constamment entre le zinc et le fer et décomposent les dissolutions salines, de sorte que par exemple dans l'eau gypseuse le calcium se précipite sur le fer et le radical acide SO^4 sur le zinc. En conséquence, chaque molécule de calcium décomposera immédiatement deux molécules d'eau en formant de l'hydrate de chaux et dégageant de l'hydrogène.

L'acide sulfurique se combinera au zinc et donnera du sulfate de zinc (Zn,SO_4). Ces deux composés en présence l'un de l'autre se transformeront instantanément en sulfate de chaux et en hydrate d'oxyde de zinc. Le gypse se trouve donc reconstitué; une partie se déposera sous forme de croûtes, et une très-faible partie seulement se déposera en boue avec l'hydrate d'oxyde de zinc. De même, suivant Commaille, avec des eaux contenant du sulfate de magnésie, il se reformera du sulfate de magnésie accompagné d'un précipité pulvérulent. Quand on aura affaire à des chlorures ou à des carbonates, des transformations analogues auront lieu; on ne voit donc pas bien comment la formation des incrustations pourrait être empêchée. Dans les expériences que nous avons citées, le zinc, bien qu'il soit oxydé, a cependant conservé sa forme primitive, il ne peut donc exister en dissolution dans l'eau ou précipité dans les boues qu'en très-faible quantité. En outre, dans l'électrolyse d'un mélange de dissolutions salines par un courant aussi faible que celui qui se développe dans les circonstances dans lesquelles nous nous trouvons, il n'y a jamais qu'un sel décomposé, et cette décomposition a lieu dans l'ordre suivant lequel les métaux se précipitent les uns les autres. Ainsi le zinc d'abord, le magnésium et le calcium ensuite, devraient se précipiter avant les combinaisons alcalines. Il n'y a donc pas lieu, dans le cas qui nous occupe, de prévoir une décomposition des sels de chaux et de magnésie.

Dans les expériences que nous avons citées, 15 grammes de zinc en contact avec le fer à la température ordinaire ne donnent, dans une solution de chlorure de magnésium ou de chlorure de calcium, pas même 1 milligramme d'hydrogène; à 100° pendant deux heures pas plus de 2 milligrammes; dans les sulfates de magnésie ou de chaux à peine 0,5 milligramme; dans l'eau distillée 0,3 milligramme d'hydrogène. Le zinc est transformé en oxychlorure insoluble, en sulfate basique et en hydrate d'oxyde de zinc qui enveloppent le métal; une partie des sels de chaux et de magnésie est également transformée en combinaisons basiques, ou séparée à l'état d'hydrates. Le contact des métaux se trouve ainsi interrompu. De plus, l'hydrogène formé empêche le passage du courant. La polarisation diminue aussi beaucoup quand la température s'élève, d'autres actions diminuent également la tension électrique. Toutes ces raisons expliquent suffisamment la rapide diminution du courant.

Dans les chaudières à vapeur, bien qu'elles ne présentent jamais une surface métallique propre, il se produit aussi au début un léger dégagement de gaz; on peut admettre que ce dégagement et la production simultanée de précipités insolubles troublent la formation des incrustations, surtout si l'on admet l'exactitude de l'hypothèse de Scheibler[1]. Mais au bout de peu de temps, cette formation d'hydrogène à la surface du fer cesse, et le zinc est de plus en plus rongé par l'action des dissolutions salines et de l'oxygène contenu dans l'eau d'alimentation, s'il n'est pas protégé contre cette attaque par les dépôts eux-mêmes.

Nous en concluons que « *le zinc ne peut prévenir les incrustations que dans des cas très-particuliers, et que c'est à peine s'il mérite d'être préféré aux agents qui opèrent mécaniquement.*

Field et d'autres ingénieurs avec lui proposent de placer la chaudière sur le passage d'un courant produit par une pile extérieure. Ce procédé ne paraît guère pratique; en effet, d'après les règles de Faraday sur l'action électrolithique, si les éléments de la pile sont placés de manière que le courant les traverse tous, chacun de ces éléments consommera, pour un équivalent d'une combinaison décomposée, un équivalent de zinc, d'acide sulfurique, d'acide nitrique, etc. Si nous négligeons les pertes notables dues à la résistance du circuit, nous voyons qu'en employant quatre éléments de Bunsen, par exemple, il faudra, pour produire 1 kilogramme d'hydrogène dans la

1. Scheibler pense que ce ne sont pas les parties métalliques polies, mais bien les parois rouillées et rugueuses des chaudières qui permettent la cristallisation et l'adhérence des incrustations. Cette supposition n'est pas confirmée par la pratique; on sait que l'on trouve des incrustations sur les parties les plus polies et les moins oxydées, comme les tubes de laiton, les plaques d'acier, les robinets, les siéges de soupapes, etc.

58
58

Iron Chip Removed from the Eye by a Magnet.

At a recent meeting of the Clinical Society of London, Mr. McHardy read notes of a case of removal of a chip of iron from the crystalline lens by means of a powerful magnet. The patient, thirty-one years of age, when at work, was struck in the eye by a fragment of steel from the hammer he was using. When seen, twenty-four hours after, there was evidence of commencing iritis; there was nothing in the vitreous; the eye was less painful than on the night of the accident; its tension normal. Atropine drops were prescribed. The next day there was no pain, and less congestion of the eye; the pupil was well dilated, and allowed of detection of a sharply defined opacity on the interior surface of the lens in a downward-inward direction from the center, the peripheral end being nearer to the margin of the dilated pupil. The cornea was almost normal. The atropine was continued, and absolute rest enjoined. The removal of the chip appeared to be imperative lest it should gravitate downward; at the same time Mr. McHardy was unwilling to remove the lens, and he also thought if it were injured by the forceps it would not be easy to tell if any subsequent opacity of the lens were due to the original injury or to the operation. He therefore had a magnetic spatula constructed by Messrs. Weiss, intending to use it in connection with an electro-magnet. On Mr. B. Carter's suggestion the procedure was modified by employing a powerful bar magnet connected with two Grove's cells. Gradually approaching it to the front of the cornea, when it was four inches away, the chip sprang from the lens to the inner surface of the cornea, and fell into the anterior chamber, whence it was removed, together with a small portion of iris. A patch of opacity exactly corresponding in size to the chip was left on the lens. Subsequently a cataract formed, and the injured lens became absorbed. The patient's vision, aided by a lens of twelve dioptrics, is normal for distant objects. Mr. McHardy acknowledged his indebtedness to Mr. Ladd and Dr. Tibbits for assistance and suggestions, and he referred to a paper by Dr. McKeown, in the *Dublin Journal of Medical Science* for September, 1876, where three or four cases are recorded of the use of magnets in the removal of fragments of steel in the eye.

Mr. Brudenell Carter, having seen the case, stated that the position of the fragment was such that any other attempt at its removal would have jeopardized the eye. If nothing had been done, the fragment would probably have fallen below the iris, and would have set up destructive inflammation; and any attempt at its removal by forceps would certainly have injured the lens. By withdrawing it from its bed and bringing it to the front of the iris, the magnet had obviated these difficulties.

Electric Bell for Incubators.—J. J. H. 4/19/79 and others ask if an electric bell arrangement can be employed to indicate when the temperature in an incubator or other heated apartment rises too high, and whether such an apparatus is now in market. *Ans.* We are not aware that such an apparatus is in market, but it would be easy to make one. All that would be necessary would be to make an adjustable insulated metallic rod a part of the circuit, and set it at such a distance from a metallic point also in the circuit that, when the maximum temperature desired is reached, the closing of the circuit would be effected by the expansion of the rod, and to place an ordinary bell-ringing arrangement also in the circuit. The bell would, of course, ring whenever the circuit was closed. A mercury column, in a glass tube, forming a part of the circuit, would be a good substitute for the expanding rod.

78 THE ELECTRIC FUSE AND HEAVY CANNON.—It seems as if we were about to abandon the old method of firing guns on board ship with the lanyard, and to use the electric fuse instead, at any rate, so far as heavy cannon are concerned. For some years past experiments have been carried on in the navy with electric firing, but it is only since we have had to do with very heavy guns, and particularly those in turrets, that this method of discharge has become almost indispensable. To be cooped inside a close iron turret in company with a pair of terrible weapons of 35 or 38 tons, and to experience the full measure of their thunder, is scarcely to be contemplated with indifference; yet this is not the reason, or at least not the principal reason, why the electric current is to be employed in future instead of the gunner's arm. The real cause is twofold; in the first place it is possible to take better aim by using electricity to do the work; and, secondly, the effect of the shots is more terrible. The simultaneous discharge of three or four projectiles against heavy armour has been found capable of penetrating the latter, when single shots are quite unable to do so. A vibration is set up in the iron plating, it is presumed, and in this condition the armour is more vulnerable. Simultaneous firing is impossible by hand and word of command, in the same way as gunners used to fire broadsides in the old three-decker days. To the ear the thunder of discharge might not appear otherwise instantaneous, but the effect upon an ironclad is vastly different if a volley is fired by lanyards, or by a flash of electricity. The other reason is more important still. The guns are so close to the water, and the portholes so limited in size, that sighting along the weapons is frequently a matter of difficulty. The operation is much more easily performed by an officer stationed above, either in the rigging, or in the armoured tower, with which most of our modern ironclads are fitted. Provided with suitable sights and electric wires which lead down into the batteries, the captain, or other officer of the ship, here has the whole of its armament under his hand. He directs at what angle the guns shall be laid, and, watching his opportunity, discharges them simultaneously at the instant he thinks most fit. Situated above the deck he is removed from the bustle and smoke below, and can act with more coolness and judgment, while obviously no time is lost when the critical moment for firing arrives.—*Standard.*

59

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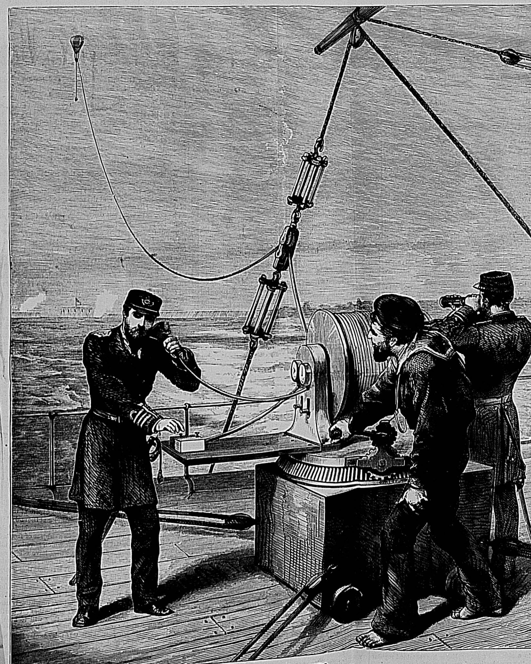
AERIAL WARFARE.

The idea first published in these columns of dropping torpedoes into an enemy's camp or cities from balloons seems in a fair way to be put in practical shape abroad. The London *Graphic* publishes the large engraving given herewith, showing how a balloon carrying a large torpedo could be sent over a hostile fort from on shipboard. Our cotemporary proposes that gunboats shall be provided with balloons large enough to carry one man and the can of nitro-glycerin or other powerful explosive suspended at considerable distance below the car To the latter is attached a rope or wire, which is rove through a fair-leader and taken to the winch shown on the poop of vessel. The length of wire paid out as the balloon moves over the point to be attacked is indicated by dials on the side of the winch drum, and by means of a telephone the officer directing operations communicates with the occupant of the car, and receives from him directions when to slacken or reel in the wire. The



THE BALLOON TORPEDO.

60

creuse également en verre. Cette boule, plus légère que le volume d'eau qu'elle déplace, assure la flottaison des figurines. Mais à la partie inférieure de celles-ci se trouve caché un petit fragment de fer et, dans le socle supportant tout l'appareil, un électro-aimant. L'effet produit se comprend aisément. Quand le courant électrique, provenant d'une pile, anime l'électro-aimant, celui-ci attire de haut en bas le morceau de fer caché dans les figurines : celles-ci descendent au fond du vase. Elles remontent, au contraire, dès que le courant électrique cessant de l'animer, l'électro-aimant redevient inerte et n'exerce plus aucune action sur le fer des figurines.

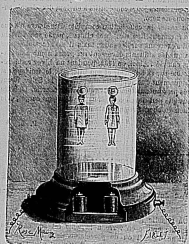


Fig. 1. — Le ludion électrique.

LES POISSONS ÉLECTRIQUES

Les poissons électriques présentent une disposition aussi simple que le ludion décrit plus haut et produisent également un effet très-curieux : ils flottent doucement, ou bien tournent à droite ou se dirigent à gauche au commandement de l'opérateur.

Pour réaliser cet effet, M. de Combettes a placé des poissons en fer peint dans un vase cylindrique en verre monté sur un socle, à l'intérieur duquel est un petit moteur ou tourniquet électrique. Quand on fait passer dans l'électro-aimant de ce moteur le courant d'une pile électrique, l'armature de cet électro-aimant tourne autour de son axe, et, comme elle participe à l'aimantation des bobines de fer, elle entraîne les poissons dans son mouvement de rotation. Si on change le courant de manière à modifier le mouvement du mécanisme électrique, les poissons hésitent un instant puis se remettent à tourner dans un sens opposé à celui de leur précédent mouvement.

Il va sans dire que pour le ludion comme pour les poissons, l'opérateur n'a nul besoin de toucher aux appareils; il doit même, pour ajouter à l'illusion, s'en tenir éloigné. C'est à l'aide d'un petit instrument habilement dissimulé dans sa main ou dans sa poche, un commutateur, pour l'appeler par son nom, qu'il établit ou qu'il rompt la communication de la pile électrique avec le ludion ou le moteur électrique des poissons.

P. L.

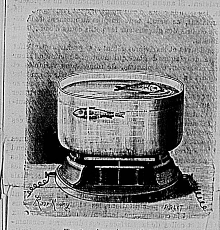


Fig. 2. — Les poissons électriques.

61

AN ELECTRICAL GYROSCOPE.

BY GEO. M. HOPKINS.

The gyroscope, though now a common toy and familiar every one, is still a puzzle to scientists. It has been properly called the "mechanical paradox," for, while it depends on gravitation for its peculiar action, it appears indifferent to it.

To render the operation of the gyroscope as nearly continuous as possible, so that its movements may be more thoroughly studied, and to combine another influence with those that unite in the gyroscope of the common form to produce the almost miraculous phenomena exhibited by the instrument, I have applied electricity as a motive agent.

The gyroscope illustrated by the engraving has a weighted base piece, from which projects a pointed standard that supports the moving parts of the instrument. The frame, of which the electro-magnets form a part, has an arm in which is fastened an insulated cup, that rests upon the point of the standard. One terminal of the magnet coil is connected with this cup, and the other terminal is connected with the bar that connects the cores of the two magnets.

Upon the top of the magnet bar a current-breaking spring is supported by a hard rubber insulator, and is arranged to touch a small cylinder on the wheel spindle twice during each revolution of the wheel.

The wheel, whose plane of rotation is at right angles with the magnet cores, carries a soft iron armature, which turns very near the face of the magnet, but does not touch it. The armature is arranged in such relation to the contact surface of the current-breaking cylinder that twice during each revolution, as the armature nears the magnet cores, it is attracted, but immediately the armature comes directly opposite the face of the magnet cores, the current is broken, and the acquired momentum is sufficient to carry the wheel forward until the armature is again within the influence of the magnet.

The current-breaking spring is connected with a fine copper wire, that extends backward as far as the pointed standard, and is coiled several times to render it very flexible, and is finally bent downward so as to dip in mercury contained in an annular vulcanite cup placed on the pointed standard near the base piece.

The base piece is provided with two binding posts for receiving the battery wires. One of the binding posts is connected with the pointed standard, and the other communicates by a small wire with the mercury in the vulcanite cup.

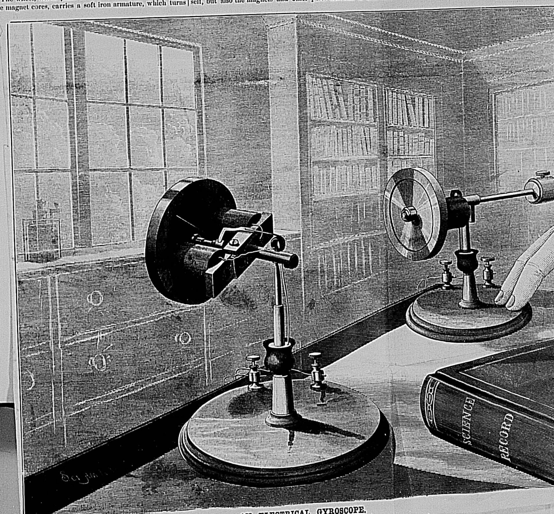
The magnets and wheel, and all of the connected parts, are free to move in any direction on the point of the standard. When two large or four small Bunsen cells are connected with the gyroscope, the wheel revolves with enormous velocity, and upon letting go of the magnets (an operation that requires some dexterity), the wheel sustains not only itself, but also the magnets and other parts between it and the point of the standard, in opposition to gravity. The wheel, besides rotating rapidly on its axis, sets up a slow rotation about the pointed standard in the direction in which the *under side* of the wheel is moving.

By attaching the arm and counter balance shown in the engraving, so as to exactly balance the wheel and magnets on the pointed standard, the whole remains stationary. By *overbalancing* the wheel and magnets, the rotation of the apparatus around the standard is in an opposite direction, or in the direction in which the *top* of the wheel is turning.

This gyroscope illustrates the persistency of a rotating body in maintaining its plane of rotation against the force of gravitation. It also exhibits the result of the combined action of two forces tending to produce rotations about two separate axes lying in the same plane.

The rotation of the wheel upon its axis, produced in this instance by the electro-magnet, and the tendency of the wheel to fall, or rotate in a vertical plane parallel with its axis, result in the rotation of the entire instrument upon a new axis, which is coincident with the pointed standard.

A MODE of equalizing the wear of the cylinders and pistons of horizontal engines, suggested by an English engineer, consists in making the piston-rod with a camber or upward bend, so that, when loaded with the weight of the piston and placed in the cylinder, it assumes a straight line, and transfers the weight to outside guides.



AN ELECTRICAL GYROSCOPE.

622

Another Curious Application of Electricity.—Electricity has been applied to stripping photographic films from glass plates. Photographers know full well that there is scarcely any substance so electric in its nature as a collodion film, and a dry film may be made to adhere firmly to a glass surface if it is simply stroked by the hand to excite it electrically. M. Boivin believes that the only adhesion of a collodion film to glass, in the ordinary way, is due to its electric state, and it is only when the electric condition is destroyed that the film is repelled so thoroughly that it may be lifted from the plate without difficulty. An excited film certainly adheres very firmly, and can only be peeled off the glass with difficulty, and clings to one's hands and around one's fingers with a disagreeable tenacity. When charged, however, with positive electricity the film comes from the glass immediately, and one has no difficulty in getting it to leave the plate. It is said that, if we simply cut round the edges with a knife, and then charge the film, first with one kind of electricity and then with another, the collodion image will leave the glass without further trouble. This is certainly a novel application of electricity.

Electrician June 78

A New Application of Electricity.—Some experiments have been made at Brussels in breaking in horses by means of an electric bridle. The apparatus, called the Engstrom bridle, after its inventor, consists simply in a couple of reins, along which run electric wires. At the end of the reins a small electric battery is attached, which is entirely in the power of the experimenter. By pressing on a little knob the electric current acts on the corners of the horse's mouth, and after a few consecutive or intermittent shocks the animal becomes perfectly docile. A very intractable mare was broken in after one experiment with the bridle. The inventor asserts that runaway horses can immediately be brought to a standstill by means of this apparatus. July 78

THE ELECTRIC FUSE AND HEAVY CANNON.

Aug 23/78

It seems as if we were about to abandon the old method of firing guns on board ship with the lanyard, and to use the electric fuse instead, at any rate so far as heavy cannon are concerned. For some years past experiments have been carried on in the navy with electric firing, but it is only since we have had to do with very heavy guns, and particularly those in turrets, that this method of discharge has become almost indispensable. To be cooped inside a close iron turret in company with a pair of terrible weapons of 35 or 38 tons, and to experience the full measure of their thunder, is scarcely to be contemplated with indifference; yet this is not the reason, or at least not the principal reason, why the electric current is to be employed in the future instead of the gunner's arm. The real cause is twofold: in the first place it is possible to take better aim by using electricity to do the work; and, secondly, the effect of the shots are more terrible. The simultaneous discharge of three or four projectiles against heavy armor has been found capable of penetrating the latter, when single shots are quite unable to do so. A vibration is set up in the iron plating, it is presumed, and in this condition the armor is more vulnerable. Simultaneous firing is impossible by hand and word of command, in the same way as gunners used to fire broadsides in the old three-decker days. To the ear the thunder of discharge might appear instantaneous, but the effect upon an ironclad is vastly different if a volley is fired by lanyards, or by a flash of electricity. The other reason is more important still. The guns are so close to the water, and the portholes so limited in size, that sighting along the weapons is frequently a matter of difficulty. The operation is much more easily performed by an officer stationed above, either in the rigging or in the armored tower, with which most of our modern ironclads are fitted. Provided with suitable sights and electric wires which lead down into the batteries, the captain, or other officer of the ship, here has the whole of its armament under his hand. He directs at what angle the guns shall be laid, and watching his opportunity, discharges them simultaneously at the instant he thinks most fit. Situated above the deck he is removed from the bustle and smoke below, and can act with more coolness and judgment, while obviously no time is lost when the critical moment for firing arrives.—*London Standard.*

93

ELECTRIC BLASTING.

On Wednesday afternoon a general meeting of the members of the Midland Institute of Mining Engineers was held at the Yorkshire College, Cookridge, Leeds. There was a good attendance. Mr. T. W. Embleton, the ex-president, in the absence of Mr. Carter, of Barnsley, the president, occupied the chair. A most important paper was read by Mr. C. Walker, Manager of Houghton Main Colliery, near Barnsley, "On Blasting in Sinking Pits by Electricity, and an Improved Method of Placing the Shot Holes." The paper, which was well received and criticised, pointed out the advantages of blasting in a 15-feet chamber. By this method he said he had sunk 21 yards through rock in seven days, and during that time only eight hours were lost in making repairs. The writer explained that dynamite, instead of gunpowder was used, and at least a dozen holes were drilled and charged in the shaft at one time. A large number of the holes were bored near the sides of the shaft, and some in the centre, to various depths. The holes having been charged and fuses attached, two pieces of cable composed of indiarubber and roping were attached to two pieces of wire. In the piece—a specimen of which Mr. Walker produced—was a chamber charged with composition. This was first exploded by electricity, and then it ignited a cap, which in turn ignited the dynamite, and in this way a simultaneous explosion was produced. It was also shown that the holes were drilled so far apart as not to impede the work, and whilst one man was pressing the dynamite, another was charging the hole, and a third could fix the fuse. In this way the whole of the holes were ready for firing at nearly the same time. In answer to a question as to what damage was generally done by the firing of so many shots at one time, it was explained that the shots so fired caused but little damage. The action of one seemed to counteract any damage which might arise from the other, by the stones, &c., which were upheaved, beating against each other. In the course of a very able and important discussion, the paper was favourably commented on. Mr. A. Lupton, teacher at the new Mining College, Leeds, referred to his experiences with regard to the cutting of a tunnel where electrical gun shots were used. The system was adopted because a special rule provided that no more than one shot should be fired at one time. Such a rule caused great loss of time in cutting a tunnel, and it was considered that by having a dozen holes connected together and fired simultaneously by an electrical machine, it was practically one shot. No difficulty was found in securing the services of an ordinary workman to use the machine. A cable was used for transmitting the electricity. Other speakers expressed their opinions on the paper, and at the close it was agreed that Mr. Walker should be requested to furnish sections of the strata passed through in the shaft to which his observations referred, as well as the expenditure entailed by that mode of sinking. A paper by Mr. J. E. Dooley, "On Improvements in Safety Lamps," was held over to a future meeting, as was also one to be submitted by Mr. J. W. H. White, "On a Contrivance for Attaching Curves of Endless Ropes on Underground Planes." Aug 17/78

Electricity as a Motive Power.—In the course of a lecture on electricity, delivered by Mr. Gerard Finch, M.A., in connection with the Wigan Mining and Mechanical School, last week, a novel illustration was given of electricity performing mechanical work. A saw-bench was placed on a platform connected with a Siemens dynamo-electric machine, which, in its turn, was connected by wires with the machine outside the hall used for producing the electric light during the lecture. On the electricity being communicated the saw was set in motion, and timber up to 5 inches in thickness was cut into strips. Lord Lindsay, M.P., F.R.S., and President of the Royal Astronomical Society, was in the chair, and among the audience were a large number of the leading colliery proprietors of the district. The latter, our Wigan correspondent states, are inclined to test the practicability of working coal-cutting machines and other underground machinery by electricity. At present compressed air is the only power that can be used for driving these machines without interfering with the ventilation of the workings. Electricity is said to produce equal effect at considerably less cost. It can also be conducted cheaply and easily to any part of the mine by means of wires. 78 Dec

64 ... 1[illegible]

spots.—*Engineer.*

EDISON'S PHONOMETER.—It is admitted that there is power in the human voice, but hitherto this power has been applied indirectly to produce mechanical results. Mr. Edison in his telephone and phonograph experiments discovered that the vibrations of the vocal cords were capable of producing considerable dynamic effect. Acting on this hint he began experiments on a phonometer, or instrument for measuring the mechanical force of sound waves produced by the human voice. In the course of these experiments he constructed the machine, which exhibits the dynamic force of the voice. The machine has a diaphragm and mouth-piece similar to a phonograph. A spring which is secured to the bed-piece rests on a piece of rubber tubing placed against the diaphragm. This spring carries a pawl that acts on a ratchet or roughened wheel on the fly wheel shaft. A sound made in the mouthpiece creates vibrations in the diaphragm, which are sufficient to propel the fly wheel with considerable velocity. It requires a surprising amount of pressure on the fly wheel shaft to stop the machine, while a continuous sound is made in the mouthpiece. Mr. Edison says he will have no difficulty in making the machine bore a hole through a board; but we consider such an application of the machine of very little utility, as we are familiar with voices that can accomplish the feat without the mechanical appliance.—*Scientific American.*

DANGERS THAT BESET SUBMARINE CABLES.—Every one who has at all studied oceanic telegraphy perfectly understands the dangers to which the shore ends of communicating wires are exposed from the action of currents, the anchors of ships, &c. But the general idea prevailed that once the cable was laid in the gloomy depths of the ocean, it was in safety. Such, however, is not the case, for the inhabitants of those regions seem to resent the intrusion. In many cases, owing to the inequalities of the bottom of the sea, the wires cannot rest wholly on the bed, but in some

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than thirty-five feet from the box; its performance suggested to me the multiplication of the carbons on the relay. To the above I may add that when the electrical current used with the carbons is too powerful, a hissing, cracking sound is produced, which is from time to time varied by the introducion of a pure musical note, which often runs through considerable variation in pitch. This voltaic tone may be due to the repulsion exerted by the electrical current on itself, causing one of the carbon points to rise and fall with regularity in a manner analogous to the motion of the Trevelyan rocker, or it may be caused by rapid changes of temperature, and hence in volume of the contact-surfaces. With fourteen small cups it occurred quite frequently." 1878

PHOTO-ELECTRIC ENGRAVING.

[THE following interesting process is extracted from a paper by Captain J. Waterhouse which appears in the Journal of the Asiatic Society of Bengal:]

Geymet's method of photo-engraving consists in electrotyping from a gelatine relief obtained by the pigment-printing process, and is somewhat similar in principle to Placet's process, but as there are important differences, and the process appears likely to prove of some utility, it may well be treated separately.

According to M. Geymet, who has very fully described the process and all the manipulations of preparing and electrotyping the reliefs in his "*Gravure Héliographique,*" it was the invention of M. Audra, a French amateur.

Pigmented gelatine tissue is sensitized and exposed to light exactly in the manner heretofore described for the autotype process. It is transferred to a smooth glass or a polished copper plate, developed in warm water, and when dry is metallized and electrotyped. If the subject is one in line or dot only, the above operations are sufficient; but if the subject is a photograph from nature, or any other with gradation of shade, it is necessary to obtain a grain, and this M. Geymet does by taking a copper plate with its surface grained or engraved with a ruled or roulette tint, inking it up in the ordinary way, and then covering it with a coating of transfer collodion. When dry, the film of collodion is stripped off the plate, and carries with it the impression of the grain. This film is then placed between the cliché and the sensitive gelatine film, and serves to break up the shadows in the more transparent parts of the cliché.

A similar process has been used at the Depôt de la Guerre, in Belgium, for the reproduction of maps.*

Last year, while making some experiments on this process, I succeeded in obtaining the necessary grain by chemical means, which produce a finer and less artificial effect, and I have also made a few other modifications in the process, which may be worth recording at length.

A piece of the ordinary autotype tissue is sensitized in a five per cent. solution of bichromate of potash. When dry, it is exposed to light under a reversed negative, and then transferred in cold water to the surface of a well polished copper plate, and squeegeed down into close contact with it. In order to prevent subsequent adherence to the newly deposited copper in the electrotyping bath, the copper plate is silvered by rubbing it with a little of the following solution mixed with tripoli:

Nitrate of silver	1 part.
Cyanide of potassium	10 parts.
Water	100 "

The gelatine tissue attached to the copper plate is allowed to dry, and then developed in warm water in the usual manner, great care being taken not to loosen the lines, an accident which is very liable to happen, though the preliminary drying of the tissue before development tends to prevent it.

When the image is quite clear from all soluble gelatine, the plate is well drained, and plunged into a bath containing—

Tannin	5 parts.
Strong spirits of wine	100 "

This at once removes all moisture from the gelatine relief, hardens it, and gives it a fine grain, coarser in the shadows than in the lights. The plate remains a few minutes in this bath, till the action is complete in the deepest shadows; the tannin is then washed off with a little spirits of wine, and the plate is allowed to dry.

The gelatine relief has now to be prepared for receiving the electrotype deposit. A band of copper having been soldered to it, the back of the plate is coated with Brunswick black, to prevent deposition of the copper upon it. When the backing is dry, the margins of the picture are cleaned with a little of the silver solution. The gelatine surface then receives a very slight coating of wax dissolved in turpentine, which is well polished off, and is rubbed over with fine plumbago or silver-bronze powder to render the surface conducting. The plate is then ready to be placed in the depositing bath.

Any good electrotyping arrangement may be used, but I prefer a Smee's battery with a separate depositing trough, containing a solution of ten parts each of sulphate of copper and sulphuric acid in one hundred parts of water.

965

A plate of copper, to serve as an anode, and connected with the silver plate of the battery, is laid horizontally about an inch above the bottom of the depositing trough, which should be large enough to allow the plate bearing the gelatine relief to be slipped under the anode. The relief-plate is connected with the zinc plates of the battery, and, when everything else is ready the circuit is completed by slipping it into the depositing trough under the anode. By laying the plates horizontally in this manner the deposit is more even, and the gelatine film seems to be more readily covered with copper.

When the deposit of copper is of sufficient thickness it is separated from the matrix, and only requires a gentle "oil-rubbing" to be fit for printing.

The plates obtained by this method show very good half-tone with an almost imperceptible grain, giving the effect of a fine chalk-drawing.

* See Maes and Hannot, *Traité de Topographie, etc.*, p. 230.

I have lately tried to obtain the images upon the copper by the double transfer process, making use of a flexible temporary support, consisting of paper coated with India-rubber, as first proposed by Swan, which can easily be removed with benzole after the transfer of the gelatine image to the copper. The grain is given to the image by soaking it in water after the removal of the India-rubber paper, and then applying the solution of tannin in alcohol. This plan seems likely to be successful; if so, it will greatly simplify the operations, and enable engraved plates to be obtained from any ordinary negative without the trouble of reversing.

By electrotyping direct from the gelatine relief, the results are always rather heavier and coarser than they should be, because, although hardened and insoluble, the gelatine relief can always absorb a little of the copper solution in the depositing trough, and consequently the image swells and loses sharpness.

The strong tanning given to the gelatine film and the preliminary coating of wax before metallizing the surface obviate this defect to a considerable extent; but it may perhaps be better to obtain a matrix in lead by pressure from the gelatine relief, and then to obtain the printing plate by electrotyping twice from the lead matrix. This is a more roundabout and expensive method, but it is likely to yield finer results, and has been adopted by Woodbury and Rousselon in their processes.

The process is simple, and, if it could be successfully worked out, it might be usefully employed in this country in reproducing shaded maps and for other miscellaneous purposes. It has the very great advantage over photo-collotype that the plates can be corrected, if necessary, and can be printed in any numbers in the ordinary copper-plate press without risk of breakage or damage to the printing surface.

NEW USE OF ELECTRICITY. Feb 24/79

THE French Minister of Public Works (according to the *Moniteur Scientifique*) has been experimenting on the River Lot, in Aveyron, with an electric apparatus designed to reproduce automatically, from a higher to a lower point of the river, the variations of level, so as to give immediate warning of floods, and enable the inhabitants to make what preparation they can. The experiments were made between two points about a mile apart. At the higher, Laroque, is a float which follows the upward and downward motion of the water (without being affected by the current). It communicates its movements, through a battery and conducting wire, to the needle of a graduated scale at Capdenac, the lower point, and the needle thus indicates all the fluctuations of level. At a certain point on the scale is the word danger, and when the needle reaches this, it sets in action a number of bells in the houses on the banks, connected by wire with the instrument. Thus the inhabitants are warned to make ready. This curious apparatus is the invention of M. Gros, of Rodez, and it has met with high approval from the Ministry of Public Works and the General Council of Aveyron. The need of something of the kind has been strongly felt, as floods in that region have proved very disastrous.

66

Vol. XXXIX.—No. 15.] [NEW SERIES.]

NEW ELECTRICAL DIAP[ASON]

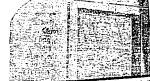
BY GEO. M. HOPKINS.

The graphic method of studying vi[brations] ... deeply interesting, especially in these ... and phonographs, when the properties ... more thoroughly investigated than eve[r] ... methods have been devised to render s[ound] ... apparent. In the novel and beautiful me[thod] ... jous, two tuning forks or diapasons, eac[h] ... mirror, are arranged so that by their com[bined] ... a beam of light is reflected, forming upon ... symmetrical figures, by which the vibrator[y] ... sounding bodies may be compared withou[t] ... ear.

Sir Charles Wheatstone, many years ... small machine for compounding rectangula[r] ... Professor E. A. Dolbear more recently devi[sed] ... to be attached to a whirling table, for the p[urpose of] ... ting two mirrors in different planes for proje[cting] ... curves. These curves have also been draw[n] ... pendulums.

In each of these forms of apparatus some[thing] ... ment is wanting. The forks lack continuity o[f] ... vibrating mirrors of Professor Dolbear ma[y] ... continuously, but no sound accompanies thei[r] ... The pendulum, while it produces beautiful ... neither the sound nor continuity of operation.

With a view to the construction of an in[strument that] would operate continuously and produce bot[h] ... figures, I first arranged two reeds or tongues t[o] ... by an electric current. These tongues were ... able as to length, so that their vibrations might ...



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VOL. XXXIX., No. 15. [NEW SERIES.] *Thirty-third Year.*

NEW YORK, SATURDAY, OCTOBER 12, 1878.

Contents.

(Illustrated articles are marked with an asterisk.)

TABLE OF CONTENTS OF

—complet ... the best re ... In one v[iew] ... style of lo ... ing the hi ... of their c ... inches; th ... inches wi ... feet, and ... of 982 sq ... prevent ... The cons ... square fe ... ordinary ...

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WAGES AND THE COST OF LIVING.

97

the spring connecting pieces that project from the back of the vibratory tongues.

The holes in the spring connecting pieces are made larger than the needle, and pieces of thin leather are attached to the connecting pieces to form a yielding bearing for the needle. To the outer end of the needle is secured a small concave mirror, in front of which a small plano-convex lens is supported by a jointed arm projecting from the main frame of the instrument.

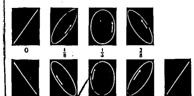


Fig. 3.

A beam of parallel rays being thrown on the concave mirror from a lantern or *porte lumière*, and the vibratory tongues being set in operation, a figure will appear upon the screen on which the instrument is focused, which will be the resultant of the two rectangular vibratory motions. This figure depends on the persistence of visual sensations on the retina, for it is really due to the rapid movement of the light spot which is seen when the tongues are at rest. The figure may be varied by moving the slide so that any possible combination of tones within the compass of one and one half octave may be produced. It is interesting to observe the change of figure resulting from the slightest alteration in the adjustment of the slides, or from the change of phase resulting from an alteration in the adjustment of the contact screws. The tones that accompany the figures are full

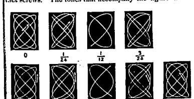


Fig. 5.

and deep, especially if the instrument be mounted on a sounding board. The effect known to musicians by the name of "beat" can be produced by this instrument, so that they may not only be heard with distinctness, but may also be seen.

If only one tongue vibrates a straight line will appear on the screen, which will be inclined at an angle of 45° from the horizontal. The line produced by one of the tongues forms a right angle with the line produced by the other, and when both tongues vibrate simultaneously the two motions combine, and the reflected pencil describes a more or less complex curve, the form of which depends on the number of vibrations of the two tuning forks in a given time.

Fig. 3 shows the luminous image on the screen when the tongues vibrate in unison, and the fractions below each fig-

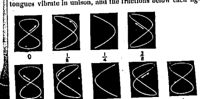


Fig. 4.

ure indicate the difference of phase between them. The curve retains its form when the tongues are in unison, but when they are not quite in unison the initial difference of phase is not preserved, and the curve passes through all its variations. Fig. 4 represents the different appearances of the luminous image when the difference between the vibratory tongues is an octave; and Fig. 5 represents curves when the number of vibrations are as 3 : 4. The loops along the vertical and horizontal edges express the ratio of the combined vibrations. The variety of figures that may be produced by this instrument is endless.

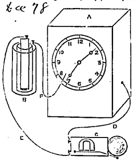
When sunlight is employed to project the figures the mirror may be plain and very small, and the lens may be dispensed with. The figures, when viewed directly in a plain mirror of one inch diameter, appear as wires of burnished gold interwoven in a most complicated and beautiful manner.

[33576.]—Electric Clock.—To "IOSTEPHANUS."—I am very sorry not to have been able to answer your query before, but have been ill. The magnets of my own clocks are about 2in. long, of ⅜in. iron, annealed in charcoal; the poles are very slightly convex, and the armature has a piece of thin oiled silk attached with shellac, to prevent the magnet holding it after the current has ceased flowing. The magnet-arms are covered with paper, and wound with 7 or 8 layers of No. 21 cotton-covered, and the whole soaked in paraffin. I suppose you know the paraffin mentioned is the ordinary solid white paraffin, costing eighteenpence per lb.; paraffin candles should not be used, as they are (or may be) adulterated with stearine, tallow, or some such stuff, which may corrode the copper. It is convenient to join the outer ends of the two coils together, as there is then no danger of the inner ends coming undone, and if they break off close they can be unrolled a little, while the bungle of twist is avoided, and with it the risk of the tightly-twisted wires touching metallically. I never used reels on any magnet: there is first the trouble of turning them, then they waste valuable space next to the iron, and it is very difficult to secure the iron of the magnet effectively without crushing the reels up. Pegging with wood is, of course, no use; while, on the other hand, the other way takes half an hour to wind, and is entirely satisfactory when done. About half a pound of wire will be more than enough. Your circuit wire is much too thin: 16 or 17 would be better, but of course it is only a question of more battery power. With such a circuit of 24 I should suppose 7 or 8 Léclanché's would be necessary; but I am not so in love with the Léclanché as I used to be. After trying all sorts of variations, I now use pint glass vessels containing 6 per cent. sulphuric acid, and zinc about 12 cm. by 2, half surrounded by platinised silver of twice the width, bent into a third of a circle. Once a month I change the acid, lift the combination (arranged on a strip of wood) out of the old jar into a fresh one, empty, and refill the old and replace with it the next cell. Every other month I replace the zincs, which are fixed in clamp screws faced with platinum, and protected from any of the solution carried up by the escaping gas. Take care that the silver gets no mercury on to it. I should think 6 of these cells would work your fine wire line; but, anyhow, I would use them—the Léclanché's are such a nuisance to recharge, especially the bought ones, and so dirty; the solution creeps over the sides and the power decreases after a time. It is very well to say that "they are put away in a cupboard and there is an end of them." There is not an end—the solution runs over, or dries up, the dust and crystals clog the manganese and form a film over the zinc, and, more than all, the wet floor wastes two-thirds of the power. Keep the five or six cells of Smee in a case with a glass front, paraffin the top of the glass vessel (heating the glass first) if the solution creeps up, and don't let the paraffined wood bar that holds the plates get crystallised over. Another thing is that the Léclanché boasts of its considerable electromotive force, nearly half as much again as that of the Smee, but says nothing of the tremendous resistance of its porous cell, stony manganese, and saline solution. So much for that. After writing the letter in Vol. XXIII. I was still troubled occasionally by a skip of one of the clocks. I thought of the condemnation awarded to electric clocks by electric authors, and felt inclined to give it up; but observing that a great improvement followed the lengthening of the time that the current is allowed to flow, and not being able to lengthen the time any further on account of the recoil of the old eight-day, I made a clock in which a uniformly rotating seconds' arbour drives an endless screw and conical pendulum—that is, a pendulum swinging (nearly) in a circle; by this contrivance I can give any desired length of "exposure" without fear of a double contact being made. Of course the current is all round the circuit the moment the points touch, but the armature requires an appreciable time to overcome its "inertia," or natural laziness. One second, however, is ample to avoid any chance of failure. I intend shortly to make a clock with a chronometer escape and a *remontoir* (which latter drives a heavy contact without any jerk or influence whatever on the escapement), in order to avoid the dust and fluff that clog the present one, which is too large to go under a glass-case, as the escape-wheel has 42 teeth and the pendulum revolves 42 times a minute, and is, therefore, just half a metre long. I shall continue the subject shortly.—IOSTEPHANUS.

ELECTRICITY AND THE LOOM.—Many different kinds of "stop-motions" have been introduced into textile machinery for the purpose of stopping the loom automatically, when, from some cause or other, such as the breaking of a yarn, it begins to perform its work improperly. These purely mechanical contrivances are all more or less delicate, but an electrical stop-motion, not open to this objection, has been invented by Messrs Bullough and Smalley, and applied to the cotton machinery of Messrs. Howard and Bullough, Accrington. The current is supplied by a small magneto-electric machine, weighing a few pounds, and driven by a strap from the main shaft. The current from this machine is so applied that when contact is made by the breaking yarn, or other cause, it traverses an electro-magnet which causes a soft iron armature to drop into a ratchet wheel, whose motion being impeded, makes the strap work upon the loose pulley, and thus stops the machine. This stop-motion is applied to the carding engine, the drawing frame, and a roving frame. In the drawing frame the insulating property of dry cotton is taken advantage of in closing the circuit This invention is giving great satisfaction to the cotton spinners of Lancashire. A full account of it was recently read before the Scientific and Mechanical Society of Manchester by Mr. W. H. Bailey.

[31122.]—Connecting Clock with Electric Bell.—I think "J. W. E." will find the following method of connecting an electric bell with a clock easier than the other arrangements which have been represented before, and trust it may not be too late to be of use. The rough sketch, I hope, will explain

Oct 78



itself:—A, clock; B, battery; C, bell. The wire D from one terminal of the bell is connected with any part of the works behind the clock; the wire E leads from the battery to the other terminal of the bell; and the wire F is placed at whatever hour the bell is wanted to ring. F has a little crook at the end, so that, when the hour hand of the clock touches it, it is carried round with it, the bell continuing to ring till the crook detaches itself by the hand going round—i.e., about 3 hours. I ought to mention that F is placed in such a manner that, although the hour hand touches it, the minute hand passes above it. This adjustment, though not so scientific as others, is most successful, and costs nothing.—MECHANICIAN.

EXPERIMENTS WITH THE ELECTRIC TOURNIQUET.*

Oct 4 78

If an insulated electric tourniquet be put in communication with an electric machine, and if, when its velocity of rotation is considerable, it be covered with a bell jar, it will

* M. Bichat in the *Journal de Physique*.

NCE: No. 706. Oct. 4, 1878.

stop. This (it is said) is because the air of the bell jar is electrified. If the bell jar be then touched with the hand, the tourniquet goes on again; and the explanation given is that the proximity of the hand has changed the electric distribution in the gas. The experiment succeeds very well when made under the conditions indicated. It is no longer so if we operate in the following manner:—

The tourniquet is placed at the centre of a glass plate, perforated at this point with a hole, by which communication can be effected with the electric machine, and it is covered with a glass bell jar. At this moment only the machine is set in action; the tourniquet does not move, or there is but a slight tendency perhaps to move, which is presently suppressed.

On looking at the instrument in darkness, one sees small "aigrettes," darting not from the extremities of the points, but from the metallic base of the torniquet and of the rod which connects it with the machine. These aigrettes are directed towards the glass plate.

If now the experiment be re-commenced, the tourniquet being supported no longer by a metallic base, but by an insulating base (*e.g.*, sulphur), and if the wire connecting it with the machine be *perfectly* insulated, the tourniquet turns immediately on working the machine, and does not stop.

If in the first case the hand be brought near the bell jar, the tourniquet is set in motion, and in the second case the velocity of motion is considerably increased.

From these experiments it may be concluded, I believe, that if the tourniquet stops in the confined air when the experiment is made in the usual manner, this is not due to electrification of the air, as is generally said. One cannot understand, indeed, how the movement should be nil when the precaution is taken to cover the tourniquet with the bell jar before working the machine. Nor would it be easy to see why the tourniquet goes much better when supported by an insulating base. The electrification of the air must be much stronger in the second case than in the first. The explanation must be quite different. We shall reach it without difficulty if we suppose that for badly conducting bodies as well as for non-conductors, electricity tends to go towards the exterior surface of the bodies. If that is the case, the electricity supplied by the machine to the tourniquet placed under the bell jar tends to go towards the exterior along the glass plate, or producing on this plate phenomena of successive inductions on to the borders of the jar. What leads one to think it is so is the appearance of the aigrettes starting from the base of the tourniquet, and from the different points of the communicating wire.

When the tourniquet acts—that is, when it is supported by a well-insulating base, and in well-insulated communication with the machine—the electricity escapes in part by the points, and goes to fix itself on the walls of the bell jar along a circumference in the plane of the tourniquet. Thence it proceeds by degrees towards the exterior, according to the ordinary laws of propagation in badly-conducting bodies. The action of this electricity found on the walls must certainly become perceptible on the tourniquet. Then it will be that if the hand be brought near, or a good conductor communicating with the ground, the phenomenon of ordinary condensation will be produced. As a necessary consequence the delivery of the tourniquet will be augmented, and so the movement of rotation will become more rapid.

Taking these remarks into account along with those made by M. Mascart in his "Traité d'Electricité" (p. 175, &c.) all the peculiarities of the electric tourniquet may be accounted for. There is one other experiment I wish to cite, which well shows the difficulty experienced in making electricity penetrate directly into badly-conducting bodies. Take a cylindrical glass vessel, filled with spirit of turpentine, in which put an electric tourniquet; let this tourniquet communicate with the machine by means of a copper wire traversing the walls of the vessel at the lower part. Under these conditions the tourniquet does not act. The electricity expands on the exterior walls of the vessel. The experiment will succeed very well, on the other hand, if the tourniquet be placed in the vessel, supported by its sulphur base, and there be brought near it, by the open upper part of the vessel, the extremity of a metallic wire, perfectly insulated, in communication with the electric machine.

INTERFERENCE OF ELECTRIC SPARKS.—M. de Wall, finds that when two electric sparks are simultaneously produced at the extremities of a short tube smoked inside, the two discharges give figures of interference in the form of a black ring at the middle of the tube. If the sparks are not quite simultaneous the ring is slightly displaced. This method might serve to determine the velocity of sound. It can also be employed to measure the speed of propagation of electricity in a conductor by causing a spark to blaze forth at the middle, and another at the end of a long wire. It would be necessary, however, for this purpose, to obtain complete symmetry at the extremities of the tube, and to ensure that the two waves produced are identical. When the spark is from a battery discharge, the ring examined by microscope, is seen to be formed of several rings due to the oscillating discharge. From the position of these rings, it follows that the partial discharges are separated by an interval of about a quarter of a millionth of a second.

Oct 78

APPAREIL

ÉLECTRO-MÉDICAL À COURANT CONSTANT

DU DOCTEUR ONIMUS.

Nous avons récemment décrit quelques appareils électro-médicaux. Nous croyons utile de compléter nos précédentes notices en parlant d'un des systèmes les plus avantageux dont nos lecteurs apprécieront les avantages. La pile se compose d'un vase extérieur en verre A (fig. 2) renfermant un petit cylindre de zinc (Z) et une tige de cuivre terminée par une plaque de cuivre (c) (fig. 3). De plus, dans le milieu du vase et entouré par le zinc, plonge un tube en verre B ouvert par ses deux bouts, mais dont l'ouverture inférieure est fermée par une substance poreuse f (fig. 4). On a choisi à dessein, comme substance poreuse, la bourre du fusil, calibre 24, afin qu'il fût facile à tout le monde de la remplacer lorsqu'il en serait besoin. C'est dans ce tube en verre B que l'on met les cristaux de sulfate de cuivre, qui en remplissent environ la moitié, et la pile est alors représentée par la disposition de la fig. 5. Pour faire marcher la pile, il suffit de verser de l'eau ordinaire dans le vase extérieur et dans le tube où se trouvent les cristaux, de manière que le niveau de l'eau atteigne à peu près le bord supérieur du zinc, comme cela est représenté fig. 5, où la ligne $x\ y$ indique la hauteur que doit atteindre le niveau de l'eau. Deux pipettes pleines d'eau suffisent, en général, pour chaque élément. Le courant est établi d'une façon constante au bout de quelques heures, et la pile marche alors régulièrement pendant plusieurs mois. A de rares intervalles, il suffit d'ajouter quelques gouttes d'eau et d'examiner les tubes pour voir s'ils contiennent encore des cristaux de sulfate de cuivre et en remettre quelques-uns dans les tubes où ils ont disparu.

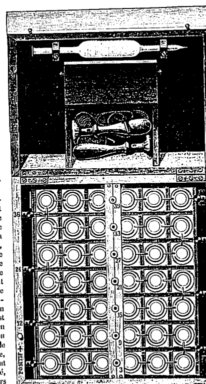


Fig. 1. — Disposition générale de l'appareil.

Les éléments sont disposés dans la boîte de manière à pouvoir augmenter ou diminuer le courant par trois éléments; lorsqu'on veut se servir de l'appareil, on place un des fils, le fil rouge par exemple, au point marqué + (positif), et l'autre fil est placé successivement dans les trous 3, 6, 9, 12, 42, selon que l'on veut avoir un courant de 3, 6, 9, 12...42 éléments. Ce dernier fil représente toujours le pôle négatif.

Il est bon, lorsque la pile a été chargée pour la première fois, de fermer le courant pendant une heure, en faisant communiquer par un même fil la première pile (positive) avec la dernière (négative).

Cette disposition est celle des boîtes ordinaires; M. Brewer, le fabricant, construit également d'autres boîtes, plus élégantes et plus complètes, dans lesquelles les éléments sont réunis à un collecteur commun, en même temps qu'il se trouve avec ce collecteur un galvanomètre et un renverseur de courant.

Ces accessoires, qui n'ont d'utilité que dans certains cas, augmentent nécessairement le prix de l'appareil, et rendent l'entretien et le nettoyage de

nie les œufs de Saumon nécessaires aux travaux d'empoissonnement, et elle vient d'obtenir de la libéralité de la Commission supérieure d'être comprise pour un lot important (100 000 œufs) dans la récolte faite cette année sur les frayères de la rivière Mac Leod.

Depuis l'extension donnée à l'exploitation des minerais, les frayères de beaucoup de rivières californiennes ont été presqu'entièrement détruites; mais celles de la rivière Mac Leod, affluent du Pitt, ont conservé une richesse exceptionnelle. C'est donc sur les bords de cette rivière, au milieu de tribus indiennes d'une sympathie douteuse pour les *visages pâles* que M. le docteur Livingstone Stone se rend chaque année, dans le courant du mois d'août pour recueillir les œufs du *Salmo quinnat*, dont la fraye a lieu beaucoup plus tôt que celle du Saumon ordinaire.

La quantité d'œufs recueillis cette année par M. Stone est plus considérable encore que de coutume, et s'élève au chiffre de 7 millions environ. La plus grande partie de cette récolte est naturellement destinée aux nombreuses et importantes piscifactures des États-Unis; mais des lots considérables doivent être aussi expédiés à la Nouvelle-Zélande ainsi qu'en Europe : en Hollande, en Allemagne, enfin à la Société d'acclimatation de Paris.

Cette Société compte répartir l'envoi qui lui est destiné entre un certain nombre de ses membres le mieux en situation de donner aux œufs tous les soins nécessaires pour en mener l'éclosion à bonne fin, et assurer à l'expérience le plus de chance de réussite possible.

Dès le premier essai fait l'année dernière dans un pays voisin du nôtre, 25 0/0 des œufs reçus d'Amérique ont éclos et donné naissance à 25 000 alevins lesquels peuplent aujourd'hui les bassins d'un établissement qui, hélas! n'appartient plus à la France et qui s'occupe spécialement du réempoisonnement du Rhin.

L'entreprise actuellement tenté par la Société d'acclimatation ne paraît donc nullement irréalisable et l'on ne peut que faire des vœux pour la réussite de cette utile et intéressante expérience.

RAVERET-WATTEL.

ÉLECTROMÈTRE ENREGISTREUR

DE M. MASCART.

Un des problèmes les plus délicats que l'on puisse se poser dans l'enregistrement des observations météorologiques est certainement l'inscription de l'électricité atmosphérique et du magnétisme terrestre. Les quantités à mesurer sont tellement petites et la force qu'on peut demander aux appareils de mesures si faibles que, jusqu'à ces derniers temps, on a dû se borner à l'enregistrement photographique.

Ce procédé, parfait en théorie, présente dans la pratique de sérieux inconvénients. L'emploi de la photographie est en réalité, très-coûteux et exige un personnel spécial. Enfin, et surtout pour l'électricité atmosphérique, l'inscription est loin d'offrir la continuité sur laquelle on croirait pouvoir compter. Il faut, en effet, un temps notable pour que le faisceau lumineux incident produise une impression suffisante sur le papier photographique, parce que la sensibilité de ce papier n'est jamais très-grande, et si les mouvements de l'instrument sont rapides, l'impression ne se fait plus. Il semble donc qu'il reviendrait au même, dans tous les cas, de remplacer une inscription continue par des mesures faites de temps en temps, toutes les cinq minutes, par exemple. Si les variations sont rapides, l'inscription photographique est insuffisante; si elles sont lentes ou nulles, la continuité absolue des observations n'est plus nécessaire.

C'est en sacrifiant cette continuité d'inscription presque impossible à réaliser que M. Rédier a pu, sur les indications de M. Mascart, construire un électromètre enregistreur purement mécanique, que l'on peut voir, fonctionner au pavillon météorologique de l'Exposition universelle, dans le jardin du Trocadéro.

L'instrument dont il s'agit d'enregistrer les indications est l'électromètre à quadrants de sir William Thomson. Sans vouloir entrer ici dans le détail de cet instrument, nous rappellerons qu'il se compose essentiellement d'une aiguille métallique en forme de 8, suspendue horizontalement par deux fils de cocon très-rapprochés qui forment une suspension bifilaire. L'aiguille se met au-dessus de quatre quarts de cercle ou quadrants, reliés deux à deux en croix et communiquant avec les pôles opposés d'une pile, qui les charge d'électricités contraires. Suivant que l'aiguille en 8 est électrisée d'une manière ou de l'autre, elle est plus ou moins repoussée par une paire de quadrants et attirée l'un par l'autre; ces actions, contrariées par la force nécessaire pour tordre la suspension bifilaire, conduisent à une position d'équilibre, et l'on sait que la charge électrique de l'aiguille est proportionnelle au sinus de la déviation, ou à la déviation elle-même, tant que celle-ci ne dépasse pas quelques degrés.

Pour se mettre en équilibre avec l'appareil collecteur de l'électricité atmosphérique, l'aiguille porte à sa partie inférieure un fil de platine qui plonge dans un vase isolé contenant de l'acide sulfurique, liquide conducteur, dans lequel arrive en même temps le fil partant du collecteur, celui-ci est muni d'une flamme de gaz ou d'un écoulement continu d'eau, destinés à prendre le potentiel électrique de l'air en un point déterminé[1].

Si l'on veut inscrire par un procédé mécanique les déviations de l'aiguille, il est clair que l'on ne peut demander à cette dernière le moindre travail, car il suffit d'une force insignifiante pour la faire tourner. Dans le nouvel inscripteur, comme dans tous ceux que construit M. Rédier, la force est empruntée à un rouage différentiel qui produit tout le travail, tandis qu'on ne demande à l'instrument

[1] Voir, pour les détails, le *Traité d'électricité statique* de M. Mascart, et un article sur l'électricité atmosphérique, publié par M. Angot dans l'*Annuaire de la Société Météorologique de France*, 1877, t. XXV, p. 155.

72

An apparatus recently devised by M. Celi, for experimenting on the action of electricity on living plants, consists of a large bell jar, into which electricity is admitted thus: An insulated metallic vessel is placed on a support about two metres high, and filled with water, which is then allowed to flow out by a very narrow tube. The vessel thus becomes charged with electricity, positive or negative, according to the state of the atmosphere (commonly the former). A collector, formed of metallic wire, is attached to this vessel, and penetrates into the bell jar, where it is connected with a crown of sharp metallic points for distributing the electricity. Under the bell jar are placed plants in vessels communicating with the ground. The bell jar is supported on glass, and air can be admitted or withdrawn through tubulures connected with a trompe. For comparison, similar plants to those under electric action are inclosed by another bell jar of the same size without application of electricity, but otherwise treated similarly. On July 30th M. Celi sowed some grains of maize in the manner described. On August 10th the plants in the electrified air had a length of 17c., while those in the unelectrified air were only 8c. Some researches on the composition of the air and the plants are in progress.

NOUVEAUX APPAREILS

ÉLECTRO-MÉDICAUX PORTATIFS

A RÉGULATEUR DES INTERMITTENCES

Oct — PAR M. G. TROUVÉ — 78

M. Trouvé a présenté récemment à la Société de physique deux interrupteurs de courant remplissant le même but, quoique basés sur des principes différents.

Le premier, par sa grande précision, est destiné plus particulièrement aux études physiologiques, car il donne à chaque seconde de temps le nombre d'intermittences à 1 centième de seconde près.

Le second, bien que ne pouvant rivaliser de précision avec le précédent, les donne à un quinzième de seconde près, ce qui est plus que suffisant pour la pratique médicale et répond à un désidératum souvent formulé.

On sait quelle importance il y aurait en faradisation à pouvoir régler à volonté le nombre des intermittences. Jusqu'à présent dans la pratique médicale ordinaire, on s'était contenté d'appareils munis du trembleur de Neef avec lequel on peut faire varier le nombre des intermittences entre des limites plus au moins étendues, mais sans jamais en connaître le nombre.

Disons toutefois que des physiologistes, comme Duchesne de Boulogne, avaient cependant entrevu la nécessité de contrôler le nombre des intermittences ou le nombre des passages successifs du courant par chaque seconde de temps. Duchesne de Boulogne à cet effet avait fait disposer une pendule dont le balancier marquant la demi-seconde lui donnait à volonté une interruption ou deux par seconde. On utilisa également dans le même but le métronome et même la roue de Masson, mais, comme on le voit sans peine, ces divers systèmes d'interrupteurs avaient pour principaux inconvénients d'avoir un champ de variations trop restreint, d'être d'un prix élevé et de n'être pas transportables.

M. le docteur Onimus pour juger de l'influence des intermittences lentes ou rapides sur les mouvements du cœur et sur la contractilité musculaire dans certains cas de paralysie, s'adressa à M. Trouvé et voici l'appareil portatif qu'ils réalisèrent et que nous allons décrire.

Cet appareil d'induction à chariot (fig. 1) est constitué par une bobine inductrice indépendante des bobines induites, d'une pile hermétique Trouvé à renversement, des différents accessoires en usage en électrothérapie et d'un interrupteur spécial qui constitue la partie principale de l'appareil et fait l'objet de cette communication.

Cet interrupteur (fig. 2) se compose d'un cylindre divisé dans le sens de sa longueur en vingt parties; chaque partie est munie suivant la circonférence du cylindre d'un certain nombre de touches ou chevilles dont le nombre croît suivant une progres-

73

sion arithmétique, c'est-à-dire qu'à la première division il y a une touche ou cheville, à la seconde, deux à la vingtième, vingt.

Le cylindre est mû par un mouvement d'horlogerie dont la vitesse se règle au moyen d'un régulateur, ou volant, à vitesse variable, ce qui permet de donner au cylindre le nombre de tours que l'on désire par seconde. Un stylet se meut à volonté parallèlement à l'axe du cylindre et peut être mis successivement en contact avec les différents nombres de touches, ce qui a pour but d'interrompre le courant autant de fois qu'il y a de touches à la position qu'il occupe.

Supposons que le stylet se trouve à la première division, où il n'y a qu'une touche; si le cylindre ne fait qu'un tour par seconde, le courant sera interrompu toutes les secondes et si on lui fait occuper successivement toutes les positions jusqu'à la vingtième on aura 2, 3, 4.... 20 interruptions du courant par seconde.

Donnant donc au cylindre une vitesse de 1, 2, 3, 4, 5, etc., tours par seconde, chaque touche sera multipliée par ce même nombre de tours et l'on obtiendra avec la plus grande précision, depuis une interruption jusqu'à cent, en passant par les intermédiaires, et l'on aura dans un temps donné un nombre d'interruptions donné.

Comme dans la marche du cylindre il serait impossible de lire les divisions et par suite placer le stylet au nombre voulu, on a placé parallèlement au cylindre une petite règle en ivoire divisée aussi en vingt parties qui correspondent aux divisions du cylindre, et en regard du stylet une petite aiguille que l'on met sur la division déterminée pour obtenir le nombre d'intermittences voulu.

Nous allons expliquer maintenant comment M. Trouvé est parvenu à obtenir que les passages successifs du courant principal ne varient pas en durée quelqu'en soit le nombre dans un temps donné. Cette précision dans la durée du passage successif du courant a une importance capitale; autrement, quelle comparaison établir entre des phénomènes qui varieraient entre eux justement comme la source qui les produirait?

A cet effet, le stylet E (fig. 3) comporte deux contacts A, B, en platine, superposés l'un à l'autre sur une plaque d'ébonite.

Ces contacts sont mis directement et à volonté dans le circuit au moyen d'un ressort à boudin. On conçoit dès lors que si le contact supérieur B est dans le circuit, le passage du courant sera établi au moment même où le stylet sera soulevé par une touche du cylindre C, pour cesser immédiatement lorsque la touche sera passée.

Or, comme d'un côté, toutes les touches du cylindre ont la même vitesse, et que de l'autre, le stylet E et le ressort antagoniste D restent invariables, il en résulte que le temps du soulèvement du stylet reste lui-même invariable, quelque soit le nombre de soulèvements pour une révolution du cylindre.

Il en est de même du passage du courant qui est lié au soulèvement du stylet.

Les choses se passent autrement si la communication électrique a lieu par le contact A, car le passage du courant aura lieu pendant toute une révolution du cylindre, si le stylet est placé sur la première division, soit une seconde, par exemple, tandis que le stylet placé sur la division 20 du cylindre, le temps du passage des courants n'atteindra pas une vingtième de seconde. En un mot, la durée des passages successifs du courant variera comme le nombre même des intermittences, et c'est là le fait de tous les interrupteurs. Il résulte des deux effets que nous venons d'expliquer que pour produire des courants induits successifs, rigoureusement égaux, ce qui n'a lieu qu'avec cet appareil, il faudra établir la communication électrique avec le contact B et avec A, pour produire des courants continus intermittents, sur des courants induits variant en durée.

Les deux serre-fils 1 et 2, ont été disposés à cet effet pour placer le patient et l'interrupteur dans le circuit d'une batterie à courant constant et continu. Il suffit alors de mettre l'interrupteur en mouvement pour avoir des intermittences.

M. Trouvé s'en sert encore pour déterminer d'une manière irréfutable le nombre des vibrations que doit donner le trembleur d'une bobine de Ruhmkorf quelconque pour obtenir de suite de cette bobine le maximum d'effet.

Dans ce dernier cas, les contacts au lieu de se faire par les frotteurs métalliques A, B, se font dans une auge à mercure, comme dans l'interrupteur de Foucault.

Si on examine de près la figure 3, on s'aperçoit facilement que les contacts du stylet E avec les deux ressorts flotteurs A B, se font à glissements et tangentiellement, et que par conséquent la fermeture et l'ouverture du courant se font instantanément, sans passer par des variations de pression, conditions les plus favorables à la production des courants induits et des chocs musculaires isolés, nets et bien tranchés.

On recueille ces derniers en plaçant les cordons des électrodes en 5 et 6, pour l'extra-courant en 6 et 7 on recueille les induits; en 5 et 7, l'extra-courant et les induits réunis.

M. Trouvé, voulant doter la pratique médicale d'un appareil remplissant les mêmes conditions, mais qui fut tout à fait à la portée de tous les praticiens, sous le rapport du prix et du volume, fit présenter à l'Académie de médecine, par M. le professeur Gavarret, l'appareil que nous allons également décrire (fig. 4). Voici à ce sujet la note remise pour le bulletin de l'Académie par le savant professeur lui-même, séance du 5 juin 1877.

« M. Gavarret présente, de la part de M. Trouvé, un nouvel appareil d'induction destiné à la pratique médicale; cet appareil très-portatif réalise un perfectionnement considérable. »

THE ELECTRICAL DEPARTMENT IN THE MECHANICS' FAIR, BOSTON, MASS.

Nov 9 78

At the Mechanics' Fair held four years ago in Boston there were nine entries classed under the head of electrical inventions; to-day there are eighteen. This increase marks the great advance we are making in the application of electricity to the useful arts.

Even in the approach to the exhibition building, which is opposite the Boston and Providence depot, corner of Columbus avenue and Pleasant street, one face is illuminated at night by an electric light, which simulates the white gleam of moonlight, throwing dark shadows and enabling one to see to pick up a pin on the sidewalk with perfect ease.

The illumination of the main building by electricity is the most important feature of the exhibition. One side of the large hall is lighted by five lamps which are run by the Wallace Farmer machine, and the opposite side is lit by four lamps run by the Brush machine. The Wallace Farmer lights are provided with plate carbons two inches by five or six in area. The voltaic arc plays across the smaller side. From three to five lamps are run upon one circuit by the Wallace Farmer machine. If one light should happen to go out, the others in the circuit are not extinguished, for the plate carbons close together and the light is relit. These lights necessarily flicker to a certain extent; they are, however, steadier than would be imagined when the great play of the voltaic arcs in each lamp is considered. It has been demonstrated at the fair that five lights at least can be furnished on one circuit by the Wallace Farmer method. This in itself is a decided achievement.

The Brush lamp makes use of what may be called the pencil carbon points in contradistinction to the Wallace Farmer carbon plates. Each of the Brush machines furnishes four lights, which are fed by four different currents running on two conductors to each lamp. The Brush lights appear to be steadier than the Wallace Farmer lights, but not so powerful. The question of the amount of power used by both machines and the resistances of the circuits of both machines enter, however, in the question of the amount of current generated which produces the lights. The Brush lamp is c.rtainly very steady in its action. The Wallace Farmer lamp and the Brush lamp do not differ in principle with the exception of the use of broad plates by the one and pencils by the other. The carbons of the Brush light are electroplated with copper, which, it is claimed, prevents the heating of the carbon below the point of burning and regulates the consumption at the points.

We have said that both lamps do not differ in principle. In the Brush lamp the upper carbon is lifted by the movable core of a straight electro-magnet; in the Wallace Farmer by the armature of a horseshoe magnet; and practically the same mechanical device is used in both lamps to prevent the upper carbon from falling when the circuit is made. In the Art Gallery the two rival lamps confront each other, and one can judge better there of the relative brilliancy of the two. The details of the pictures are clearly seen in the brilliant lights, which are softened by heavy ground glass or opal shades. Great interest is manifested in these lights, which seem to be the prominent ones before the American public.

No less than twenty different electrical lamps were exhibited this summer at the Paris Exhibition; and three hundred lamps were lit during the nights of the past summer in the French capital. The Jablochkoff candle has not made its way to this side of the water, and American makers of dynamo-electric machines are attacking the problem of electric lighting by means totally different from those used in France. While we use the continuous current machines the French makers are altering their machines into alternate current machines, so as to obviate the unequal wearing away of the positive and negative carbons. The Jablochkoff candle dispenses with a regulator and thus enables more than one light to be produced by the same alternating current. The American regulators exhibited at the Mechanics' Fair would not work with an alternating machine.

The subject of electric illumination is evidently in its infancy; four years ago, however, the Mechanics' Fair could not have been so satisfactorily lighted as it is every night at the present time by the Brush machines and the Wallace Farmer machines.

The next important invention, and by some considered the most important, is the telephone. Both the Bell telephone and the telephones of the Western Union and Gold and Stock Company are placed on exhibition. The forms of the Bell telephone are well known; both the hand and the box instrument are at the fair, and are connected with the various telephone dispatch companies in and out of Boston, so that one can converse about the fair with one's distant friends. It appears from various trials that a message can be heard better from Cambridge than from a neighboring room in the exhibition building; there is a certain condition of outside resistance beyond the mere resistance of the circuit which seems to give the best effect. In the Gold and Stock Company exhibit can be seen and heard the various forms of Phelps' telephones and also Edison's carbon transmitter. The latter, in combination with a Bell or Phelps telephone, gives the best effect of any telephones or telephonic combinations. It is claimed that the New England Telephone Company (Bell's patent) have succeeded in improving their methods of communication in cities and towns. The same company also exhibit a new and very sensitive call. It is marvelous how quickly a new industry has sprung up with the introduction of the telephone! New forms of flexible telephone cords, provided with binding ends, which obviate the expensive terminals now in use, are exhibited by Mr. Hale, and are practical improvements. Redding & Co. also exhibit enamel covered wire for telephones and electro-magnets in general. Copper wire is coated with a very thin black insulating preparation which is said to stand heat and moisture remarkably well. More turns of this wire can thus be wound upon a given bobbin or magnet than of silk or cotton covered wire.

Edison's electric pen, which is well known to readers of this journal, has a liberal space devoted to it in the exhibition. Many specimens of its work are given, including some fine writing by Edison himself.

An apparatus for lighting street lamps and gas jets in fire engine houses is shown by Mr. Stevens; it seems to be a very practical device, and superior to that which has lately attracted much attention in London. Mr. Stevens makes use of the direct current to turn on the gas, and of the spark produced by the extra current to light it. Many forms of hotel electric annunciators and burglar alarms are exhibited. The exhibition building is protected from fire by the automatic electric fire signal company. The principle of their device consists in the use of a small coil which expands by heat and completes an electric circuit, which thereupon gives an alarm. If electricity could be used to heat the buildings, it could be said to afford in itself both the means of preservation and destruction of the fair.

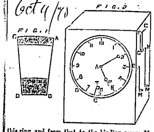
Nov 78

Longitude by Telegraph.—As a specimen of the precision now attainable in the determination of longitudes by galvanic signals, we may quote the three results, obtained at different times, and in different ways, for the difference of longitude of Greenwich Observatory and Harvard Observatory, Cambridge, Mass. They are as follows:—

	h.	m.	s.
In 1866, by Anglo-American Cables ...	4	44	31·00
In 1870, by French Cables, to Dixbury	4	44	30·99
In 1872, by French Cable, to St. Pierre	4	44	30·96

[34122.]—Connecting Clock with Electric Bell.—Solder a piece of platinum round the point of the small hand of the clock, and fasten or solder a piece of copper wire on to any part of the framework of the works, so that the wire will be in electric connection with the piece of platinum on the small hand; cut a piece of tin or ferrotype in the shape of Fig. 1; solder pieces of platinum foil on the parts denoted by the shading; file the end, A C, so that it slides easily between the brass ring, D C B, which holds the face, and the face; then connect a wire to

Oct 4/78



this ring, and from that to the binding screw, M. Connect the wire, E F, from the works with a pivot, F, on which works a brass spring, F G. The end, G, when pressed back, must touch the brass stud, H, which is to be connected by a wire to the binding screw, N. One pole of the battery (preferably a Léclanché) must be connected with N, the other being connected with one binding screw of the bell; the other screw of which must be connected with M. The action is as follows:—Having first pushed G on to H, and slipped the piece T C to the hour at which the bell is required to ring, the platinum point, P, coming in contact with the piece T C completes the circuit, and thereby rings the bell, which may then be stopped by slipping F G off H. Care must be taken that the point P, while making good contact, slides easily over B D (Fig. 1), or else, of course, the clock will stop. It is better to bevel the side, C D, to make it easier for the small hand to slide over it. The length, B D, depends on the time you want the bell to ring. Mine is just as wide as 2 minutes' space, and will ring for 24 if I don't stop it. I have had it for 4 months, and it has waked me every morning. I hope this will suit "J. W. E."—A. Wright.

Ingenious Application of Electricity in the Arts.—A new and useful application of electricity has been made by an American inventor to the apparatus for reeling silk from the cocoon. The delicate filaments of silk are carried over wire arms, which are so nicely balanced that they do not press against the silk strongly enough to break it, and in this relation a current is kept open; but, if the filament breaks, the arm falls, the circuit is closed, and an electro-magnet instantly stops the reel until the break is repaired. As the work is now done, the detection of a broken filament depends entirely upon the skill of the workmen, and the work must be carried on slowly that the eye can note any break, while with this automatic stop it is said the labour will be much more rapidly done, and a more uniform thread produced. The invention is being introduced into France and Italy, the two great silk-producing countries of Europe.

Dec 78

Jan THE TELECTROSCOPE. 79

M. SENLECQ, of Ardres, has recently submitted to the examination of MM. du Moncel and Hallez d'Arros a plan of an apparatus intended to reproduce telegraphically at a distance the images obtained in the camera obscura. This apparatus will be based on the property possessed by selenium of offering a variable and very sensitive electrical resistance according to the different gradations of light. The apparatus will consist of an ordinary camera obscura containing at the focus an unpolished glass and any system of autographic telegraphic transmission; the tracing point of the transmitter intended to traverse the surface of the unpolished glass will be formed of a small piece of selenium held by two springs acting as pincers, insulated and connected, one with a pile, the other with the line. The point of selenium will form the circuit. In gliding over the surface, more or less lightened up, of the unpolished glass, this point will communicate, in different degrees and with great sensitiveness, the vibrations of the light. The receiver will also be a tracing point of blacklead or pencil for drawing very finely, connected with a very thin plate of soft iron, held almost as in the Bell telephone, and vibrating before an electro-magnet, governed by the irregular current emitted in the line. This pencil, supporting a sheet of paper arranged so as to receive the impression of the image produced in the camera obscura, will translate the vibrations of the metallic plate by a more or less pronounced pressure on that sheet of paper. Should the selenium tracing-point run over a light surface the current will increase in intensity, the electro-magnet of the receiver will attract to it with greater force the vibrating plate, and the pencil will exert less pressure on the paper. The line thus formed will be scarcely, if at all, visible; the contrary will be the case if the surface be obscure, for, the resistance of the current increasing, the attraction of the magnet will diminish, and the pencil, pressing more on the paper, will leave upon it a darker line. M. Senlecq thinks he will succeed in simplifying this apparatus by suppressing the electro-magnet and collecting directly on the paper by means of a particular composition the different gradations of tints proportional to the intensity of the electric current.

MECHANICS.

January 21, 1882.

Electric Clocks.

Mr. James Hamblet, manager of the time service of the Western Union Telegraph Co., delivered a lecture on electrical clocks on last Wednesday evening before the New York Electrical Society. The speaker described his various experiments in the construction of his clock, the wires of which extend in five directions through this city and Brooklyn. He stated that the correct operation of this piece of mechanism depended, first, upon its pendulum, the most sensitive power in all mechanics, then upon its battery, and finally upon its dial. When these parts are perfectly made the success of the electrical clock could not be denied. The experiments of the past ten years directed toward this end had resulted in an almost perfect clock, in proof of which the lecturer read from the correspondence of parties now using instruments constructed in accordance with the most recent discoveries in this branch of science. He illustrated the making of a clock by a stereopticon display. The greatest number of dials manipulated by a single clock is 58, placed in the various apartments of the Boston High School. He described the New York time service and its results, and estimated that not more than a difference of three-tenths of a second ever existed between its record and those of the Washington and Cambridge observatories. This difference was mainly due to the sudden changes of temperature, and he prophesied that in a very short time a remedy would be provided for it. After he had concluded his lecture, he introduced to to the society Prof. Cleveland Abbey, of the Signal Service Bureau at Washington. Prof. Abbey stated that he had just been advised of the action of the American Institute of Civil Engineers calling for a national convention of engineers, business men, railroad men, and scientific societies generally, for the establishment of national conformity in time. He considered this a most sensible and important action. He didn't see how it mattered to any man whether his watch said 5, 10 or 1 o'clock when he got up in the morning, nor could he conceive any reason why we should have to count up 55 minutes every time we made a business engagement in Chicago, when it was just as easy for our watches everywhere to agree. The great railroad lines of the country had 70 different standard times, and the only reason they gave for such "standard confusion" was that it was difficult to alter an old method—a small reason for so bad a plan. He proposed, in lieu of a single national time, a compromise of three standard times—Philadelphia time for the Atlantic Coast, St. Louis time for the Mississippi Valley and San Francisco time for the Pacific Coast. He indorsed the action of the American Institute of Civil Engineers, and hoped it would lead to a radical reformation of this absurd confusion.

L'ÉLECTRICITÉ

REVUE SCIENTIFIQUE ILLUSTRÉE

BEAUX-ARTS — INDUSTRIE — MARINE — ART MILITAIRE — MÉDECINE

1re SÉRIE — N° 17 — 5 DÉCEMBRE 1878

SOMMAIRE

L'ÉLECTRICITÉ

A L'EXPOSITION UNIVERSELLE DE 1878

(12e *article*)

Roue phonique de M. Paul Lacour

(Suite)

Dans notre précédent article, nous avons dit que la roue phonique était susceptible de nombreuses applications; nous allons, aujourd'hui, étudier les principales.

Application comme chronographe. — Les chronographes sont, comme on le sait, des appareils destinés à mesurer de très-petits intervalles de temps écoulés entre deux ou plusieurs phases d'un phénomène que l'on veut étudier. Pour obtenir cette mesure, il est essentiel d'obtenir de la part du moteur appelé à fournir les indications un mouvement parfaitement uniforme, et nous avons vu que la roue phonique résolvait précisément ce problème, et cela de la manière la plus simple.

Si on calcule, d'après les données que nous avons exposées dans le précédent article, la limite de l'erreur qui peut résulter de ce système e mesure on reconnait qu'elle est plus petite que 1/25000.

Application comme horloge. — Le mode d'action de la roue phonique la rend susceptible d'être appliquée à l'horlogerie dans certains cas. En effet, comme trois systèmes d'appareils concourent à son fonctionnement, et que ces systèmes peuvent être placés à telle distance que l'on veut, on peut placer, par exemple, l'appareil vibrateur dans des conditions telles que les causes extérieures qui agissent sur les horloges de précision se trouvent soustraites à ces influences, et alors l'appareil compteur dirigé par la roue phonique peut fournir des indications rigoureusement précises en tel endroit qu'il convient.

En second lieu, plusieurs roues phoniques pouvant être introduites dans le même circuit ou commandées les unes par les autres, on pourra avoir plusieurs horloges marchant tout à fait synchroniquement.

Enfin, l'aiguille des secondes, ou toute autre marchant plus rapidement encore, pourra effectuer son mouvement sans secousse et d'une manière parfaitement régulière dans toute sa révolution.

Application à la détermination du nombre des vibrations d'un son. — La roue phonique peut être avantageusement substituée à la sirène pour la détermination du nombre des vibrations d'un son. Pour obtenir ce résultat, l'axe de la roue phonique porte une vis sans fin qui fait fonctionner un compteur comme on le voit fig. 10. Pour faciliter l'observation, le compteur peut être disposé d'après le système décimal ou centésimal, de manière que la différence entre deux observations donne directement le nombre d'ondes qui ont parcouru l'électro-aimant de la roue phonique pendant le temps qui s'est écoulé entre ces observations.

L'expérience se fait d'une manière différente suivant les conditions de la source sonore.

Si le corps sonore peut se maintenir longtemps en vibration, on peut l'employer lui-même comme organe transmetteur du courant, et le compteur, en indi-

had learned to adore him. Mr. Musters was a fearless explorer, and a man of unfailing tact and winning manners. Two or three years ago Mr. Musters returned from Bolivia, with which little-known country he had made a thorough acquaintance, and had, we believe, collected material for an interesting work. He recently received the appointment of Consul at Mozambique, and was to have left this month for his post, from which, he was delighted to think, he would be able to do some valuable exploring work in the African interior. By his death Her Majesty has lost a faithful and able servant, and science an eager explorer. Musters was loved by every one who had the pleasure of his acquaintance.

THE prosecution of marine surveys on the coasts of India has been for a long time much hampered by the want of a proper surveying steamer, and we are glad to learn from a Bombay paper that a new vessel—the *Investigator*—has just been launched, which will supply the defect. The steamer is well provided with all the necessary appliances for chart-making, deep-sea sounding, &c.

THE November number of the *Bulletin* of the French Geographical Society contains Dr. Jules Crevaux's account of his exploration in the interior of French Guiana in 1877. Dr. Crevaux, with little assistance and in the face of not a few difficulties, ascended the River Maroni, and striking the River Yary, traced its course to its junction with the Amazon. The two main results of his journey are the crossing for the first time of the Tumuc-Humac chain at the level of the sources of the Maroni, and the discovery and complete delineation of the Yary, an important affluent of the Amazon. The Maroni he describes as a fine river of about 140 leagues in length, with a breadth of 1,200 to 1,500 metres at 20 leagues above its mouth, and from 400 to 500 at 90 leagues. The River Yary, Dr. Crevaux considers as more important than the Maroni; it is 150 leagues long, and both rivers are much obstructed by falls and cataracts. Dr. Crevaux gives some very useful notes on the forests of Guiana and the different species of trees which they contain. The highest summits of the Tumuc-Humac range do not exceed 400 metres above sea-level. In summing up his observations on the geology of the region traversed, he says that all the formations met with from the mouth of the Maroni to that of the Yary have an ancient physiognomy. They ... may be

with the aid of reindeers or dogs. Herr Sibiriakoff has telegraphed to Baron Fredericks, asking him to send a party to the assistance of the Swedish Expedition. He has received a letter from Dr. Lindemann, of Bremen, in which the former says that at the coast where the *Vega* is believed to be lying there is a large native village, and from this village the nearest post of white merchants is distant only about 200 English miles, which may be traversed in winter in three or four days.

A REPORT has been received of a journey by Mr. Baber in the north-west of the Chinese province of Szuchuen. The original intention was to examine, between Suchow and Kiating, the River Tatu, which falls into the Yangtze-Kiang, and then to cross the mountains from Kiating to Fu-lin in long. 103°. At Fu-lin, however, Mr. Baber was induced to extend his exertions into the country further west, and he travelled onwards to a place called Tzu-Tati, the head-quarters of a Sifan chief. Here he heard of the existence of a mountain path to Ta-chien-lu, the French missionary station lying nearest to Tibet. After travelling three days through pine forests, the mountain range was crossed by a snowy pass, and on the northern slope yaks were found grazing, and many slates, inscribed with Sanskrit characters, were noticed. The appearance and language of the people also pointed to the fact that though Tibet proper is many hundred miles west of this point, yet tribes of the Tibetan race and language extend up to the banks of the Tatu River. This confirms the views already expressed by Mr. T. T. Cooper and other travellers.

THE *Japan Gazette* translates an article of some interest from the *Osaka Nippo*, on the subject of Japanese relations with Corea. After commenting on the progress made by Japan during the past few years, the writer remarks that "the Coreans, on the contrary, obstinately cling to the customs of Gio, Wu, and Shin, three Chinese sages who lived 3,000 years ago, and they believe their country is a part of Paradise, next in rank to China, and that western countries are inhabited by barbarians and savages."

COUNT WILCZEK and Lieut. Weyprecht intend to visit the northern coast of Novaya Zemlya in the course of this year, and will remain at that station for a twelvemonth in order to make a series of exact magnetic, electric, hydrographical, and meteorological observa-

A Practical Application of the Electric Current. Jan 4/79

A very important application of the electric current, says the British *Trade Journal*, is now being carried out by Sir William Armstrong on his estate. A volume of water descending at the outfall of a Northumberland lake has been utilized by the interposition of a turbine, by means of which the requisite revolutions are given to a dynamo electric machine. The electric current thus generated is conveyed through a stout copper wire to the private residence of Sir William at Cragside—a distance of about a mile and a half. The current is there conducted through a lamp, in which the regularity of the light is maintained by clockwork, subject to the control of an electro-magnet, which magnet reflects the strength or weakness of the current, so as to regulate the distance between the points of the carbon electrodes. It has been found necessary to provide a second wire to take the return current, so that the first cost of the light is somewhat large, but the working expense is very small. In addition to this use of the electric current as a source of light, Sir W. Armstrong intends to avail himself of the power thus brought into his house by applying it to several domestic purposes. This is to be accomplished by means of an electric engine situated in or near the house, and receiving the current transmitted from the machine at the lake outfall. In this way Sir William will be able to make a more constant use of what may be termed his electrical "plant," and thus may look forward to a satisfactory result in an economical respect. This example of the conversion and transmission of power will be viewed with great interest, the distance of a mile and a half being sufficient to indicate a much more extended sphere of action for the electric current than has hitherto been found practicable.

80

An electro-magnetic railway-ticket counter, to indicate the number of passengers going by a particular train, and so the number of carriages of each class required, has recently been adopted at the station of the Kaiser Ferdinand's Nordbahn, in Vienna. The date press of each of the three ticket boxes is furnished with an electric contact, actuated each time a ticket is pushed in to be stamped. Three lines connect the presses with a clock-shaped counter in the office, where the train is arranged, having discs with numbers and pointers, so that the number of passengers booked can be seen at once. The arrangement conduces to promptness in ordinary circumstances, and where great crowds are travelling, successive trains can be quickly despatched without overloading with passengers. Mayer and Wolf, of Vienna, supplied the apparatus. Jan 79

THE VOLTAIC PENCIL OF M. BELLET.—According to *l'Electricité*, means
have been found to engrave upon stone or metal by the effect of a voltaic
are produced from the point of a pencil. It is said that, by these means,
an artist can himself reproduce, immediately and without the interven-
tion of any skilled workman or mechanic, the most delicate and compli-
cated designs. If this statement can be confirmed, it will be of no small
interest to the proprietors of illustrated papers. Feb 15/79

THE VOLTAIC PENCIL. Feb 1/79

There is at the present time scarcely a single branch of industry to which electricity is not lending its aid. Art, however, has thus far received but little benefit from this source, if we except the application of electricity to electro-metallurgy. We are pleased to learn, then, that an important discovery has just been made at Paris by M. Bellet, whose invention consists of a voltaic pencil, by the use of which designers and draughtsmen will be enabled to dispense entirely with the aid of the engraver. The editors of *Electricité* state that they have examined beautiful proofs of lithographs and etchings obtained, without the use of the graver, by the effect of a voltaic arc produced at the point of an ordinary lead pencil. Encouraged by his success the inventor has taken out patents in various countries, and a company has been formed to carry out the process, which will soon be placed before the public. At present there are being prepared models of a series of apparatus which will allow any artist, however ignorant of the mysteries of electricity, to reproduce immediately, and without the aid of any artisan, the most delicate and complicated drawings; and this, too, by a very simple process and at a very moderate price. By a slight modification of the system there may be produced: (1) Stencils analogous to those produced by the Edison pen; (2) lithographs; (3) etchings; (4) stereotypes for typographical work. The initiators of this discovery are confident that an entire revolution will take place in the process of illustrating papers by means of their electrography.

ELECTRICAL CLOCK DIALS. Feb 1/79

M. RECORDON, of Paris, has since been manufacturing illuminated dials on an entirely different principle from those produced by the use of chemicals. His device is this: A Geissler tube containing a gas which gives a brilliant light is placed on the dial; a battery about the size of a thimble is attached as an ornament to the watch chain, and a miniature induction coil is also hidden in the latter. When it becomes desirable to consult the watch in the dark, a spring is pressed, the current passes into the coil, then into the Geissler tube, and illuminates the dial. The portable battery used for this purpose is that of Trouvé, which, in a small compass, has considerable strength. Reduced to the size of a thimble, it is still sufficiently strong in its action to last a year. M. Recordon also applies the same principle to the illumination of clock faces.

place under circumstances and conditions special to themselves, and which do not exist in the case of industrial or other works. These arise in part from the paramount necessity of providing in the lighthouse an illumination of the most perfect character, and abundant in intensity, as well as of providing an amount of extra plant to guard against any cessation in the illumination. The generally isolated situation of the lighthouse also adds to the cost of the materials employed, and causes the personal staff employed to be of a more skilled class, than where assistance in the matter of repairs is readily available. Any comparison, on purely economical grounds, between the electric illumination in lighthouses and in industrial works, must necessarily be unfavourable to the former.

(TO BE CONTINUED.)

THE TROUVE ELECTRICAL POLYSCOPE AND SAFETY LAMP, FOR POWDER MAGAZINES, MINES, DIVERS, CORAL AND OYSTER SEEKERS, &c.

The electrical polyscope, or the modification of it which constitutes the safety lamp, is composed of:—

1st. A reservoir in which dynamical electricity may be stored up, *i.e.*, a secondary battery of M. Planté.

2ndly. A series of reflectors, with or without mirrors, adapted for various modes of illumination, whether it be that requisite for a powder magazine, or that adapted for cavities in the animal organism. These reflectors are all parabolic. The reflecting lamp intended for powder magazines is provided with a double transparent envelope, which affords the requisite protection.

3rdly. A battery of four Trouvé-Callaud elements, for the purpose of charging the reservoir, together with various conductors and a stand, to which may be attached the reflectors of the safety lamp.

4thly. Of a special resistance coil or regulator of extreme simplicity, intended to regulate the flow of electricity from the reservoir. We use here the term "flow" of electricity, because those who are acquainted with secondary batteries will understand how analogous these are to a hydrostatic reservoir. The adjustment obtained by means of this regulator is so perfect that platinum wires, varying in diameter from 1-15th millimetre to 1¼ millimetre, may be raised to a temperature approaching the point of fusion of the metal without any danger of actually reaching this point.

5thly. A double-circuit galvanometer in which the electromotive force of the reservoir and that of the battery are in opposition. Thanks to this simple and ingenious arrangement, the operator or the practitioner can always know, on the one hand, the capability of the battery to effect the charge of the reservoir, and, on the other hand, the degree to which the reservoir is actually charged. Thus, when the reservoir is completely exhausted, the needle returns to its initial position, *i.e.*, to a *minimum* deflection of 30°. Should the deflection be less than this, it may be concluded that either sulphate of copper or a zinc element requires to be supplied.

The utility of the apparatus in the case of powder magazines will readily be understood. At the entrance to each magazine is placed a box containing three or four Trouvé-Callaud elements; and on the box is stood the reservoir or secondary battery, the charge of which is to be maintained by the primary elements in question. Whenever the artillerist requires to enter the magazine, he takes the reservoir in one hand, and in the other the stand which carries the reflector; and, the moment he completes the circuit by means of the key attached to the stand, the darkness is dispelled by the magic light of this ingenious apparatus, a light which, if necessary, will last for several consecutive hours. In case of accident, the artillerist would carry with him a duplicate reflector, which could be substituted for the other upon the stand.

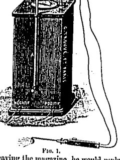


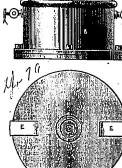
FIG. 1.

On leaving the magazine, he would replace the secondary ...

81

AN ELECTRICAL MOUNTING TABLE.

[15531.]—I VENTURE to inclose tracing and brief description of an electrical mounting table, devised



Apr 79

by me last winter, thinking that it may be likely to interest some of your readers who, like myself, mount their own objects for the microscope, and like to have both hands free while doing it. I found it irksome to have one hand occupied in turning the table, so set about making a table that would work independently of any manual help. I use a small bichromate battery, and find that by raising or lowering the zinc I can very evenly regulate my speed. Upon connecting the two battery wires with the terminals A, a current traverses the electro-magnet pivoted upon the shaft C. It then turns towards the highest point in the nearest inclined armature, of which there are several, cast in the wall of the casting B. Before it reaches quite the top of incline, the current ceases, and with it any retarding action upon the revolving magnet. Acquired momentum carries it past this point, when the current again excites the magnet, which commences to climb the next. A continuous rotatory motion is thus imparted to the table, and any slide or other object held under the steel clips E. I shall be glad to give you any further details. The table is provisionally registered. F. M. Rogers.

29, Moorgate Station Buildings, E.C.
March 31, 1879.

82

AN ELECTRIC TELESCOPE.

[15374.]—It may be of interest to your readers to know the details of some experiments on which I have been engaged during the last three months, with the object of transmitting a luminous image by electricity.

To transmit light alone all that is required is a battery circuit with a piece of selenium introduced at the transmitting end, the resistance of which falling as it is exposed to light increases the strength of the current, and renders a piece of platinum incandescent at the receiving end thus reproducing the light at the distant station.

By using a number of circuits, each containing selenium and platinum arranged at each end, just as the rods and cones are in the retina, the selenium end being exposed in a camera, I have succeeded in transmitting built-up images of very simple luminous objects. Feb 7/78

Correspondence.

[We do not hold ourselves responsible for the opinions of our correspondents.]

CLERAC'S TUBE.

To the Editor of THE TELEGRAPHIC JOURNAL.

DEAR SIR,—Enclosed I send you official communications just received from the French Government relative to Clerac's Tube.

Sincerely yours,

3rd Feb., 1879. D. E. HUGHES.

"Paris, le 1er Février, 1879.

"MONSIEUR LE PROFESSEUR,—Conformément au désir que vous m'avez exprimé, je vous adresse ci-joint une série de documents établissant que les tubes de resistance ou rhéostats à charbon imaginés par Monsieur Clérac, remontent certainment à une date anterieure au 4 Mars, 1866.

"Recevez, Monsieur le Professeur, l'assurance de ma consideration tres distinguée,

"COCHERY,

"Le sous Secrétaire d'Eat des Finances.

"Monsieur le Professeur Hughes,
"94, Great Portland Street, London, W."

The following is a translation of the above letter:—

"Paris, Feb. 1, 1879.

"MONSIEUR LE PROFESSEUR,—Conformably to the desire that you have expressed to me, I send you herewith a series of documents establishing that the resistance tubes or carbon rheostats, invented by M. Clerac, go back certainly to a date anterior to the 4th March, 1866.

"Receive, M. le Professor, the assurance of my very distinguished consideration,

"COCHERY,

"The Under-Secretary of State for Finance.
"(Now Minister of Posts and Telegraphs.)

"Professor Hughes,
"94, Great Portland Street, London, W."

[Here follows the original letter from Professor Hughes to M. Clerac respecting his tubes, which we published in the Correspondence of our last number. It bears the Paris postmark for March 10, 1866, on its back.—ED. T. J.]

The other documents are:—

"Paris, January 27, 1879.

"My dear M. Clerac,—It was in 1866 that I delivered to the Administration des Telegraphes the first Hughes' apparatus that I constructed. It was equally in the same year that I was nominated a member of the Comité de Perfectionnement de Lignes Télégraphiques, of which Professor Hughes was also a member. These dates make me absolutely certain that Prof. Hughes spoke about and described to me, either at the end of 1865 or in the beginning of 1866, your rheostat formed of powdered carbon or pulverised plumbago, which you mixed more or less with other substances, and which you compressed more or less. I recollect perfectly this little tube which I held in my hands, and in answer to my question, 'Can this serve as a standard of resistance?' Professor Hughes replied that you had found that the conductivity was variable with the pressure. (M. Hughes m' a repondu que vous aviez reconnu que la conductibilite etait variable avec la pression.)

"All this, my dear M. Clerac, I recollect perfectly, and I attest it willingly to you by this letter, begging you to believe me,

"Votre plus devoué,

"E. HARDY,

"Ingenieur-Electrician.

"5, Avenue de la Motte Piquet, Paris."

"Paris, January 27, 1879.

"I, the undersigned, declare that I constructed in the course of the year 1873, with carbon, metallic, and other powders, agglomerated by means of fatty bodies, sundry resistance apparatus, which had for their starting point (qui avaient pour point de départ) the economical rheostats, formed of powdered carbon compressed in insulating tubes by regulating screws, invented anteriorly by M. Clerac.

"(Signed) BEAUFILS,

"Chemist, Chargé du Laboratoire à la Reception du Material."

"Paris, January 27th, 1879.

"L'Inspecteur-ingenieur, Chargé du Service de la Reception du Materiel des Telegraphes, certifies to having made use in 1873 for to establish leakages (établir des derivation) on lines from Paris to Marseilles, some of the resistance apparatus which form the subject of M. Beaufils' certificate.

"(Signed) LAGARD."

"Paris, January 28th, 1879.

"The undersigned certify to having executed towards the end of the year 1865, and during the year 1866, according to the instructions of M. Clerac, and under his direction, certain rheostats of powdered charcoal and graphite, dried, and compressed in glass and wooden tubes by aid of a regulating screw, whose degree of pressure permitted the resistance to be varied.

"This work was done in the premises set apart for the course of instruction on the Hughes' apparatus at the seat of the Administration des Télégraphes, Paris.

"(Signed)

"L. MANDROUX, L. RAULT, L. BARDEZ."

Agents speciaux des Telegraphes a l'Administration Telegraphique.

The following letters on the above subject have also been addressed to the TELEGRAPHIC JOURNAL.

SIR,—Prof. Barrett's arguments would be more readily understood as coming from a lawyer rather than from a man of science. He pretends that since I did not speak of the variation of resistance with difference of pressure, in my note of 1874, to the *Journal Telegraphique* of Berne, it was because I was ignorant of the phenomenon. To that the reply is easy: I had no call in a note of several lines to give the theory of my apparatus, but only to set right an allegation of M. Zetzsche who attributed that invention to a German. It will suffice to re-read my note and the article to which it replied for to convince any one that there was no need then either to describe the article or to give the theory of it.

If now any one examines my tubes, he will be led to ask himself why I employed pressure screws, if it was

83

not for the purpose of varying the compression of the powder until the resistance sought is obtained.

Further—and this is a criticism that I have myself addressed to my inventions since the beginning—as Prof. Hughes will be able to recall—the variations of temperature in dilating or in contracting the glass or wood, produced variations of the resistance of the powder; but it is not necessary to be *un grand savant* for to render an account of that phenomenon. These changes of resistance proceeded from a variable state of compression of the powder which was of necessity subjected to the mechanical action exerted by temperature on the tube which contained it. I have truly no merit in explaining this simple cause which has struck all those who have handled my tubes. I will add besides, that if it had been able to escape my own notice it would certainly not have escaped that of everybody else at that time.

I believe that it would not have said much for Prof. Barrett, supposing he had been in my place, if he had hesitated a single instant to recognise the cause whose effect he had thus ascertained. This being so, is it possible for any unbiassed mind to suppose that I could not then explain the action of pressure?

To sum up, in whatever manner I reason, I cannot find the least appearance of solidity in the arguments of Prof. Barrett, and it seems to me that it is only necessary to ask my tube itself in order that it should respond for me.

HIPPOLYTE CLERAC,

Inspecteur Ingenieur des Telegraphes.

Paris, Feb. 3, 1879.

Allow me, sir, some new reflections on the subject of the pretensions of Mr. Edison mentioned in the last letter of Professor Barrett.

Even admitting that the tubes of Clerac were not furnished with resistances variable with pressure, which is contrary to the opinion of all those who have had acquaintance with these tubes, it does not therefore follow that Mr. Edison made that discovery, even for carbonaceous powders. For here is what I have myself published on this subject in the *Comptes Rendus* of the Academy of Sciences for Dec. 2, 1872, in regard to the electric resistance of carbon powders and metallic filings:—

"The resistance of the middle medium with dry powder of wood charcoal was from 1,200 to 2,000 kilometres of telegraph line, and with metallic powders or retort carbon, from 1,200 to 2,000 metres, according to the more or less brilliant state of the surface of the metal grains and their degree of closeness (tassement) round the electrodes, &c."

For the rest I have been occupied with this question at four different times since 1856.

1. In 1856 I studied it from the point of view of the imperfect contact of the metallic studs of current interrupters (see my *Exposé des Applications de l'Electricité*, 2nd Edition, Vol. I., p. 246).

2. In 1864 I studied it from the point of view of the relative insulation of the spires of an electro-magnetic helix with bare wires (see my Memoirs on this subject in the *Annales Telegraphique*, Vol. VIII., p. 211, the numbers for March-April, 1865).

3. In 1872 I studied it from the point of view of the conductivity of semi-conductors (see the *Comptes Rendus*, Dec. 2, 1872).

4. In 1874 I studied it from the point of view of the application of electrodes on ligneous bodies (see my Memoirs in the *Comptes Rendus* for July 6, 1874, Aug. 10, 1874, Sept., 1874, and May 2, 1875).

Like Professor Barrett, I concluded that the effects determined by the pressure proceeded from a more intimate contact of the molecules of the bodies at the point of contact. The following is what I said, in fact in my note of July 6, 1874:—

"It is always the case that the conductivity is in ratio to the degree of pressure of the plates of communication. This last action evidently depends on the *greater or less intimacy of contact which is produced at the time between the two superposed surfaces.* For in substituting a drop of distilled water instead of the pressure, we immediately get, with the plate simply placed upon the table, the maximum of deviation, just as if these plates had been pressed by presses."

This question of indifferent contacts has engaged my attention during twenty years. I have even devoted a chapter to it in my *brochure* on the conductivity of semi-conductors, and Mr. Edison cannot honestly call himself the author of a discovery made when he was hardly six years of age. It is, therefore, not without a certain sentiment of regret that I see Mr. Edison, whom I was the first to herald into France, continue to sustain pretensions which cannot be sustained, and to put forward as his own an apparatus under the name of *Pressure Rheostat*, and which is only the Clerac Tube with a micrometer added. Such a course of action is unworthy of him.

Accept the expression of my best sentiments,

DU MONCEL.

HYDRO-ELECTRICITY AND HYDRO-MAGNETISM are the names given by M. C. A. Bjerknes, of Christiania, to certain attractions and repulsions observed by him between bodies in water. The bodies he experimented with were oscillating glass bells inverted in the water, and by means of tubes and an air-pump, pulses of air, causing pulsations in the water, could be sent into the bells. When the pulsations in the two bells were concordant, attraction ensued, when discordant, repulsion. A neutral or critical point was also observed in certain cases, and lateral deviation could also be produced. We do not see why this effect should be laid at the door of electricity since it appears to be quite mechanical. Mar 79

THE VOLTAIC PENCIL.—Bellet's voltaic pencil, which has been patented in England in the names of Louis Bellet and Count Hallez D'Arros, founder of *L'Electricite*, was exhibited, along with some of its work, at the Scientific Soirée given by Admiral Mouchez, at Paris, on Feb. 21. These works comprised engravings on copper, steel, and stone, executed at first hand by the spark from the pencil point, and electro-stencils or copies of documents and drawings. It is believed that this electric graver and pencil will be useful in military topography. apr 79

——A vibrating needle, actuated by clock-work, and intended as a substitute for Edison's well-known electric pen, is the subject of a recent patent.——If newspaper reports may be credited, Mr. Edison has succeeded in perfecting his electric lighting system to his satisfaction, and purposes at once to make a public display of it.——A French inventor proposes to temper and scatter the electric light by the use of wadding made of glass fiber in place of using clouded glass shades. He claims to reduce the amount of loss by absorption by at least 25 or 50 per cent.——Engravings on copper, steel, and stone, executed by what is known as Bellet's voltaic pencil or electric graver, were exhibited at a late scientific soirée given at Paris. April 79

84

Recent Electrical Work at the U. S. Torpedo Station, Newport.

PREMISING that comparatively little has been done at Newport for the improvement of torpedoes during the past two years, owing to the smallness of the appropriations therefor, a special correspondent of the *World* writes that one of the most important discoveries made within that time has been Lieutenant A. R. Couden's improved method of determining the internal resistance of galvanic batteries. The method hitherto practiced at the station is described by Professor Farmer as follows:

"Introduce into the circuit of a galvanic battery a convenient rheostat and a suitable fine wire galvanometer. Open and adjust the rheostat until a convenient deflection is obtained (42° 21' is liable to least error); note carefully the deflection. Next reduce the total external resistance of the circuit one half. (Th's presupposes that the rheostat, as opened, offers more resistance than the galvanometer.) The needle will now be deflected more than it was at the first observation. If now another adjustable rheostat be used as a shunt across the terminals of the battery, this shunt can be so adjusted that the reading of the galvanometer shall return to the same position as in the first observation. When this is the case, the resistance of the shunt is equal to the internal resistance of the battery.

Lieutenant Couden conceived the idea that if the two changes, viz.: shortening the resistance and applying the shunt, were made simultaneously, there would be at the first instance no movement of the needle, if the proper shunt were first chosen. He availed himself of the two keys used in manipulating the Wheatstone bridge to carry out the idea. The results were quite satisfactory, but the two keys being independent of each other and fat apart, required two fingers to press them, and sometimes failed to operate with complete simultaneity. To remedy this Professor Farmer had made for Lieutenant Couden a key with a single finger piece, but with two independent contact closers, which admitted of such adjustment as to secure the required simultaneous closing of the two circuits when the key was depressed. The apparatus, as thus constructed, operates with entire satisfaction.

Improvements have also been made in the method of splicing the torpedo cables and leading wires now issued to ships. Mr. Farmer says that in all insulated wire now issued to ships for permanent wires, for spar leading-wires, and torpedo cables, the conductor consists of seven strands of small copper wire, and is therefore very flexible. Should it become necessary to join two pieces of cable together, it can now be done by knotting the wire by, first, a sheet bend; second, a reef knot; third, a carrick bend. The advantages over the earlier form of splicing are four-fold, viz., first, the splicing nippers and splicers in the supply-box are abolished; second, instruction to the sailor is unnecessary, and the operation is more quickly performed; third, it is the strongest way of joining two pieces of wire; fourth, the electrical properties are all that can be desired.

The modification and improvements in the electric primer are as follows: In putting in the bridge great uniformity in length and consequently in the electrical resistance is obtained; rounding up the quills so that the primers will enter the vent guns freely; a method of "choking in" the quills and securing them firmly to the wires.

The United States steamer *Trenton*'s electrical apparatus is a noteworthy result of discoveries at the torpedo station. A full description of it would occupy too much space, but it may be stated that it is for two distinct purposes—firing of guns and torpedoes, and calls and automatic fire alarms. That intended for guns and torpedoes is designed to place the firing under the control of a single officer stationed at some central point, who shall be able to fire any gun when it is ready, or either or both broadsides, or as much of a broadside as may be ready.

Experiments have also been made with the telephone in order to ascertain its suitableness for communication between the bridge and the powder magazine, as well as between other parts of the ship. It has been found possible to communicate over a cir-

cuit of 22,000 ohms, having a stated capacity of eight microfarads, whence it is easy to see that it would be entirely feasible to communicate through an ocean cable between two stations that should be at least 500 miles apart. The rapidity of communication, too, is astonishing, since 145 words in 17 seconds were distinctly heard over a short circuit this is at the rate of 512 words per minute. The possibility of communicating with way stations at a distance from the direct line, and without a loop, has been satisfactorily demonstrated by Professor Farmer and his assistants.

Europe ...

An Electric Blowpipe.

June 7

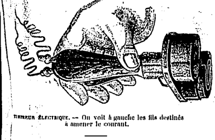
M. JAMIN, in *Comptes Rendus*, remarks that the electric arc which plays between two carbon conductors is a true current. If submitted to the influence of a neighboring current, of a solenoid, or of a magnet, it experiences an action regulated by the laws of Ampère, identical with that experienced by any metallic conductor put in its place, but as its mass is exceedingly trifling its speed is considerable. The author takes advantage of this fact to submit small quantities of matter to an intense heat. By causing the arc to be drive.. upon lime, magnesia or zinconia, the light is directed downwards, and its intensity increased at least threefold.

Timbreur électrique

Cet appareil, d'invention américaine, est destiné à remplacer l'instrument dont se servent les employés des postes pour annuler les timbres apposés sur les lettres. Le système en est bien simple. Un mince fil de platine, contourné de manière à former un dessin quelconque, peut être mis en communication avec une pile électrique. On ferme le circuit en pressant sur le ressort *a*, le fil de platine rougit et si l'on appuie l'instrument sur le timbre, e papier sera brûlé par le platine qui formera ainsi une marque complètement ineffaçable.

Apr 20

Le cliché qui suit est tiré du *Monde de la Science et de l'Industrie* à qui nous l'avons emprunté.



TIMBREUR ÉLECTRIQUE. — On voit à gauche les fils destinés à amener le courant.

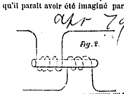
Nous avons bien des fois à citer des exemples dans lesquels le succès de l'audition téléphonique a été empêché par les bruits parasites résultant du passage d'un courant dans une ligne voisine.

Il y a déjà quelque temps que le problème de leur suppression occupe les électriciens.

Nous nous bornerons à faire comprendre le principe tel qu'il paraît avoir été imaginé par M. Wilson.

Apr 79

Fig. 2.



... Wilson avec bobine de résistance.

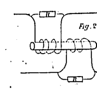
Comme on le voit par la figure ci-contre, on enroule autour d'un morceau de fer doux le fil du téléphone et un bout du fil de ligne qui lui est parallèle pendant un nombre plus ou moins grand de milles.

Il en résulte que le courant qui se propage dans la ligne télégraphique donne naissance à deux courants, le courant d'induction dont on veut se protéger, et un courant inverse produit par l'enroulement sur le fer doux.

Ces deux courants, allant en sens inverse l'un de l'autre, tendent forcément à se détruire.

Pour qu'il y ait neutralisation parfaite, M. Wilson a imaginé de placer dans chaque circuit une bobine de résistance dont on fait varier la longueur.

Fig. 2



Extincteur Wilson pour les bruits parasites gênant l'audition téléphonique.

85

MR. LATIMER CLARK has issued an address to the President and Council of the Society of Telegraph Engineers, suggesting wider scope for the Society.

MR. SCUDAMORE has gone to Beyrouth at the request of Midhat Pasha.

AN ELECTRIC BORER.—M. Gaston Planté has published his important researches on electricity and the electric discharge in an octavo volume dedicated to the Emperor of Brazil. From a copy of these very interesting studies now before us, we extract the following passage relative to the boring power of the electric spark:—"We have seen that one of the electrodes which conveys a current of a certain electromotive force on being put in contact with glass, in presence of a saline solution, acts as a graver or a diamond in cutting furrows on the surface of the glass, ploughing it even deeply. Rock-crystal can also be attacked, despite its hardness, by the same method, and if it does not yield regularly it at least bursts into pieces under the influence of the electrode, and ends by breaking up. In America black diamonds are employed in rock drilling for wells and mines. Could these expensive tools not be replaced by the action of the electric current in conditions analogous to those which have been described, and the perforation of rocks be performed by electricity? Electrodes of platinum would not be necessary, for it is not the metal of the electrode which alters, but merely the silicious matter in presence of the saline solution. Metallic points or studs conveniently distributed at the end of the drill and put in rotation would direct the electric discharge to the rock, which it would pulverise as in the case of the diamond drill. The recent advances

in the production of electricity by mechanical means would facilitate this application."

A New Departure in Electrical Education.

WE learn that Dr. Muirhead and Professor Ayrton propose receiving at their electrical laboratory, adjoining the telegraph works of Messrs. Latimer Clark and Muirhead, pupils who desire to receive a complete education as telegraph engineers, and especially those who are anxious to be trained in conducting original research in electricity and magnetism. In addition to their receiving practical instruction in the manufacture and testing of electrical apparatus and in the mathematical theory of electricity as technically applied to telegraphy, we understand that it is proposed that all the students shall be placed in charge of original experimental investigations. We need hardly refer to the difficult task of duplexing the long submarine cables in the Atlantic, Mediterranean, Red Sea and Indian Ocean, successfully accomplished by Dr. Muirhead with his "inductive resistance," or to the numerous experimental researches of Professors Ayrton and Perry, carried out in the electrical laboratory at the Imperial College of Engineering in Japan, as evidence of the thorough training students are likely to receive.—*The Electrician.*

June 79

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PREMISING that comparatively little has been done at Newport for the improvement of torpedoes during the past two years, owing to the smallness of the appropriations therefor, a special correspondent of the *World* writes that one of the most important discoveries made within that time has been Lieutenant A. R. Conden's improved method of determining the internal resistance of galvanic batteries. The method hitherto practiced at the station is described by Professor Farmer as follows:

"Introduce into the circuit of a galvanic battery a convenient rheostat and a suitable fine wire galvanometer. Open and adjust the rheostat until a convenient deflection is obtained (42° 21′ is liable to least error); note carefully the deflection. Next reduce the total external resistance of the circuit one half. (Th's presupposes that the rheostat, as opened, offers more resistance than the galvanometer.) The needle will now be deflected more than it was at the first observation. If now another adjustable rheostat be used as a shunt across the terminals of the battery, this shunt can be so adjusted that the reading of the galvanometer shall return to the same position as in the first observation. When this is the case, the resistance of the shunt is equal to the internal resistance of the battery.

Lieutenant Conden conceived the idea that if the two changes, viz.: shortening the resistance and applying the shunt, were made simultaneously, there would be at the first instance no movement of the needle, if the proper shunt were first chosen. He availed himself of the two keys used in manipulating the Wheatstone bridge to carry out the idea. The results were quite satisfactory, but the two keys being independent of each other and far apart, required two fingers to press them, and sometimes failed to operate with complete simultaneity. To remedy this Professor Farmer had made for Lieutenant Conden a key with a single finger piece, but with two independent contact closers, which admitted of such adjustment as to secure the required simultaneous closing of the two circuits when the key was depressed. The apparatus, as thus constructed, operates with entire satisfaction.

Improvements have also been made in the method of splicing the torpedo cables and leading wires now issued to ships. Mr. Farmer says that in all insulated wire now issued to ships for permanent wires, for spar leading-wires, and torpedo cables, the conductor consists of seven strands of small copper wire, and is therefore very flexible. Should it become necessary to join two pieces of cable together, it can now be done by knotting the wire by, first, a sheet bend; second, a reef knot; third, a carrick bend. The advantages over the earlier form of splicing are four-fold, viz., first, the splicing nippers and splicers in the supply-box are abolished; second, instruction to the sailor is unnecessary, and the operation is more quickly performed; third, it is the strongest way of joining two pieces of wire; fourth, the electrical properties are all that can be desired.

The modification and improvements in the electric primer are as follows: In putting in the bridge great uniformity in length and consequently in the electrical resistance is obtained; rounding up the quills so that the primers will enter the vent guns freely; a method of "choking in" the quills and securing them firmly to the wires.

The United States steamer *Trenton's* electrical apparatus is a noteworthy result of discoveries at the torpedo station. A full description of it would occupy too much space, but it may be stated that it is for two distinct purposes—firing of guns and torpedoes, and calls and automatic fire alarms. That intended for guns and torpedoes is designed to place the firing under the control of a single officer stationed at some central point, who shall be able to fire any gun when it is ready, or either or both broadsides, or as much of a broadside as may be ready.

Experiments have also been made with the telephone in order to ascertain its suitableness for communication between the bridge and the powder magazine, as well as between other parts of the ship. It has been found possible to communicate over a cir-

cuit of 22,000 ohms, having a stated capacity of eight microfarads, whence it is easy to see that it would be entirely feasible to communicate through an ocean cable between two stations that should be at least 500 miles apart. The rapidity of communication, too, is astonishing, since 145 words in 17 seconds were distinctly heard over a short circuit this is at the rate of 512 words per minute. The possibility of communicating with way stations at a distance from the direct line, and without a loop, has been satisfactorily demonstrated by Professor Farmer and his assistants.

Europe ...

An Electric Blowpipe.

M. JAMIN, in *Comptes Rendus*, remarks that the electric arc which plays between two carbon conductors is a true current. If submitted to the influence of a neighboring current, of a solenoid, or of a magnet, it experiences an action regulated by the laws of Ampère, identical with that experienced by any metallic conductor put in its place, but as its mass is exceedingly trifling its speed is considerable. The author takes advantage of this fact to submit small quantities of matter to an intense heat. By causing the arc to be driven upon lime, magnesia or zirconia, the light is directed downwards, and its intensity increased at least threefold.

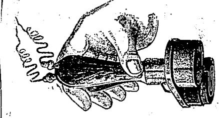
June 79

Timbreur électrique

Cet appareil, d'invention américaine, est destiné à remplacer l'instrument dont se servent les employés des postes pour annuler les timbres apposés sur les lettres. Le système en est bien simple. Un mince fil de platine, contourné de manière à former un dessin quelconque, peut être mis en communication avec une pile électrique. On ferme le circuit en pressant sur le ressort *a*, le fil de platine rougit et si l'on appuie l'instrument sur le timbre, e papier sera brûlé par le platine qui formera ainsi une marque complétement ineffaçable.

Apr 20

Le cliché qui suit est tiré du *Monde de la Science et de l'Industrie* à qui nous l'avons emprunté.



TIMBREUR ÉLECTRIQUE. — On voit à gauche les fils destinés à amener le courant.

Nous avons bien des fois à citer des exemples dans lesquels le succès de l'audition téléphonique a été empêché par les bruits parasites résultant du passage d'un courant dans une ligne voisine.

Il y a déjà quelque temps que le problème de leur suppression occupe les électriciens.

Nous nous bornerons à faire comprendre le principe tel qu'il paraît avoir été imaginé par M. Wilson.

Apr 79

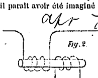


Fig. 2.

... avec bobine de résistance.

Comme on le voit par la figure ci-contre, on enroule autour d'un morceau de fer doux le fil du téléphone et un bout du fil de ligne qui lui est parallèle pendant un nombre plus ou moins grand de milles.

Il en résulte que le courant qui se propage dans la ligne télégraphique donne naissance à deux courants, le courant d'induction dont on veut se protéger, et un courant inverse produit par l'enroulement sur le fer doux.

Ces deux courants, allant en sens inverse l'un de l'autre, tendent forcément à se détruire.

Pour qu'il y ait neutralisation parfaite, M. Wilson a imaginé de placer dans chaque circuit une bobine de résistance dont on fait varier la longueur.

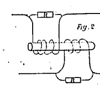


Fig. 2

Extincteur Wilson pour les bruits parasites gênant l'audition téléphonique.

MR. LATIMER CLARK has issued an address to the President and Council of the Society of Telegraph Engineers, suggesting wider scope for the Society.

MR. SCUDAMORE has gone to Beyrouth at the request of Midhat Pasha.

AN ELECTRIC BORER.—M. Gaston Planté has published his important researches on electricity and the electric discharge in an octavo volume dedicated to the Emperor of Brazil. From a copy of these very interesting studies now before us, we extract the following passage relative to the boring power of the electric spark:—"We have seen that one of the electrodes which conveys a current of a certain electromotive force on being put in contact with glass, in presence of a saline solution, acts as a graver or a diamond in cutting furrows on the surface of the glass, ploughing it even deeply. Rock-crystal can also be attacked, despite its hardness, by the same method, and if it does not yield regularly it at least bursts into pieces under the influence of the electrode, and ends by breaking up. In America black diamonds are employed in rock drilling for wells and mines. Could these expensive tools not be replaced by the action of the electric current in conditions analogous to those which have been described, and the perforation of rocks be performed by electricity? Electrodes of platinum would not be necessary, for it is not the metal of the electrode which alters, but merely the silicious matter in presence of the saline solution. Metallic points or studs conveniently distributed at the end of the drill and put in rotation would direct the electric discharge to the rock, which it would pulverise as in the case of the diamond drill. The recent advances

in the production of electricity by mechanical means would facilitate this application."

A New Departure in Electrical Education.

WE learn that Dr. Muirhead and Professor Ayrton propose receiving at their electrical laboratory, adjoining the telegraph works of Messrs. Latimer Clark and Muirhead, pupils who desire to receive a complete education as telegraph engineers, and especially those who are anxious to be trained in conducting original research in electricity and magnetism. In addition to their receiving practical instruction in the manufacture and testing of electrical apparatus and in the mathematical theory of electricity as technically applied to telegraphy, we understand that it is proposed that all the students shall be placed in charge of original experimental investigations. We need hardly refer to the difficult task of duplexing the long submarine cables in the Atlantic, Mediterranean, Red Sea and Indian Ocean, successfully accomplished by Dr. Muirhead with his "inductive resistance," or to the numerous experimental researches of Professors Ayrton and Perry, carried out in the electrical laboratory at the Imperial College of Engineering in Japan, as evidence of the thorough training students are likely to receive.—*The Electrician.*

June 79

86

Le domptage des chevaux par l'électricité. — Dans le domptage des chevaux méchants, on emploie des procédés bien différents. Certains dompteurs n'agissent que par la force, d'autres par la douceur, par l'habileté, ou par la fatigue, ou encore par l'affaiblissement résultant de la privation de nourriture, en somme par un grand nombre de moyens. La Compagnie des omnibus de Paris emploie depuis quelque temps à cet usage l'effet de l'électricité. A la dernière séance de la Société nationale d'agriculture, M. Bella a donné sur ce sujet de très intéressants détails; par l'emploi de ce procédé, des chevaux vicieux, soit cherchant à mordre, à ruer, à frapper, deviennent inoffensifs, obéissent et se laissent atteler et panser sans résistance. Il a suffi pour obtenir ce résultat de faire passer dans la bouche de l'animal un faible courant électrique à chaque tentative de résistance. Sous cette impression, la volonté du cheval semble annihilée, et celui-ci se soumet. Le courant est produit par une petite machine d'induction, du système Clarke, dont les fils communiquent avec le mors de la bride. Cette idée avait déjà été proposée à l'Exposition. Dans la section suédoise, se trouvait un appareil ayant le même but. Il se composait d'une petite boite de 10 à 12 centimètres contenant une pile dont les fils communiquaient au mors par les rênes; en cas de résistance du cheval, le conducteur n'avait qu'à pousser un bouton pour qu'aussitôt le courant passât et que l'animal fût dompté. L'emploi de l'électricité produit plutôt une gêne, un engourdissement qu'une douleur, et est en somme beaucoup moins barbare que les procédés de domptage employés jusqu'à ce jour. (*Correspondance P. Guyot.*)

An ingenious apparatus, intended to reproduce telegraphically at a distance the pictures obtained in a camera obscura, has, says *Galignani*, recently been invented by M. Senlecq, of Ardres. The principle on which it is based is the property possessed by selenium of presenting a very variable and very sensitive electrical resistance according to the different gradations of light. 79

AN ELECTRICAL MOUNTING TABLE.

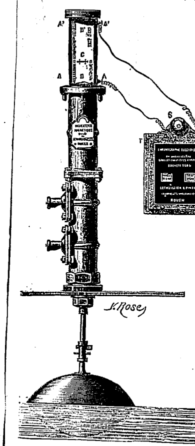
[15560].—On page 112 I notice a description of an electrical mounting table, and as I have thought some of the many readers of the Mechanic might be interested in the subject, I will give my experience with regard to such tables, driven mechanically. About a year ago, I thought I would apply clockwork to a table I was then using, but on considering the matter, it seemed to me quite unnecessary to apply a continuous motion to it, as a slide can be ringed in a very short time, and the table must then be stopped to remove it. I therefore adopted a method which I consider simpler, and at the same time more convenient, and far less costly than the one described by Mr. Rogers, and which I will, without filling up your space with unnecessary diagrams, try to make clear to your readers.

The milled portion which is used to spin an ordinary turntable is replaced by a small cog-wheel, and in a horizontal slot in the mahogany support, in a line with this small wheel and gearing into it, is a segment, of about 1-6th of a cog-wheel, say 4½in. diameter; this segment is continually pressed by a strong spring to the left-hand side, against a small indiarubber stop, and has then moved so far as to be out of gear with the small wheel, and plenty of clearance. A trigger in the form of a hook, working vertically in the mahogany,—the hook catching the lower side of the segment when pushed over—completes the arrangement. The action is as follows. The segment is pushed over and is held by the catch, the slide being in position, and brush and varnish handy. On placing the hand holding the brush on the support, the catch is released, the segment flies round, carrying the table round in the opposite direction; and clearing it, the table continues to revolve. If we could only manage to remove and replace the slides, a moderately well-balanced and weighty table would turn a sufficient time to ring, perhaps, five or six slides. But with all its advantages there is a considerable drawback to all contrivances of this kind; and that is their cost. During the years I have worked amongst scientific men, I find that nearly all our really hard workers are untroubled by a superfluity of cash. Money makes men too lazy to work, as science requires, for love alone. My aim has, therefore, been to cheapen such appliances, and still retain their efficiency. I have been so far successful as to at least satisfy myself as regards a good and simple mounting table, and I will in a few days send a sketch and description, and impose upon the kindness you so freely extend to all.

Spencer Rolfe.

87

tablet is connected with the magnetic indicator by two electric wires. At the lower part of the dial of the indicator are placed two pieces of copper, A, and upon each of these is fastened a platinum plate, B. These platinum plates are superposed at a distance of about two millimeters. When the index, C, descends, it rests on the upper piece of platinum, depresses it, and puts it in contact with the lower. An electric current is thereby established, the bell, S, rings,



ELECTRIC BOILER INDICATOR.

and, at the same time, the sign "*Low water*" appears on the tablet. Similar pieces of copper and platinum are fixed at the upper part of the dial; and, when the index reaches this limit, the bell rings, and the indication "*Too much water*" turns up on the tablet. In order to remove the warning words from the tablet, a button is pressed, which returns the indicating parts to their normal position.

THE ATLANTIC AND PACIFIC INTEROCEANIC CANAL.

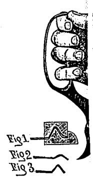
To the Editor of the Scientific American:

It is now twenty-two years since I had the honor of reading before the Institution of Civil Engineers, London, a paper "On the Junction of the Atlantic and Pacific Oceans and the practicability of a Ship Canal, without Locks, by the Valley of the Atrato," and the President, Robert Stephenson, M.P., then remarked, with the kindness and urbanity that distinguished him, "the Institution was much indebted to Mr. Kelley for his highly interesting paper, which had induced the expression of valuable opinions," and concluded with the following words: "A few years longer would probably decide, whether it was feasible to make an interoceanic canal; at any rate it could not fail to be remembered that Mr. Kelley had produced more intelligible information upon the subject, than had hitherto been given to the world." In view of those opinions of a deeply lamented and great man, I hope I shall not be deemed presuming too much on them in venturing to call the attention of your readers to the advantages of constructing a ship canal *via* the San Blas route, surveyed under my direction in 1864, by Mr. A. McDougal, chief engineer. I offer them to you in hopes that their publication may suggest to the English people that a short and safe route for a ship canal through the American Isthmus can be secured for European commerce to Australia, New Zealand, and all the trading ports in the North and South Pacific Ocean, and which may be preserved strictly neutral, under the joint protection of England and the United States—the two great English speaking nations, enjoying the same religion, reading the same literature, maintaining the same liberty, and practicing the same laws; therefore they ought to go hand in hand in the execution of the work.

Great projects seldom die. When once any considerable number of men become convinced of the importance and utility of an enterprise, however vast, it is considered and discussed from year to year, from generation to generation, and from age to age, until the time, the facilities for execution, and the men are collected together, and the work is accomplished. The Suez Canal is a striking example. From the earliest days of modern commerce a strong desire for its

REMOVING WIRE AND IRON FROM WHEAT BY MAGNETS.

THE removal of wire from the miller's wheat seems su denly to have expanded into one of the subjects most i portant to the miller. The bits of wire that are found the thrashed wheat are a nuisance that can be said to ha had its origin about two years ago, as before that time t wire self binders were but comparatively little used. La season, however, at least 25,000 wire binders were employ by the farmers, principally in the Northwest, and the man facturers of agricultural machinery are now preparing sell as many more during the coming season. One Clev land firm now has on its books orders for over twelve m lion pounds of the steel wire used by the self binders. Th certainly shows something of the magnitude of the busine which is expected to be done in wire binders this seaso It certainly cannot be denied that the self binders are a va improvement over the old method of harvesting, and,



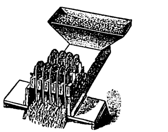


FIG. 5.


FIG. 6.

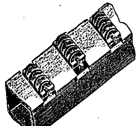


FIG. 7.

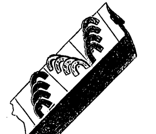


FIG. 8.

REMOVING WIRE AND IRON FROM WHEAT BY MAGNETS.

such, are likely to be sooner or later adopted by the farmers of the country.

The cost of the wire for binding the wheat ranges from fourteen to forty cents per acre cut, and one machine will cut about sixteen acres of wheat in one day. We can readily see the advantages, to the farmer, of using such a machine, but to the miller, the result of the introduction of the self binders has been injurious in many instances. Small bits of wire find their way through the thrashing machine into the wheat, and, concealed by their specific gravity, into the miller's garners. It may appear strange that these small steel particles should pass through all the cleaning machinery of the mill to the burrs, through these into the meal and bolts, and sometimes through the bolting cloth into the flour and biscuit.

The pieces of wire range in size from a pin head to an inch in length. They are flattened by passing through the burrs, and their edges, when examined through a microscope, are found to be serrated, and, therefore, admirably suited for cutting the bolting cloth to pieces. We have before this enlarged on the evils which such sharp instruments produce, and any further comment or citation is unneces-

Fig. 2 shows the bend or crimp made before the wire is commenced to be cut, and which prevents the spring of the bundle pulling it out when the cut is finished, or the wire finally parted.

Fig. 3 shows the crimp (which is made before the cut) intensified, when the cut is finished, into a sharp V, making a positive hold, so that the wire cannot be pulled out, unless the operator relaxes his grip, or chooses to let it pass into the thrasher.

If farmers could be persuaded to use the best possible means for removing the wire, united with some degree of care, but little wire would find its way into the mill. Nevertheless, even with the greatest care, the wire will get there, especially if the bands have rusted from exposure. The wheat cleaning machinery will remove many of the bits of wire, and the efficiency of the separators may be increased by making "riffles" straight up and down, on the sieves, i the same manner as employed for taking out gold. But, far, the most perfect instrumentality that has been employ is the magnet. We have, in former articles, explained h these magnets are used. Their application is simple, they may be placed in any part of the mill or on any

China, and excellent silk may be made by dexterous management with a good hand-reel.

"Raw silk is classified into organzine, tram, and floss. Organzine is considerably twisted and is the choicest. Tram is made from inferior cocoons and is but slightly twisted. Floss is made of the loose silk, carded and spun like cotton or wool.

"The thread of silk as it unwinds from the cocoon is valueless for manufacturing purposes, several of them combined going to make the staple of commerce. The persons employed in unwinding silk are mostly women, one standing or sitting before each basin, of which she has entire charge. The basin is made of copper, and, in the large establishments, the water in each basin is heated by steam, at the control of the operator. The cocoons are plunged into the water, when it is near the boiling point, and moved about so that the gum which fastens the threads becomes uniformly and thoroughly softened. They are then beaten with a small birchen broom, having the tips split, so that the loose threads readily fasten to them. After beating a short time, the operator gets all the cocoons fastened, and, taking the bundle of threads, shakes the cocoons till each hangs but by a single one. She now takes up five or more threads (*brins*), according to the quality of silk wanted, unites them, and introduces the combined staple or strand (*fil*) into a little glass eye on one side of the basin. She then forms a second similar strand and introduces it into a second eye on the other side. The strands are then brought together, twisted several times, separated above the twist, and introduced into two other glass eyes or ringlets, through which they are led, one to each end of the reel or *tambour*, which is kept revolving in a steady, rapid manner, and to which is also given a certain back-and-forth side motion. The great object in reeling is to get the threads uniform, rounded, well joined, properly freed from moisture, and so crossed on the reel that they will not stick or glaze, as it is termed. These objects are attained by the twisting and the to-and-fro lateral movement of the reel, as also by properly regulating the distance between reel and basin. The uniformity of the thread depends on the skill of the operator, who must supply a new thread as soon as one begins to give out. This is called nourishing the silk, and is done by dexterously casting, with the thumb, the new thread upon the combined strand, to which it immediately adheres. In this she must use much judgment, for the silk of a cocoon gradually gets lighter and finer as it approaches the end, and the uniformity of strand does not entirely depend on the uniformity in number of the individual threads forming it. Whenever the silk rises in locks the temperature of the water is known to be too hot, and when it unwinds with difficulty the temperature is, on the contrary, too low. The operator is supplied with a skimmer with which to remove all chrysalides and refuse silk; also, with a basin of cold water in which to cool her fingers, which are being constantly dipped in the hot. This constitutes the whole operation of unwinding, and before the skeins, as they come from the reel, are ready for the manufacturer they must undergo still further manipulation. The staple is first passed through a cleanser, consisting of a clasp lined with cloth, which catches any loose silk or other matter that may be adhering to it. It is then further cleansed and purged by being passed through four similar cleansers (*purgeurs*), then twisted about 500 times to the yard, then doubled and again twisted about 400 times to the yard. It is finally run on to reels about 1½ feet in diameter, and taken off and twisted in a peculiar knot or hank. Through all these operations the oscillating to-and-fro lateral motion is kept up, so as to produce the diagonal crossing of the strands, and it will be readily understood that each

Rock Drilling by Electricity.

In a recently published work of M. Gaston Planté, "Recherches sur l'Electricité," noticed in one of our French exchanges, the author mentions a new application of electricity which had not been hitherto published by him, and which is of considerable interest.

After describing the process of engraving on glass by electricity, that he made known in 1877, and the account of which has been so widely copied by scientific papers, M. Planté goes on to say: "We have seen that one of the electrodes conducting an electrical current of a certain tension being brought in contact with glass, in the presence of a saline solution, it acts like a graver or diamond by tracing grooves in the surface of the glass, and even digs into it quite deeply. In spite of its great hardness, rock crystal can also be attacked by the same method; and, if not engraved regularly, it at least cracks into small fragments, and is finally disintegrated." In view of this, M. Planté suggests that the electric current, under conditions analogous to those above described, might be substituted for diamonds in the operation of drilling rocks. He states that electrodes of platinum would not be necessary, for here it is not the metal of the electrode that is affected, but the silicious matter in contact with a saline solution. Metallic points or projections suitably located at the extremity of the drill, isolated on a part of its length and actuated by a rotary movement, would lead the electric current to the surface of the rock to be pulverized, and would thus replace those numerous and expensive diamonds which are set in the head of the drills employed in the present system of rock boring.

May 79

L'électricité appliquée aux pompes à incendie

May 16 1880

L'American Register nous fait connaître qu'aux États-Unis on a trouvé le moyen d'appliquer l'électricité aux appareils des pompes à incendie. Un fil métallique parcourt le tuyau de la pompe dans l'intérieur de la toile ou du caoutchouc, et sert de conducteur à l'électricité produite par une roue à volant de la pompe à vapeur. A l'extrémité du tuyau, à côté de la lance, est un système permettant au pompier, sur le lieu du sinistre, qui est souvent à une assez grande distance de la pompe, de communiquer avec celle-ci et de faire cesser, ralentir ou activer le jeu; le signal se donne au moyen d'un timbre mû par l'électricité et frappant sur un tam-tam suspendu à la machine.

89

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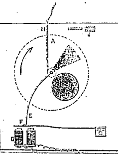
[36146.]—**Electric Shutter for Camera.**—I have made such a shutter not only to work in an ordinary camera, but adapted it to my 11in. reflector, and used it in conjunction with my chronometer to take solar photographs, thus using the same current to take photos and time. The shutter may be thus described: the centre of a revolving disc of thin metal, A, is placed at the side of lens (say ½in.), and is inclosed in a light thin box of wood, B; this box fixes on the lens or eye-piece, C; the opening through which the rays of

light pass is cut out of both sides of thin box in which disc revolves. Cut an angular opening out of disc, D (inasmuch as the velocity of its various parts differ); the disc is fixed by a light metal axis,



one end of which is bent at right angles *to axis* outside front side of box, E, and therefore moves in a plane parallel to face of box. The end of this arm can be fixed under a very small catch, soldered on the spring, F; this is acted upon by a small electro-magnet, G. The disc is caused to revolve by a slender piece of indiarubber elastic, H, running over a little pulley or grooved wheel fixed to axis of disc; this may be tightened to increase the rapidity of revolution. J is a buffer to check lever of rubber. Carry a small portable battery cell in pocket, stand immediately behind camera, and make contact when necessary.—H. A. Severn, Herne-hill, S.E.

Dr. Coffin recently exhibited before the Physical Society a Trouvé polyscope, which consists of a small, hand, incandescent platinum wire electric light, designed for illuminating the more inaccessible cavities of the body in surgical examinations. The current is supplied by a Planté secondary battery, and the light is half inclosed in a small silver reflector fitted with a convenient handle. The apparatus is portable. Dr. Coffin found that it was open to several objections which he has remedied. First, the heat generated made the lamp so hot that it could not be held to the body for more than a very short time. He overcame this by making the reflector of double silver plates, and circulating water between by means of india-rubber pipes and a bulb which can be worked by the patient himself, thus serving to distract his attention from the operation. Secondly, the secondary battery exhausts itself in twenty minutes, and the light therefore goes out, while from twelve to twenty-four hours are required to recharge it. Dr. Coffin has superseded it by a Leclanche battery of eight elements, made by Messrs. Coxetter and Sons, in which the carbon pole is replaced by a copper plate faced with platinum, and no porous diaphragm is employed. This gives a constant light for several hours. June 79

Le labourage à l'électricité. — L'application de l'électricité, comme force motrice, appartient désormais à la science et à l'industrie. Elle a été affirmée, le jeudi 22 mai, par la remarquable expérience faite à Sermaize en présence d'une délégation de l'Institut, une Commission de la Société nationale d'agriculture de France et de la Société des agriculteurs de France. June 79

Une foule de 1200 à 1500 étrangers était accourue des villes et bourgades voisines.

Les inventeurs ne se servent pas de piles, mais emploient les machines Gramme, qui fonctionnent déjà pour la production de la lumière. Le courant électrique, produit à l'usine, est transmis, au moyen de fils de cuivre, à la locomobile électrique faisant mouvoir la charrue. Les fils peuvent être considérés comme une longue courroie de transmission, et l'ensemble comme un immense télégraphe, transportant une force énorme, au lieu d'une force insignifiante. Avec un moteur unique, on peut transmettre la force à plusieurs kilomètres; la déperdition de force est moindre que par tous les autres procédés employés, et surtout que celle d'une locomobile à vapeur fonctionnant à l'air pour le labourage ou le battage des grains.

On peut utiliser comme moteur principal les cours d'eau, les moulins à vent, en un mot toutes les forces naturelles ou autres. Dans une ville, dans un village, il suffira d'établir une puissante machine électrique près de la roue d'un moulin, et chaque industriel pourra, au moyen de fils communiquant de son usine au moteur, trouver la force nécessaire pour son travail. Chaque cultivateur pourra, par le même système, faire marcher sa batterie, en payant un faible tribut au propriétaire du moteur principal. Sur les canaux, l'eau qui sort des écluses, au moment du passage des bateaux, peut, au moyen d'un petit moteur hydraulique qui se trouverait en dehors de l'écluse, donner le mouvement à une machine électrique; celle-ci, à son tour, communiquerait l'impulsion à une locomobile électrique, et cette dernière, se mouvant d'elle-même, s'avancerait seul sur la berge du canal, et ferait facilement le halage des bateaux. Les travaux mécaniques des carrières, mines, souterrains, seront désormais possibles sans l'emploi de la vapeur et avec une dépense très minime.

Péronne.

An Electrical Rock-Drill.—The electric currents of high tension, which M. Planté has been studying for some years past, give many curious and suggestive effects. One of their effects is that of electric engraving on glass and on rock crystal. M. Planté had the idea of utilising this force in boring operations. In America and elsewhere, it is known, hard rocks are often attacked by means of diamonds, the price of which is, of course, high, and which are gradually lost by being detached through the violence of the action, from the pieces to which they have been fixed. "Might not these diamonds be replaced," M. Planté asks, "by the action of the electric currents referred to, and the rocks be bored by electricity?" He points out that electrodes of platinum would not be necessary; for it is not the metal of the electrode that is altered, but the silicious matter, in presence of the saline solution. Metallic points or projections suitably placed at the extremity of the drill rod, insulated in a portion of its length, and animated by a rotatory movement, would bring the electric current to the surface of the rock to be pulverised, and would thus replace the numerous diamonds set in the head of drills employed in the present system of rock-boring. The progress recently accomplished in production of electricity by mechanical methods might facilitate this application. June 78

An Automatic Electric Bell.—An ingenious and simple apparatus for making a bell ring at any predetermined hour of the day, is described in a recent number of *L'Electricite*. It comprises a lens by means of which the solar rays are concentrated and directed on a metallic strip, which is susceptible of very rapid and great dilatation. The result of the dilatation is electric contact, giving passage to a battery current which rings the bell. Although the sun may be covered by clouds, its calorific power is never diminished so much as not to dilate the strip. Mining & Sci. Press Dec 20 1879

The Electric Hose.—A new thing in fire apparatus is the electric hose. A wire runs along in the cotton or rubber part of the hose, continuing the connection as each section is attached, and over this passes electricity, generated by one of the fly wheels of the engine. Connected with the nozzle is a little contrivance by which the engineer can be directed, although squares distant from the man who is playing water on a fire, to turn her on, cut her off, stop, go ahead, or any thing else that may be agreed upon by a signal which is struck on a gong attached to the engine.
Manufacturer & Builder

~~Manufacturer~~ & Builder

An Electric Sentinel.

Persons who have occasion to cross the Providence railroad on Washington street, at Forest Hill, Boston, are frequently surprised to hear a heavy gong continually ringing on a danger-signal post close by, while no approaching train is seen or heard; but from three to five minutes after the alarm first sounds a train dashes around the curve and speeds along, while, as it leaves the crossing, the gong ceases to ring. This crossing signal is part of the system of the Union Electric Signal Company. It is known as the Union Electric Signal, and is exceedingly simple. By this system electricity is carried in the rails, holes being drilled in

To the Editor of The Telegraphic Journal.

ELECTRO-SOLAR ALARM.

Sir,—I read in your interesting Journal that an electro-solar alarm *has been invented*, by which a bell is rung when the sun passes the meridian. Already certain French journals had reported that so-called invention with a great fuss, and I did not think it worth while to claim it, because of its small importance; but since the Telegraphic Journal, which is a serious organ, seems to attach some interest to it, I feel myself called upon to inform you *that this invention is only the germ of an apparatus which I designed and constructed in 1856 under the name of the Electro-solar Regulator.* You will find a long description of it in volume ii., page 255, of the second edition of my work on the Applications of Electricity, published in 1856. That apparatus aimed not only at indicating the moment of passage of the sun across the meridian, but also to adjust to the true meridian the hands of a clock, and thereby to indicate the true time. I described two plans for this purpose: but the second gave the best results. My descriptions are accompanied by very exact figures, which are engraved in plate vii. of the said volume.

This description is also reproduced in the fourth volume of my last edition, page 78. The idea has been taken up two years later by M. Régnard, and in 1868 by the Abbé Candido de Lecce.

I beg you to accept the assurance of my best sentiments,

DU MONCEL.

Libisy, near Caen, Oct. 18th.

Telegraph Journal Nov 1 1879

Nature Mch. 15, 1881

Nature Mch 15 1881

Edinburgh

Royal Society, February 21.—Prof. Fleeming Jenkin in the chair.—Sir William Thomson communicated a paper by Mr. Witkowski on the effect of strain on electric conductivity. A cylindrical brass tube, with a magnet and attached mirror suspended horizontally in the centre at right angles to the axis, was traversed from end to end by an electric current. In its original unstrained isotropic condition the cylinder so conducted the current that the inclosed magnet was unaffected. A couple was then applied in a plane at right angles to the axis, so as to distort the metal tube by a definite twist, thus rendering it æolotropic as regards its electrical conductivity, and giving to the current a spiral set, which was evidenced by the deflection of the suspended magnet. The lines of flow set spirally round in a direction contrary to that of the applied couple—a result in complete accordance with the theory of twists, which requires a lengthening (and therefore an increase of resistance) along spiral lines that set round with the couple and a simultaneous compression (and corresponding decrease of resistance) along lines at right angles to these. Quantitative results were obtained by balancing the electro-magnetic action of the current in the strained tube by means of an external circular movable conductor traversed by a steady current.—Sir William Thomson described certain experiments which he had lately made on the effect of moistening the opposing surfaces in a Volta-condenser, and of substituting a water-arc for a metallic arc in the determining contact. The main features of the paper were, the non-existence of any measurable difference of potential when contact was made by means of a drop of clean water between opposed polished surfaces of zinc and copper, the effect of oxidising the surfaces in the pure metallic contact experiment, and the exact similarity in the action of dry polished zinc and wet oxidised zinc when opposed to dry copper and brought into contact by a metallic arc. Sir William also described the "vortex sponge." A vortex column spinning at the heart of a mass of fluid revolving irrotationally inside an imperfectly elastic cylindrical case forms a system in a position of maximum energy; and any slight disturbance from the truly circular rotation of the vortex core results in a gradual drawing off of energy, in virtue of the imperfectly elastic character of the bounding material, until the system assumes its position of minimum energy with the rotationally-revolving fluid on the immediate inner surface of the inclosing case and altogether surrounding the irrotational fluid, which is now in a state of quiescence. The intermediate stages between these first and last conditions are what Sir William Thomson characterises by the name of vortex sponge.—Mr. T. Muir presented a paper on continuants, to which special form of determinant he could, by suitable transformations, reduce any given determinant of ordinary type, and so was able to express a determinant as a continued fraction.—Prof. Chrystal added a note on this paper showing how in the most general case n equations between n unknown quantities can be made to yield by suitable elimination n other equations, in no one of which more than three terms appear, so that a continuant form of determinant is got which bears a simple relation to the determinant formed by the coefficients of the original equations.

Le Science pour tous

PHYSIQUE

April 1880

L'électricité et la végétation sylvestre

Au début du siècle, que savions-nous de l'électricité? Aujourd'hui la science commence à entrevoir les puissants effets de cette force à laquelle rien ne résiste. Parmi les étonnantes productions du fluide électrique, citons seulement pour mémoire: la télégraphie, la dorure et l'argenture, le paratonnerre, etc. Avec son aide, on a décomposé les corps réfractaires à la chaleur ainsi qu'à tous les agents chimiques; plusieurs maladies ont été soignées avec succès; on a tenté le chauffage électrique, et il y a lieu de croire que les grandes villes seront bientôt éclairées par cet agent destiné à transformer le monde.

Nul n'ignore que la plupart des phénomènes naturels ne soient accompagnés d'une production de force électrique. Des végétaux et des corps organiques en général viennent-ils à se décomposer; l'évaporation de l'eau, une combustion quelconque, la rouille du fer, se produisent-elles? le fluide impondérable est là. L'atmosphère, fût-elle pure et sans nuages, est toujours plus ou moins chargée d'électricité.

Le temps est lourd, disons-nous quelquefois; c'est qu'un agent invisible agit sur nos nerfs, qu'il excite le plus souvent. L'électricité, plus abondante à mesure qu'on s'élève davantage dans l'air atmosphérique, fait défaut dans les maisons, sous les arbres et, en général, partout où règne un abri, un ombrage.

Ces phénomènes naturels sont connus depuis longtemps déjà, et cependant l'influence pernicieuse du couvert des arbres sur la végétation sous-jacente était jadis attribuée au défaut de lumière.

Tout récemment, des expériences faites par M. Grandeau, notre éminent professeur à l'École Forestière, ont démontré péremptoirement que, sans électricité, les végétaux sont impuissants à assimiler les principes carbonifères de l'air atmosphérique.

Sous une cage en treillis de fer, posée sur un terrain parfaitement découvert où le soleil dardait ses rayons, il plaça des graines de très-bonne qualité et récoltées par lui. D'autres, de même espèce et de provenance aussi certaine, avaient été semées tout près de là dans un sol également bien préparé. Au bout de quelques jours, celles-ci sortirent de terre et se développèrent fort bien. Les autres, qu'on avait placées sous la cage, ne germèrent point d'abord; mais, dès que la cage fut enlevée, les cotylédones se manifestèrent, la gemmule apparut et le petit végétal se montra. On replaça bientôt cette sorte d'écran et la croissance fut suspendue.

Au cours de l'expérience, les graines étaient arrosées chaque jour et les rayons solaires passaient aisément au travers des larges mailles de la cage en fer. Ni l'air, ni l'eau, ni la lumière ne faisaient défaut à la jeune plante. Que lui manquait-il donc pour se développer? La force électrique sans doute.

Dans la forêt, comme en rase campagne, l'arbre joue le même rôle que la cage de fer sur les graines qu'on a semées à l'ombre de ses rameaux.

Avant cette belle découverte, on disait, pour expliquer l'action pernicieuse des arbres sur la végétation sous-jacente, que le végétal dominé ne recevait pas directement l'action des eaux pluviales et qu'il ne pouvait assimiler les principes carbonifères de l'air atmosphérique sans le secours de la lumière blanche. Cette explication est réduite à néant par l'ingénieuse expérience de notre honoré maître qui donna à ses graines tous les éléments nécessaires, sauf l'électricité.

Pour se rendre un compte exact de l'importance du rôle que joue la force électrique sur l'assimilation des végétaux, nous ajouterons que la production moyenne de nos forêts est annuellement de 6.000 mètres cubes de bois pesant 3.000 k., et en outre du même poids de feuilles et de graines.

AN ELECTRICAL WATER LEVEL INDICATOR.

Amongst the objects exhibited at the recent *soirée* of the Institute of Civil Engineers, held at South Kensington, the Electrical Water Level Indicator, belonging to the Nottingham Waterworks Company, and designed and constructed in the engineering department of the Postal Telegraphs, excited much interest. The apparatus exhibited consisted of a "Transmitter" and a "Receiver," the latter being in connection with a transmitter fixed at one of the reservoirs of the Company referred to, at Nottingham. During the course of the evening the visitors had thus the opportunity of seeing the actual working of the apparatus, and of observing the changes in the level of the water in the reservoir at Nottingham. Apart from the ingenuity of the invention, the apparatus exhibited was a masterpiece of constructive finish, and did extreme credit to the Postal Telegraph mechanicians. The principal part of the apparatus is the "transmitter," by means of which, on the rising of the float attached to it, a *momentary* contact is made, which causes a positive current to be sent to line at every inch of rise, and a momentary negative current at every inch of fall of the float. The importance of arranging the apparatus to make *momentary* contacts only is evident, otherwise, from the slow rise and fall of the water level, the series of currents would be continued ones which would soon exhaust the battery.

June 79

The method by which the object in view is obtained is shown by fig. 1, which represents the arrangement of the "transmitter." *f* is a small metal disc, having a quarter of its circumference faced with a projection of platinum *b*; this projecting piece makes contact, when the disc is turned, with either the spring *d'* or *d''*, the ends of the latter being faced with platinum to insure good contact being made.

The disc *f* is fixed to an axis, to which is also attached the weight W; on the axis is a pinion, into which the wheel A gears.

Behind wheel A is a second wheel A' (shown by the dotted line); this wheel has a pin *p'*, which works in the slot S cut in the front wheel A; the length of this slot is such that if we suppose the pin to be at one end of the slot, and the wheel A' to be held in that position, then a rotatory movement of the wheel A, sufficient to move the other end of the slot up to the pin, will cause the disc *f* and the weight W connected to it to make a complete revolution, that is to say, the weight W will have been turned in the direction of one or other of the arrows according as A is turned, in one direction or the other, and when it has made a complete revolution, together with the disc *f*, then the latter will have made contact with both the springs *d'* and *d''* in succession.

Fixed to the face of the disc *f* is a pin *p*. This pin, when the apparatus is in the position shown in the figure, lies between two pawls *l l*, attached to the triangular piece B, which rocks on a centre *a*. The pawls are maintained in the position shown, relative to the piece B, by a small spiral spring *e*, which draws them down against small stop pins fixed on B.

The whole rocking piece can be thrown over against either of the contact screws *g'* or *g''*, and

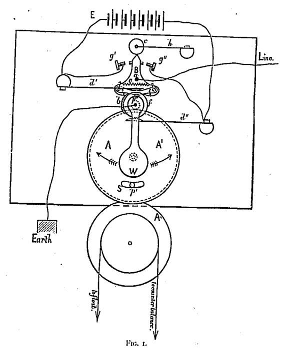


Fig. 1.

94

when against either of them will be held firmly there by the little wheel *c*, which presses, by means of a spring *h*, against either one side or the other of the pointed top of B.

The wheel A' which gears into A' is connected to the float by means of a chain, and the whole arrangement of the gearing is such that an inch rise of the float can turn the disc *f* through a complete revolution.

The electrical connections are those shown, the line being connected to the rocking piece B, which is insulated from the rest of the apparatus.

To understand the working of the arrangement, let us suppose that all the parts of the apparatus stand in the position shown, when the float stands at an exact inch mark. Let us suppose the water commences *rising*: for the first half inch of rise then, the wheel A' will have been turned so as to bring the pin *p* to the left hand end of the slot; as the wheel A' then continues to rotate it now turns the wheel A and rotates the disc *f*, and also moves the weight W, in the direction of the right hand arrow. The rotation of the disc causes the pin *p* to push against

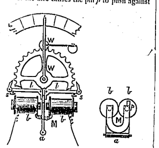


FIG. 2.

the left hand pawl of the rocking piece B, and to move the latter over towards the contact screw *g'*. After a certain angular movement of B has taken place, the action of the spring c carries it completely over to *g'*, and in this position the pin *p* clears the left hand pawl. Supposing, now, the rotation to be continued so that the lever of the weight W is at right angles to the position shown, then the platinum projection *b* will be making contact with the spring *d'*; but this will not cause any current to pass out to line, since in this position both line and earth (which is connected to the frame of the apparatus) are both connected to one pole of the battery, whilst the other pole of the latter is free. On continuing the rotation, however, the weight W arrives at the vertical position, which completes the inch movement of the float, and then topples over to the left making contact in its fall, by means of *b*, with the spring *d'*; at the moment when this takes place zinc is to earth through the spring *d'* and the projection *b*, and copper is to line through *g'* and B, consequently a positive current is sent to line. When the weight has completed its descent the whole arrangement resumes the position shown.

The pin *p*, it may be observed, in passing the right hand pawl, when the weight is falling, merely lifts it up and passes under it without affecting the position of B; in fact, as long as the rotation of *f* takes place in the direction just indicated, B will remain over against *g'*.

Inasmuch as *f* is geared, through the medium of the pinion, direct on to A, the quick fall of the weight will cause A to rotate through a corresponding angle: this the slot *s* allows A to do without affecting A'.

If the float falls, all the motions become reversed, viz.: the rocking piece B becomes thrown over to *g*, and a negative signal is sent when *b* makes contact with *d'*, for then zinc is to line through *g*, and copper to earth through *d''*.

It will be evident that the whole arrangement is such that a signal cannot possibly be transmitted unless the weight makes a complete revolution, and then it can only be a momentary signal.

The receiving portion of the apparatus does not possess any particularly novel points. It is represented by fig. 2 (drawn to a smaller scale than the transmitter); M is a horse-shoe permanent magnet, fixed on an axis *a*, so that its poles can move backwards and forwards between the poles of two ordinary electro-magnets *b b*, whose wires are joined together in one circuit. A projecting piece *p*, of the horse-shoe magnet, lies between the bent arms of the levers *l l*. These levers rest normally against the stop screws *s s*. When a positive current passes through the electro-magnets, the permanent horse-shoe magnet is moved, say to the left, thereby moving the left-hand lever, the pawl at the end of which moves the toothed wheel W one tooth forward, representing one inch of movement of the float. Similarly a negative current moves the horse-shoe magnet in the reverse direction, thereby actuating the right-hand lever, and moving the wheel in the reverse direction.

The levers *l l* are so arranged that, when in their normal position, the pawls attached to them stand clear of the teeth of the wheel W. The little wheel W at the end of a spring falls between the teeth of the wheel W and keeps it steady.

Journal of Tel. July 1, 1879
Journal of Tel July 1 1879

95

Perforating Glass by Electricity.

PROF. WALTENHOFEN, of Prague, has recently described the following experiments:—A thin glass plate, having on it a small drop of stearine, is introduced into the spark-path of an electric machine. It is perforated at the part where the drop is, and more easily so when the drop-side is turned to the positive electrode. A glass plate, hung bifilarly between the electrodes of a Holtz machine, is driven by the discharge towards the negative electrode, and more strongly, if the side turned towards the positive electrode be partly covered with stearine. Prof. Waltenhofen considers that the rapidly moving air molecules in the spark-path are ruled by a component of velocity directed from the positive to the negative electrode.

Nature July 3 '79

the former.

A VERY ingenious application of electricity to the purposes of navigation has recently been effected by Mr. Henry A. Severn, of Herne Hill, who has succeeded in producing a mariner's compass which enables the captain or officer in charge to hear, by the ringing of a bell, when the vessel is out of the ordered course. The whole of the apparatus is contained in a small box which is easily carried about, and is intended, as a rule, to be placed in the captain's cabin. Over the card are two index hands, which can be adjusted to any angle allowing of greater or less deviation in steering to either the port or starboard side. Assuming the captain, on quitting the deck, to have given instructions to steer the ship on a certain course, he sets the index hands to a certain angle, allowing the steersman a given latitude for deviation either to port or starboard of that course. Should the ship be steered off her course beyond the limit allowed on either side an electric alarm-bell rings instantaneously, and, moreover, continues ringing until the right course is resumed. The metal point on which the card is hung is insulated from the compass bowl, and to it is attached a wire from one pole of a small battery. About an inch above the card, placed parallel to its surface and attached to its metal centre (which is insulated from the needle) is an arm of metal reaching nearly to the edge of the card. This arm is, therefore, in metallic communication with the wire from the battery already referred to. The glass lid of the compass has a short brass rod working within a tube passing through it. These are severally attached to two brass milled heads above the glass lid and to the two movable index-hands beneath the glass. These are in metallic contact with the brass-work of the compass, and this with the other pole of the battery. Beneath the outer extremities of the index-hands are suspended two pieces of platinum wire about three-quarters of an inch long. These hands can, by means of the two milled heads, be moved round to any position over any point of the card. Hence they admit of being placed on either side and equally distant or otherwise from the end of the metal arm on the card. It will thus be seen that whenever the platinum wires come into contact with the metal arm on the card the circuit is completed. The electric bell being placed in the circuit sounds whenever such contact takes place. Two bells of different tone can be used, and thus the instrument will indicate to the captain whether the deviation in steering is to port or starboard.

Manufacturer & Builder

Rock Drilling by Electricity.

July 79

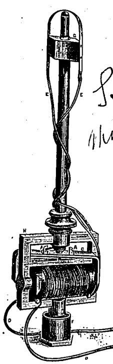
In a recently published work of M. Gaston Planté—"Récherches sur l'Electricité"—the author mentions a new application of electricity which had not hitherto been published by him, and which is of considerable interest.

After describing the process of engraving on glass by electricity, that he made known in 1877, he goes on to say: "We have seen that one of the electrodes conducting an electrical current of a certain tension being brought in contact with glass, in the presence of a saline solution, it acts like a graver or diamond by tracing grooves in the surface of the glass, and even digs into it quite deeply. In spite of its great hardness, rock crystal can also be attacked by the same method; and, if not engraved regularly, it at least cracks into small fragments, and is finally disintegrated."

In view of this, M. Planté suggests that the electric current, under conditions analogous to the above described, might be substituted for diamonds in the operation of drilling rocks. He states that electrodes of platinum would not be necessary, for here it is not the metal of the electrode that is affected, but the silicious matter in contact with a saline solution. Metallic points or projections suitably located at the extremity of the drill, isolated on a part of its length, and actuated by a rotary movement, would lead the electric current to the surface of the rock to be pulverized, and would thus replace those numerous and expensive diamonds which are set in the heads of the drills employed in the present system of rock boring.

AUTOMATIC GAS LIGHTING.

A new plan for lighting and extinguishing the street lamps by electricity has lately been tested by one of the London gas companies with results which point to a still more extensive trial. The system is one in which electric currents are made to turn the gas on, light it, and subsequently turn it off. Although three operations are thus involved the arrangement is remarkably simple. A single wire may be carried along a line of lamps and then connected with the earth, or the wire may be carried around through a circuit of lamps, so as to terminate at the station from which it started. At this station there would be a magneto-electric apparatus for generating the required currents, and one operator at this point would be able to command a number of circuits, each comprising any number of lamps up to 300 or more.



S. A.
Mar 75

FOX'S GAS LIGHTER.

The experiments alluded to were made on the premises of the company, and have been published by *The Engineer.* A single line of wire, about half a mile long, was conveyed by a zigzag course along a series of twenty-three lamps. The wire was chiefly an aërial line, suspended to the lamp posts and attached to various intervening structures. It was insulated only at those points where it would otherwise come in contact with some conducting substance. The mechanism applied to each lamp, in addition to the wires, is contained in a small metallic box of circular form, so arranged as not to obstruct the light.

The accompanying engraving shows the mechanical arrangement. The socket, F, is screwed on the top of the gas pipe, and the frame, H, is made hollow for the purpose of allowing the gas to flow up to the nipple at the summit. The gas is turned on or off by means of a valve or stop cock, the lever of which is shown caught by one of the studs, A. The two studs, A A, are borne on the upper part of the permanent horseshoe magnet, C, the latter being supported on the point of a fine pivot working in a cross piece in the frame, H. This permanent magnet is capable of a reciprocating motion horizontally, and supposing its position in the drawing to be reversed, the other stud, A, would carry the pin or lever back through a short space. This shifting of the lever one way or the other serves to turn the gas either on or off, as may be desired. The movement of the magnet is effected by a change in the polarity of an electro-magnet consisting of a soft iron wire in a coil at B. According as the current is sent forward or backward through the coil, so the polarity of the core is altered and the permanent magnet is turned on its pivot. The electric current is conveyed from the magneto-electric machine at the station by the wire, D D, which connects all the lamps. Supposing the current to be sent in such a direction as to turn the gas on, the next operation consists in transmitting along the wire, D D, a powerful discharge obtained from a condenser raised to an electro-motive power of several thousand volts or units by means of a Ruhmkorff coil. Around the primary coil at B is wound a secondary coil of fine wire and of much greater length. The discharge from the condenser has the effect of producing a secondary current along the wire, E E, thereby developing a small spark just over the burner. The discharge which passes along the primary wire has the same effect simultaneously on the secondary wire in all the lamps of the circuit, so that the gas being previously turned on in the manner described, the whole of the lamps are lit. If the first and last lamps of the circuit are in sight of the station the continuity of the circuit will be proved by the lighting of these two lamps. When it is required to extinguish the lights a reverse current is sent through the primary wire, causing the permanent magnet to turn and the gas to be shut off, as described above.

Sc. Am. Aug 24 1879

SPAR TORPEDO VESSEL ACHERON.

About eighteen months ago the government of Sydney, Australia, voted £8,000 for the construction of two torpedo launches, and their design and supervision of construction were intrusted to Mr. Norman Selfe, of Sydney. As nothing over ten knots had ever been realized in launches there up to that time, Mr. Selfe sought for information in our own pages and those of our contemporaries; but editors are not at liberty to publish all they know concerning such craft for obvious reasons, so Mr. Selfe had to rely on his own resources. He had to begin at the beginning, and work the whole thing out. Since the boats have been in hand he has learnt a few particulars, but the original design has not been departed from in the slightest degree. One vessel is launched, and on a trial in a very heavy sea realized over fifteen knots; but Mr. Selfe is confident of getting thirty or forty more revolutions at the least, as he only had 330 revolutions, and steam blowing off abundantly. When he decided to use a balance rudder, he had never heard of a similar vessel being fitted with one. With regard to the air pump, he could not understand how an ordinary air or feed pump could work noiselessly at from 300 to 400 revolutions; so he designed special pumps, the air pump with two buckets in one barrel moving in opposite directions, and dividing the stroke between them. It has turned out a great success, works noiselessly at any speed, and Mr. Selfe informs us that he gets 26½ inches to 27½ inches of vacuum; the feed pump also works well. In the present case the blower is driven direct by friction rollers made of disks of leather, brought into contact with a large wheel or pulley on the engine shaft, and a small pulley on the fan shaft, by a pair of levers worked by a screw in such a way as to nearly equalize the pressure on the fan bearings. The fan is of a silent type, with gun metal frame and steel blades of No. 30 gauge, and works well. A turn of a hand wheel throws the leather pulleys out of gear, and stops the fan at once. The

boiler is of the Belpaire fire box type, with Cudworth's mid-feather. The engine is all steel and wrought iron, except the cylinders. The crossheads and guide blocks are all forged of steel in one piece to save height, and few engines of 14 inch stroke with such long connecting rods have ever been made so low before. The steel plates were telegraphed for from England, but the steel for the engine and screw, copper for fire box, and other materials, had to be rummaged out from all over the colony, and Mr. Selfe had often to adapt what he could get. The propeller blades are of hammered steel on a wrought iron boss.

Our engraving below is from a photograph. The engine has two cylinders, 11 inches and 10 inches diameter by 14 inches stroke; the boiler has 300 1¼ inch tubes; the pressure is 140 lb.; the length of the boat is 80 feet; per beam, 10 feet 3 inches.—*Engineer.* Sc. Am. aug 24 79

July 1879

Peppard's Electric Torpedo Balloon.

For the SCIENTIFIC NEWS.

The Electric Torpedo Balloon is the invention of F. Peppard, of Basking Ridge, N. J. A partial description of it was published in a scientific paper in the summer of 1877. In this balloon the means of dropping the torpedo at any instant desired is the electric current. A small balloon capable of carrying from 10 to 500 pounds of nitro-glycerine is all that is desired. A couple of light electric wires, insulated and encased as one, are attached to a small electro-magnet just under the balloon. This magnet operates a simple and ingenious device, tripping it the instant the electric current is on, and thus allowing the suspended torpedo to drop. The wire plays out on a reel, and at the retained ends a ten-inch Grenet Battery is placed in the circuit to supply the current. The operators get on the windy side of the enemy, fort or camp that is to be attacked or blown up, and with a sufficient length of wire attached they allow the balloon to waft up and out of range of shot over the object attacked, and the instant the desired position is reached (this can be readily observed by the use of the sextant glass) the operator presses the finger key, and the current thus sent into the electro-magnet under the balloon operates the detent, and like a flash of lightning, the torpedo drops straight down, and does not explode until it strikes, when it will explode. The dropping of a 500-pound torpedo is said to be sufficient to blow up a whole fort at once; it would, doubtless, kill many from the concussion of the air also. Thus in a few minutes forts could be blown to atoms, when in the ordinary way it would take days and weeks, perhaps, of hard fighting. Such a small balloon could probably be drawn back again after dropping the torpedo, by having a strong rope attached to it so as to reel it in, and thus save the balloon, magnet, &c. The device works instantly and accurately, and costs but very little. No person need be in the balloon.

The portable balloon now used in the army is large enough to carry up torpedoes, and is readily converted into an Electric Torpedo Balloon at a very small expense. Several Governments have inquired into the working details of this balloon, with a view of adopting it into service.

[We give the latter statement simply as communicated to us, the names of the Governments who are said to have made inquiries not having been supplied. We must also say that we cannot share the views of the writer of the article as to the precision with which the apparatus can be operated. Winds are notably variable both in speed and direction, and the movements of a balloon, either free or captive, are often quite peculiar. However, the proof of the whole matter is a subject of easy and inexpensive experiment, which may show our opinion to be unfounded. Could torpedoes be thus dropped over vessels, forts or armies in the field, they would prove a terrible means of warfare.—Ed.]

Iron July 18 1879

In an electrical apparatus for controlling unmanageable horses, shown by M. A. Engström, of Paris (Stand No. 664), a peroxide of iron battery, which lasts for a long time without attention, sends a current, through the reins, to the bit, and prevents the horse from keeping it between his teeth. A similar arrangement cures a horse of crib-biting. In a new jointed buckle for harness, the middle tongue or tang is withdrawn to facilitate unfastening. A first-class honourable mention was accorded to M. Engström, whose inventions are in use by the Compagnie Générale d'Omnibus, Paris.

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Nature July 31 1879

METEOROLOGICAL REGISTERS[1]

THERE is now scarcely a meteorological observatory which is not provided with registering instruments. The number of these is already considerable,

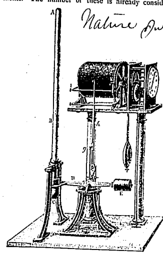

FIG. 1.—Registering Barometer.

and the methods of their construction are almost as numerous. At the observatory of Montsouris I have preferred continuous registration to registration by points, and the tracings effected by a fine metallic point on glazed paper blackened with smoke to the use of the pencil or to the *gaufrage* by pressure or by shock.

The barograph of Montsouris is a barometer-balance devised by P. Cecci, and latterly adopted by P. Secchi. The barometric tube A B (Fig. 1) is of iron, of 3 centimetres internal diameter, and of the same calibre throughout its length. It is fixed, and has, at its lower extremity, a cylindrical plunger, the full section of which is equal to the vacuum section of the barometric tube. The cistern, C, is of steel, and suspended to one end of the beam of a balance, D, the other end of which carries a counterpoise. The centre of gravity of the weighted beam coincides, as nearly as possible, with the central knife-edge, so as to render the equilibrium indifferent. Hence it results that when, in consequence of a rise of the barometer, a part of the mercury rises from the cistern into the tube, the former, thus rendered lighter, tends to rise, with the effect of introducing into the mercury of the cistern a greater length of the cylindrical plunger. Equilibrium is only re-established when (the volume of mercury displaced by the plunger being equal to that which corresponds in the tube to the increase in height of the barometric column) the level of mercury in the cistern returns to its constant point, and when, consequently, the apparent weight of that cistern has resumed its fixed value. The needle, *h*, of the beam of the balance marks its displacements on the surface of the blackened cylinder, K. It only remains to read the indications. To do this as accurately as possible, the support of the cylinder carries an electro-magnet, the armature of which is provided with an arm bearing a metallic point.[1] In ordinary weather this point is fixed, and traces on the cylinder a datum-line from which the ordinates of the barometric curve are measured; but every hour the electro-magnet is acted on by a clock marking the time on all the registers; the point departs momentarily from the line, and makes a clear stroke, which is reproduced at the same instant on the other cylinders. At the end of each week the cylinder is taken away, to be replaced by another kept ready, and is placed on the reading apparatus.

This apparatus (Fig. 2) consists of a horizontal steel bench, *f g*, provided on its upper surface with two columns, *h h'*, intended to support the axis of the cylinder, and on a vertical stand with two microscopes, which may be moved either separately or together in a horizontal direction. By means of an endless screw a movement of rotation on its axis may be communicated to the cylinder for the purpose of presenting successively to the microscopes the various faces of the cylinder. The microscope *b* is always pointed on the datum-line, and it is to follow this line in its accidental displacements, that the two microscopes may be moved together by the action of an adjusting screw. The microscope which points to the traced line carries at its focus two crossed threads, one horizontal and the other vertical. At each hourly reading one of the horizontal tracings on the datum-line is brought under the horizontal thread of the microscope. But, as the barometric curve often presents inflexions of which it is useful to note the exact time, the critical point of this curve being brought under the movable microscope *a*, a second horizontal thread, movable by a micrometric screw, serves to measure the distance of this point from the hourly mark immediately preceding.

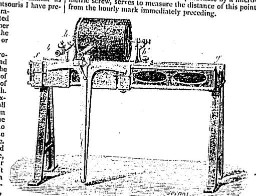

FIG. 2.—Micrometer or reading curves traced by the register.

The microscope *a* is supported at the extremity of an arm of a lever the length of which is equal to that of the barometric needle; it describes, consequently, an arc of a circle of the same radius as the point of the register. This second microscope has a cross of threads like the first, but without a movable thread. The first microscope being pointed to an hourly sign, the axis of the second is directed to the corresponding point of the curve. The sine of the angle of position of its lever, multiplied by a

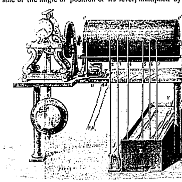

FIG. 3.—Thermograph.

constant factor and increased by a number equally constant, gives the height of the barometer at the moment selected. When the reading of the curve is made and verified, the sheet of blackened paper is taken off the cylinder and soaked in a weak solution of gum-lac or of copal in alcohol. By this means the smoked sheet is "fixed," and thereafter put in a portfolio.

The feeblest barometric variations are thus shown with

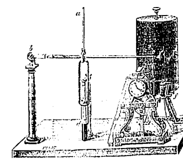

FIG. 4.—Register of the Atmograph.

great fidelity, and by examination of the curves we readily recognise the influence which the dynamical state of the atmosphere exercises in increasing or diminishing the weight of its pressure on the ground. It should be added that the uniformity of the calibre of the barometric tube annuls almost completely the action of temperature on the indications of the instrument.

The thermographs act in an analogous way, except that the motor is here formed by a Bourdon tube of hammer-hardened copper, with a very elongated elliptical section, and twisted into a sort of spiral, the thread of the spire varying from 2 to 3 centimetres, according to the purpose for which it is intended. A B (Fig. 3) represents one of these tubes, forming a little more than one spiral. This tube is exactly filled with alcohol, and closed at its two ends. The expansion of the alcohol compels it to untwist; but in order that its elasticity may be preserved, the internal pressure, corresponding to the highest temperatures to be reached, should not exceed 8 or 9 atmospheres. This pressure is all the greater in proportion as the thread of the spire is short. The twisted tube is fixed by one of its ends, the other free extremity bears the needle which gives the indications. At Montsouris this needle is 5 centimetres long, as is also that of the barometer. The process of reading the curves is thus exactly the same for all the needle registers. The new thermograph of Montsouris Observatory contains seven needles acting on the same cylinder. The first needle (No. 1, Fig. 3) belongs to the electro-magnet which traces the datum-line, and the hourly signs; needles 2 and 3 belong to the psychrometer; needles 4 and 5 record the temperature of the surface of ground exposed to the air without shelter; needles 6 and 7 correspond to the actinometer.

The psychrometer is formed of two twisted tubes placed outside on the north face of the wooden kiosk, which shelters the cylinder, and perpendicular to that face. Their furthest extremity is fixed, the other is prolonged through the wall of the kiosk by a stem of copper carrying the indicating needle. One of the twisted tubes is uncovered, and forms the dry thermometer; the other is covered with cambric, and kept moist by means of cotton-wicks dipped in small glass cups, connected with a Mariotte flask placed in the kiosk by means of a long and fine tube of caoutchouc. An instrument of this kind has been in use for fifteen months at Montsouris; its action is regular, and its sensibility very great.

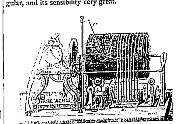

FIG. 5.—Anemograph.

The earth-thermometer is composed of two parts:—A thermometric reservoir of black copper is placed on the surface of a mass of vegetable mould, the top of which is flush with the platform of the roof of the kiosk; this reservoir communicates by a capillary tube of copper with a twisted tube placed in the kiosk under the cylinder of the register. When the temperature of the ground rises, a portion of the alcohol passes from the upper reservoir into the twisted tube, the pressure increases and the tube untwists; but the twisted tube itself and its capillary tube of

[1] Paper by M. Marié-Davy, *Journal de Physique*, April, 1879.

[1] This electro-magnet, which is seen in the thermograph (Fig. 3), is not shown in Fig. 1.

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Eng Mechanic

QUICK-ACTING ELECTRIC LENS-SHUTTER. Aug 8 18

[16020.]—As some of your correspondents have asked for an account of an instantaneous lens-shutter, I will endeavour to describe one, invented and used by my father. The construction will be best understood by reference to the following diagrams:—

FIG. 1

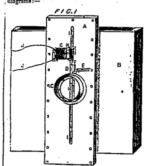
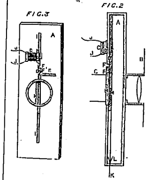


FIG. 3 FIG. 2



The shutter apparatus is inclosed in a box made of fine cedar wood, which has an arrangement to enable it to be screwed on to the lens of the camera with which an instantaneous picture is to be made. Inside this box are two shutters or screens, which slide up and down inside the box, and run in grooves well black-leaded, to diminish friction. A groove is cut through on the outside of the box, and to one side of it an electro-magnet is screwed, connected to a battery, the wires from which are furnished with a touch-button, in order to make and break the current. Working on a pivot opposite to the electro-magnets, is a piece of iron (D) with two notches (F and F) cut in the lower part of it, and in these notches fit two small pins, which keep the shutters from falling; and a spring (E) is connected with the lower part of D, the piece of iron, and keeps it away from the electro-magnets, when the current is not passing. When the touch-button is pushed the current passes, and lets fall the lower shutter by drawing away the prop (F); and while the current passes another prop (F) is put under the upper shutter (L). But as soon as the current does not circulate in the magnets, the spring (E) asserts its power by pulling away the other prop, and letting the top shutters fall and cover the mouth of the lens.

A is the shutter-box which screws on to the lens.
B is the camera.
C the electro-magnets.
D the iron with the two notches in it, in which rest the pins which support the shutters.
E the spiral spring.
F the upper notch, which when the current is not passing does not support the shutter, which is supported by the lower one; but when the current passes, the notch supports the top shutter; the lower notch (F) which when the current is passing releases the lower pin in the lower shutter and lets the shutter fall, but when no current passes the upper shutter is supported.
G is a lens screen made of brass.
H is the part of the shutter which runs in the grooves.
I is a groove in the box.
J J are the wires to battery.
K is a piece of wire to push the shutters up with.
L is the uppermost shutter.
M is the lower shutter, made of thick cardboard, covered with a solution of lampblack and varnish.

Gateshead. Cameron Swan.

A New Electric Current Breaker.—A simple form of contact breaker is described by Dr. [illegible]. To the middle of a wire stretched horizontally is attached a platinum point which touches the surface of mercury held by a small vessel. The current passes through the wire, and over that part of the wire through which the current passes when all the apparatus in its normal state is a small magnet. This magnet, acting on the current, causes vibrations in the wire, and so breaks and makes contact. The number of vibrations can be readily modified by changing the length of the wire, and as high a number as 1000 breaks per second can be obtained. By passing an intermittent current over the wire, it can be set in vibration without the intervention of mechanical means. This happens when the fundamental note of the string is in unison with the pitch of the breaker.

Electrical Letter Boxes.—Among the recent applications of electricity is an attachment to street letter boxes, so arranged that if an attempt is made to rob the box an alarm will be instantly sounded at the nearest police station.

Sc Am Aug 23 1879

Electric Blowpipe.

Journ of Sc Aug 1879

At a recent meeting of the Academy of Sciences, M. Jamin submitted a new electric burner, which he also recommended to chemists and physicians as a blowpipe. Two carbons are supported vertically, abreast, hinged below, and drawn together at the top by a spring. A current is sent up one, down the other, then round a rectangular circuit inclosing the two, and passing first round the first one by current attraction, the carbons are drawn apart, and the arc appears at the top and descends gradually, consuming one or both carbons. When the action of the rectangle is sufficient, the arc driven beyond the points is like a gas flame, and M. Jamin receives it on a piece of lime, magnesium, or zirconium, getting intense light. It is also so hot as to fuse the lime. For the electric light this burner has considerable advantages, since it has no mechanism and requires no preliminary preparation beyond a support and the carbon points. The size of the flame is almost doubled and the light is augmented. The new foci are very powerful, and the quality of the light is far better, and the arrangement of the foci is more advantageous, the greatest quantity of light being directed downward, where it is wanted, instead of up into the air, where it is useless.

It is now proposed that the officers undergoing a course of torpedo instruction on board the Vernon, at Portsmouth, shall also be required to familiarise themselves with the practical application of electricity to the art of war. The teaching element has not as yet been perfected, but proper instructors will, no doubt, be provided in course of time. Steam was got up in the Dreadnought on two occasions, and the first lessons in the production and management of the electric light were imparted. The turret ship is provided with a couple of lamps placed at each end of the flying deck, the current being generated by one of Wilde's electro-magnetic machines, the motive power for which is supplied by a strap from the forward ventilating engine. The illumination is produced by a couple of vertical carbon points, which are worked by hand. There is no subdivision of the current, so that only one light can be used at a time. Until lately, however, the after light could only be obtained by disconnecting the forward one and forming a new and separate connection with the commutator between decks. This method not only entailed great loss of time, but was attended with great difficulty. Now, however, an important improvement has been introduced, by means of which it is only necessary to shut off the forward connection, and the after light may be used at once. Some experiments have also been made with the Gramme machine on board the Bloodhound and a torpedo boat. Engineer Aug 1 1879

Nature Aug 7 1879

ELECTRICAL CLOCKS AND CLOCKWORK

In the year 1843 an electrical pendulum which forms the basis of nearly all succeeding systems of electrical clockwork, was patented by the late Alexander Bain. (See Fig. 1.)

The bob of the pendulum, C, consists of a coil of insulated wire. One end of the wire passes to the axis of the tumbler A T, the other, through the suspension spring S, to the plate P_1. P_1 P_2 are plates, say of zinc and carbon, and are sunk in the earth to form the battery. From P_2 a wire W_2 proceeds to N. M M is a horse-shoe magnet. Whilst A T leans against N, a current is passing, and C is

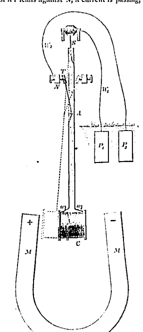


Fig. 1.

magnetic. C has its − and + poles facing the + and − poles of the horse-shoe magnet. Consequently the pendulum is driven to the left, but when it reaches a certain point, A T topples over, the current ceases, and the pendulum returns. The pendulum now proceeds on its swing to the right, but on approaching the limit of its oscillation, overturns A T again, the current is renewed, and the pendulum again propelled to the left. This action automatically repeats itself. Mr. Bain placed within the circuit of his pendulum any number of electrical dials. Fig. 2 shows the mechanism of these. C is a coil either in the line of W_1 or W_2. When a current passes C becomes magnetic, and oscillates between the magnets M M. At every swing of C a tooth, T_1, of the wheel is gathered up by the detent D D. The click, K K, by holding a tooth, T_2, prevents the wheel returning whilst D is passing to the right.

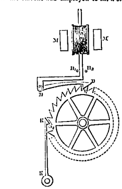


Fig. 2.

The impulse on Mr. Bain's pendulum varied with the power of his battery, a condition fatal to good time-keeping. In 1849 Mr. Shepherd patented a system in which the current was employed to lift a slight weight or spring. The fall of this propelled his pendulum, and gave an impulse quite independent of any variation in the power of his battery. Fig. 3 shows one of his plans.

P P is the pendulum, W a weight, mounted on a lever W C A. W C A can move about a centre C, and is at present prevented from turning by the catch S S. When P P swings to the right, the lower screw in P P passes under E (see side view Z) and frees W C A. W C A, under the weight of W, propels the pendulum to the left till stopped by a

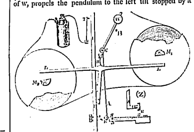


Fig. 3.

banking B. P P moves on and makes contact with T, whereupon a current passes, M_1 M_2 become magnetised, and attract L L, the vertical arm of which lifts W C A over the catch S S again. When P P leaves T the current ceases, and L L is carried back to its old position by the action of the spring R.

Mr. Bain's and Mr. Shepherd's are the leading types of electrical clocks properly so called, that is to say, of clocks which keep themselves going by electricity. But it

THE GLASGOW ELECTRIC FIRE ALARM SYSTEM.

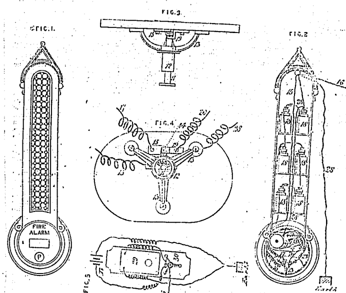
Telegraphic[?] Dec 15 1879

A SYSTEM of electric fire alarms has now been in use at Glasgow for some years, and has been very successful. The apparatus is very simple in construction, and little liable to get out of order. As the question of fire alarms is likely to receive more attention in this country than has hitherto been the case, a description of the Glasgow apparatus may prove interesting.

Fig. 1 shows the outward form of the signalling apparatus, which is placed at the corners of a number of the streets in the town. The arrangement

Fig. 2 shows an inside view of the wall-box. The upper part is occupied by batteries 18, placed on shelves as shown. In the lower part is fixed the push key 13 (which is shown on an enlarged scale by figs. 3 and 4) and the acknowledgment bell 21.

The push key 11 (fig. 4) is a tube having an annular head on its outer end, on which the word "push" is marked, and it is carried in a tubular bearing 12, fixed on a three-armed bracket 13. A helical spring is arranged inside the tubular bearing 12, to press the push key 11 outwards, and when the key is pushed inwards its inner end acts on a metal spring 14, and causes it to make a contact with a piece of metal 15, thereby closing the circuit



consists of a cast iron box, about 4 feet high, placed sufficiently high up on the wall of the building to which it is fixed to be out of easy reach of loiterers, but yet sufficiently low to be got at with a little exertion. To sound an alarm it is only necessary to depress the push key P, when a bell is rung at the fire station with which the apparatus is in communication, and on the receipt of the signal at that place an acknowledgment signal is returned, which sounds a bell placed in the lower part of the case.

of the wire to the district station, and sounding the bell at that station. The spring 14 is connected to the line wire 16 (figs. 2 and 4), and the metallic piece 15, into contact with which the spring 14 is pushed by the key 11, is connected by a wire 17 to the battery 18, shown in fig. 2 as occupying the upper part of the fire-alarm box. When the spring arm or switch 14 is not pressed in, it forms a contact with a metallic piece 19, which is connected by a wire 20 with the electro-magnetic bell 21 in the

over

s the clock, Fig. 11, the current aro

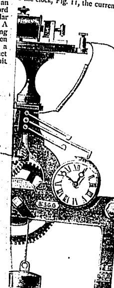


Fig. 11

ounted on the top of it. When

... method of correcting clocks ... p. 55. M. Collin, Chevalier of the Legion of Honour, and has been largely made use of by him. Fig. 10 shows his standard clock, and Fig. 11 the clock to be corrected: the latter is regulated to gain a second or two per hour. A few minutes before each hour the lower of the two detents in Fig. 10 is lifted against the upper, and a current

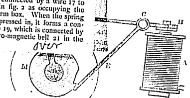


Fig. 12.

the clock, Fig. 11, reaches the hour, it allows the long

detent shown in the drawing to fall; this closes the circuit, and a hook attracted by the coil, catches a tooth cut in the escape-wheel, and holds it till the standard clock reaches the hour. At the hour the standard clock, Fig. 10, allows the lower detent to fall, and so breaks the circuit. Consequently the clock, Fig. 11, starts off side by side with the standard.

Mr. Ritchie, to whom we have referred before, has also devised a plan for correcting clocks by hourly currents. His clock, to be corrected in like manner, gains some second or two per hour. Fifteen seconds before each hour the lever D B (see Fig. 12) is attracted by the electro-magnet A, and a pin in the arm D would thereupon enter and catch a tooth of the escape-wheel, did the disc M allow the other arm of the lever E to move. When the hand reaches the hour, E falls, then D catches S and holds it till the cessation of the current at the sixtieth second of the governing clock.

Generally the use of a long telegraphic wire can only be commanded for a few minutes daily. Fig. 13 shows a very suitable arrangement to be adopted when this is the case. By means of the 24-hour disc the line wire is held in communication with the telegraph office until a

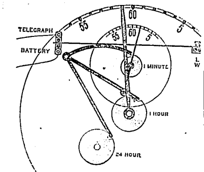


Fig. 13.

few minutes before the clock current is going to be despatched. The notch in the 24-hour disc will at last allow the system of levers to fall, but then the 1-hour disc supports them until about one minute before the clock current is coming; so that, till then, the line is being used for messages. The line wire has not been allowed to fall into circuit with the battery wire; this is still prevented by the 1-minute disc. At the sixtieth second precisely the 1-minute disc allows the line wire to join the battery wire, and out goes the clock current. Some seconds afterwards the 1-hour disc lifts the line wire back into communication with the telegraph office, where it stays for another twenty-four hours.

The Great Westminster Clock reports its own time to Greenwich by the following arrangement:—Some minutes before a signal is due, a lever is lifted by a slow wheel into such a position that a pin in the next wheel at its coming rotation will catch it. The second wheel lifts it so much further that a pin in the escape wheel reaches it, presses two slight springs together, and sends off the signal.

A method of driving an electric dial was contrived by the late E. J. Dent. A powerful magnet was lifted through a coil of insulated wire by a strong tower clock movement. Every half minute the magnet was dropped a current was generated in the coil, which proceeded to the dial and moved the hands. A plan on the same principle has lately been used for driving a number of small dials. A pendulum having a hollow coil of insulated wire for a bob, is by a heavy weight kept oscillating over a system of magnets. Currents are generated in the coil which proceed to the dials and work them.

Only the principal inventions in electrical clocks and clock-work have been indicated in this article. Since the year 1843 upwards of thirty patents have been applied for for improvements in such clocks and clockwork. It will be seen from this the subject, though not a wide one, is extensive.

Mr. Ritchie kindly lent diagrams 5, 6, 9, 12, and 13 to illustrate his plans, and M. Collin 10 and 11. Figs. 1 and 3 have been arranged to exhibit their working with clearness.

HENRY DENT GARDNER

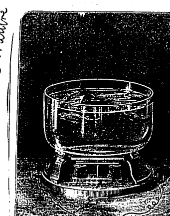
La Nature Feb 28 1880

LES POISSONS MAGIQUES

La Nature Feb. 28, 1880

Un ingénieux physicien, M. de Combettes, ingénieur civil à Paris, s'est attaché à construire un grand nombre de jouets et appareils scientifiques à l'usage de la jeunesse, parmi lesquels nous signalerons la curieuse expérience que nous représentons ci-dessous.

Un bocal cylindrique rempli d'eau tient en suspension des poissons de fer-blanc, analogues à ceux que les enfants promènent à la surface de l'eau à l'aide d'un aimant. Mais ici le mécanisme est caché ; à la



Expérience des poissons magiques mis en mouvement par l'électricité.

volonté de l'opérateur, les poissons accomplissent un mouvement de rotation, tantôt dans un sens, tantôt dans un autre. Le secret de cette expérience s'explique facilement de lui-même par la figure ci-dessus.

Dans le socle de bois qui supporte le bocal est caché un petit moteur magnéto-électrique qui agit sur le fer doux dont les poissons-flotteurs sont munis. Quand on fait passer le courant, le petit moteur de M. de Combettes se met à tourner et entraîne avec lui les petits poissons, qui nagent dans le liquide. Le mouvement giratoire est changé à volonté, à l'aide d'un commutateur.

Le Propriétaire-Gérant : G. Tissandier.

Electric Blowpipe.—At a recent meeting of the Academy of Sciences, M. Jamin submitted a new electric burner, which he recommended to chemists and physicists as a blowpipe. Two carbons are supported vertically abreast, hinged below, and drawn together at the top by a spring. A current is sent up one, down the other, then round a rectangular circuit inclosing the two, and passing first round the first one by current attraction the carbons are drawn apart, and the arc appears at the top and descends gradually, consuming one or both carbons. When the action of the rectangle is sufficient, the arc driven beyond the points is like a gas flame, and M. Jamin receives it on a piece of lime, magnesium or zirconium, getting intense light. It is also so hot as to fuse the lime. For the electric light this burner has considerable advantages, since it has no mechanism and requires no preliminary preparation beyond a support and the carbon points. The size of the flame is almost doubled and the light is augmented. The new foci are very powerful, and the quality of the light is far better, and the arrangement of the foci is more advantageous, the greatest quantity of light being directed downward, where it is wanted, instead of up into the air, where it is useless.

Electric Inscription of Words.—The transmitting apparatus is a microphonic speaker, the carbons of which instead of being pressed by a spring, are simply maintained in contact by the pressure of a small piece of paper folded in the form of a V. The vibrations of the diaphragm of the receiving apparatus cannot be written, since the movements of the style, however delicate the apparatus, can scarcely be distinguished upon the lamp-black." To enlarge the magnetic vibrations of the receiver the cover and the diaphragm of a Bell's telephone are taken away, and on the wood of the instrument there is fixed the end of a small, stiff steel spring. The other end of the spring abuts on the surface of the magnetic nucleus surrounded by its coil; to this extremity is soldered a small mass of soft iron, weighing about 10 grms., and upon this mass and in the produced line of the axis of the spring is fixed a light style of bamboo, 10 centimeters in length and terminating in a slender whale-bone pen.—*M. Boudet* July 26 1879 Mining & Sc Press

We call special attention to the advertisement of "*Edson's Recording Pressure Gauge and Electrical Alarm*," as it is an indispensable attachment, in order to completeness, to every water-works system, the "charts" showing at all times past and present the height or pressure in every reservoir or pipe to which it is connected, and *every reduction* in such pressure, as well as to define the precise time of day or night, and responsibility may be placed on the proper persons, unless such variations may be traced to other causes. Engineering News Aug 24/79

NOUVEAUX POLYSCOPES

DE M. TROUVÉ

La Lumière Electrique Aug 21 1879

Toutes les personnes, en France, qui se sont occupées d'électricité connaissent l'ingénieux instrument que M. Trouvé,

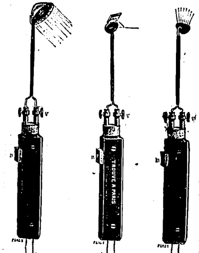


Fig. 1.

son inventeur, a nommé polyscope. Voici pourtant que des journaux étrangers attribuent au Dr Nitze, de Vienne, l'invention d'un appareil consistant en un tube de verre pouvant servir de sonde et portant dans les organes un fil de platine rendu lumineux par un courant électrique. M. Trouvé n'a pas de peine à établir que cette idée, qui est celle qu'il a réalisée, n'est pas nouvelle, et que d'ailleurs il l'a mise en œuvre beaucoup mieux. L'éclairage intérieur des cavités par l'électricité a été proposé à Paris, en 1867, par le docteur Brink, de Breslau; l'idée fut développée par le Dr Millet, et M. Trouvé exposait son appareil dès 1873. Son dispositif est beaucoup plus simple que celui du Dr Nitze. Le principal inconvénient étant la chaleur, ce dernier s'efforce de l'enlever à l'aide d'un courant d'eau; plus habile, M. Trouvé a réussi à ne pas la produire en excès. Dans ses petits appareils

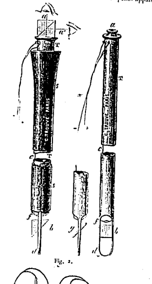


Fig. 2.

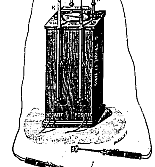


Fig. 3.

du genre de ceux qui figurent ci-dessus (fig. 1) l'électricité est envoyée par une batterie secondaire de Planté munie d'un

rhéostat de nature spéciale, en sorte que le courant est réglé avec une précision absolue; le fil est très-fin et la chaleur produite est assez faible pour être très-bien supportée.

Au reste, une des preuves de l'invention est le perfectionnement; on en signale de très-importants apportés par M. Trouvé. D'abord, l'introduction des prismes à réflection totale et à grossissement, permettant de voir à côté de l'appareil les parties qu'il éclaire à angle droit, et d'explorer ainsi complétement une cavité telle que la vessie: la figure ci-dessus (fig. 2) donne l'idée de la disposition de l'appareil.

Ensuite, la disposition, sur une même source électrique, de deux circuits pouvant porter l'un l'appareil d'éclairage, l'autre un appareil cautérisant; l'opérateur peut, à l'aide de ce système figuré ci-dessus (fig. 3), n'avoir besoin d'aucun aide et n'éprouver aucun embarras d'instruments.

Au reste, ces appareils sont passés, assure-t-on, dans la pratique: les Drs Péan, Trélat, etc., en font usage et s'applaudissent de leurs résultats. L'appareil est important et il nous a paru utile de réclamer pour la France et pour un de nos plus habiles constructeurs l'honneur de son invention.

Rock Drilling by Electricity.—The application of electricity for the purpose of drilling or boring rocks has been suggested by M. Gaston Plante, the inventor of a process of engraving on glass by the same agency, which was made known in 1877. In the latter process, one of the electrodes conducting an electric current of high tension, being brought in contact with the glass, in presence of saline solution, acts like a graver or diamond, by tracing grooves in the surface of the glass, and even digs into it quite deeply. In spite of its great hardness, rock crystal can also be attacked by the same method; and, if not engraved regularly, it at least cracks into small fragments, and is finally disintegrated. Under conditions analogous to these, the electric current might be substituted for diamonds in the operation of drilling rocks. M. Plante states that electrodes of platinum would not be necessary, for here it is not the metal of the electrode that is affected, but the silicious matter, in contact with a saline solution. Metallic points or projections, suitably located at the extremity of the drill, isolated on a part of its length, and actuated by a rotary movement, would lead the electric current to the surface of the rock to be pulverized, and would thus replace those numerous and expensive diamonds which are set in the head of the drills employed in the present system of rock-boring. Mining & Sc. Press Aug 16 1879

106

L'électricité appliquée à la surveillance des timoniers.

La Correspondance Scientifique Aug. 1. 2. 1879

Suivant la *Nature* de Londres, on viendrait de faire une application très ingénieuse de l'électricité à la navigation. Un Anglais, M. Henry Severn, aurait réussi à établir, dans l'intérieur du navire, une sorte d'instrument à l'aide duquel le capitaine est averti au moyen d'une sonnette dès que le bâtiment cesse de suivre la route prescrite. Cette sonnette est mise en mouvement d'une manière automatique par toute la déviation de la route indiquée à l'avance. Le timonier ne pourrait changer de direction sans qu'un témoin vigilant avertisse à l'instant le capitaine de la faute commise.

En supposant qu'en quittant le pont, le capitaine ait donné l'ordre de suivre une direction, il place l'aiguille de l'instrument à un certain angle, et au lieu d'avoir comme aujourd'hui à veiller constamment sur la boussole pour savoir si ses ordres sont suivis, il s'en remettrait à l'appareil de M. Henry Severn qui l'en informe par son silence, et, en cas contraire, l'avertit par son tintement. L'instrument ne cesse de résonner que quand le bâtiment a repris la marche prescrite.

Deux index métalliques sont placés au-dessus de la rose des vents de la boussole : l'un à bâbord, l'autre à tribord de la direction choisie, c'est-à-dire l'angle de route étant la bissextrice de l'angle formé par les deux index et la projection du centre de suspension de l'aiguille. La grandeur de cet angle est déterminée par la latitude que le commandant laisse au timonier pour les embardées qu'il est obligé de faire soit à bâbord, soit à tribord. Si la rose des vents, qui, comme on le sait, est mobile avec l'aiguille, porte une pointe métallique, que le courant d'une faible pile soit introduit par l'axe, le contact avec les index ne peut se produire sans que le circuit soit fermé.

Il est clair que si le navire sort des limites angulaires prescrites, un courant peut s'établir et une sonnette d'alarme le mettre en action jusqu'à ce que le navire reprenne sa route.

La sonnerie peut être établie n'importe où, et, par conséquent, rien n'empêche de la placer dans la chambre du capitaine.

La question à résoudre est de savoir si ce dispositif nuit à la disposition de la boussole.

C'est une question à laquelle l'expérience seule permettra de donner une réponse.

Nous reviendrons sur cet appareil quand nous aurons entre les mains des procès verbaux d'expériences.

Mais il nous paraît incontestable que cette nouvelle application de l'électricité appelle inévitablement l'attention sur la boussole circulaire de M. Duchemin, qui paraît avoir une force directrice plus grande et se prêter à merveille à l'application du système de M. Henry Severn, quelle que puisse être sa valeur

(*L'Electricité.*)

V.-D. Costes.

AN electric target—that is, a target which by means of electricity shows [illegible] upon another target set up at the firing station, the exact spot where a bullet strikes, and thus does away with the necessity of employing a marker to signal the result of each shot—has been lately perfected, after years of labor, by a Swiss locksmith.

Sc. American Sept. [illegible]

La Lumière Electrique

DU ROLE DE L'ÉLECTRICITÉ

DANS LES DÉFENSES SOUS-MARINES

Aug. 15/79

L'officier de mer, depuis quelques années à peine, est appelé à se servir couramment d'une nouvelle force, mise par la science entre ses mains. Les mines électriques sous-marines, ou torpilles, sont venues augmenter le cercle des études variées et nombreuses du marin. Tout en continuant à perfectionner les machines, tout en poussant encore plus loin la puissance formidable de leurs organes, le navigateur moderne a dû mener de front l'augmentation du calibre et de la portée du canon pour l'attaque, et trouver le moyen d'alourdir la cuirasse pour la défense, sans toutefois retarder la marche du bâtiment. Mais voici qu'aujourd'hui l'électricité vient prendre dans la marine une place des plus importantes, soit qu'il s'agisse de défendre la côte natale, soit qu'il importe de soutenir à l'étranger l'honneur du pavillon. Quelques appareils sûrs et peu compliqués ont suffi pour faire, d'un geste, voler en éclats ces canons, ces cuirasses, et ces admirables machines produites à grands frais par des armées de travailleurs. Est-ce là un progrès? Sans aucun doute, en ce qui concerne les peuples civilisés, si l'on convient que la guerre est plus funeste à l'humanité par les longueurs que par les plus meurtriers engagements du champ de bataille. Le progrès militaire est l'emploi des moyens les plus simples pour obtenir les plus puissants effets; mais cette simplicité même devient, si l'on pense aux peuples à demi sauvages, un obstacle dangereux à la civilisation. Les Chinois, les Japonais connaissent aujourd'hui l'usage de la torpille. Dans un avenir prochain, les plus justes réclamations du monde civilisé ne seront-elles pas tenues en échec devant une rade par quelque guetteur à demi nu chargé de presser un bouton de cuivre au moment où le port va être forcé? Si, de plus, les côtes attaquées sont défendues par des obstacles naturels s'opposant au débarquement, la marine se trouve dès lors réduite à l'impuissance, et ne peut reprendre son influence à moins qu'elle ne trouve dans l'électricité elle-même, probablement, un moyen nouveau pour se protéger de la torpille, si difficile à paralyser dans l'état actuel de nos connaissances.

Nous aurions donc beaucoup à dire sur la torpille et sur les différentes manières de l'employer. Quelques lignes au contraire suffiraient pour résumer les obstacles très-imparfaits que l'on tâche de lui opposer.

Nous offrons aux abonnés de la « *Lumière électrique* » un résumé succinct des divers systèmes employés par les grandes puissances européennes. Nous n'entrons pas dans des détails spéciaux en dehors de l'électricité; détails importants, croit-on, mais bien plus probablement tout à fait insignifiants, sur lesquels, en tout cas, chaque puissance s'efforce de garder le secret, tout en cherchant à connaître à fond les fonctionnements étrangers. Ceux de nos lecteurs qui n'ont pas eu l'occasion de se rendre compte de cet intéressant emploi de l'électricité verront peut-être entre ces lignes surgir tout à coup à leur pensée quelque application utile à notre flotte, quelque moyen tout nouveau à proposer pour la défense de nos côtes. C'est surtout, nous le répétons, dans la neutralisation de la torpille que l'on cherche à progresser.

Trouver un moyen secret, permettant, sans quitter le navire, de paralyser la torpille ennemie à dix mètres ou plus de sa verticale, serait l'écroulement de tout le système de protection électrique d'une côte.

Un autre progrès plus important encore et réalisable à bref délai, croyons-nous, serait l'invention d'un projectile électrique amortissable, c'est-à-dire tombant à pic sans rebondir à plus d'un mètre, dès qu'il a touché l'ennemi, puis éclatant sous l'eau à 3 mètres de profondeur par les moyens aujourd'hui connus dans toutes les marines, c'est-à-dire es pistons hydrostatiques. Ce boulet n'aurait pas besoin d'une grande force de projection, porterait à 200 ou 300 mètres seulement, et ne remorquerait aucun fil; il contiendrait sa source d'électricité.

Ce boulet électrique amènerait la suppression de l'artillerie perfectionnée et de la cuirasse, le jour où il pourrait être lui-même lancé par un petit bâtiment très-rapide s'avançant à toute vitesse à petite distance de l'ennemi. Or ces bâtiments existent déjà en dimensions réduites; nous en parlerons à propos des torpilles portées à toucher les flancs des attaquants de haut bord.

Les torpilles électriques employées de nos jours peuvent se diviser en deux catégories : celles de la *défense fixe* destinées à barrer un passage et établies dans une position déterminée sur le fond, et celles de la *défense mobile* légères, maniables, portées par les grands bâtiments dans leurs combats au large, ou par des embarcations rapides destinées à courir sur l'ennemi en vue.

DÉFENSES FIXES. — DÉFENSE D'UNE PASSE.

La défense fixe prend ses positions d'après la configuration des côtes et des vallées sous-marines. Tout ce qui a trait à cette branche spéciale pourra donc être pesant, laborieux à établir, mais devra être de longue durée sous l'eau, et d'un effet d'autant plus puissant que la ligne de torpilles est la dernière défense des assiégés.

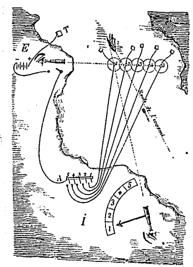
La torpille étant une masse de matières explosibles enfermées dans une carcasse en fonte ou en tôle et dont l'effet est rendu plus violent par la charge d'eau qu'elle supporte, elle devra se trouver toujours au moins à 3 mètres de profondeur. Le cercle d'action dangereuse produit à la surface par l'explosion, varie avec la profondeur, la charge, la résistance de la carcasse. — On l'estime suffisant en pratique quand il a 12 à 15 mètres de diamètre; les torpilles seront donc mouillées à 30 mètres les unes des autres en travers de la passe, mais une rangée unique a un inconvénient : la commotion produite par une torpille brise souvent par contre-coup celles qui en sont voisines. — Il vaut donc mieux mouiller les torpilles en quinconce. On les dispose ainsi en groupes qui explosent en bouleversant une grande surface.

La gerbe soulevée par une torpille se compose dans son ensemble d'un volume conique sous l'eau, dont l'axe est toujours vertical, et l'angle au sommet, partant de la torpille est plus ou moins aigu suivant la profondeur; au-dessus de l'eau la gerbe proprement dite est cylindrique à la base, conique au sommet; son diamètre, nous l'avons dit, doit être de 15 mètres environ. — Sa hauteur atteint de 25 à 50 mètres, suivant la quantité de poudre et l'immersion. Tout autour de la base, l'eau est gonflée et houleuse, mais sans danger même pour une embarcation qui n'aura, à cette distance de 8 mètres du centre, rien à redouter qu'une forte pluie retombant sur son avant, tandis qu'à 2 mètres devant elle le plus fort bâtiment serait complétement désuni par l'effet du marteau d'eau ascendant. — Il faut donc, dans l'usage des torpilles dormantes, arriver à produire l'explosion au moment précis du passage du navire sur la verticale de l'engin. — De même, pour les torpilles légères portées au bout d'une perche inclinée dont le bout est immergé à 3 mètres sous l'eau, il suffit que cette perche ait 8 à 10 mètres de long pour que l'embarcation n'ait aucun dommage sérieux.

La précision du tir nécessaire à la défense fixe a été l'ob-

107

jet de dispositions variables suivant les puissances et la configuration des passes. S'il est permis d'employer le mot dans la circonstance, la plus élégante de ces dispositions est celle qui place le guetteur de la passe sur un point élevé voisin de la mer, où il voit, enfermé dans une chambre obscure, se peindre sur un tableau blanc l'image de la passe. On a préalablement envoyé un canot à l'aplomb de chaque torpille; il a décrit autour de ce centre un cercle de 7 mètres de rayon, cercle dangereux, et on a tracé en même temps sur le mur de la chambre noire la trajectoire de ce canot, un numéro indique quelle pédale il faudra presser lorsque l'ennemi viendra se peindre au même endroit. — Ce système employé d'abord en Amérique a été vite abandonné, les



ellipses correspondant aux torpilles éloignées étaient trop aplaties pour bien juger la situation de l'ennemi surtout avec de la houle. De plus, le point élevé était en vue et servait de but au tir de l'assaillant.

On emploie généralement aujourd'hui le système de visée simultanée par deux postes assez éloignés l'un de l'autre et aussi ras de terre que l'on veut; l'un de ces postes dit *extérieur* est sur la ligne même des torpilles; l'autre, le poste *intérieur*, est autant que possible sur la perpendiculaire à cette ligne. Au poste extérieur, une lunette fixe est braquée dans la direction des torpilles, un commutateur à pédale est à portée de la main du guetteur. — Dans un coin, une forte pile d'inflammation de 30 éléments Bunsen modifiés (bichromate de potasse autour du charbon, et eau saturée de sel marin autour du zinc.) — Enfin un appareil télégraphique pour parler au poste intérieur. — Celui-ci contient une lunette qui se meut horizontalement, entraînant une queue qui se déplace sur un arc de cercle dont chaque secteur porte un numéro correspondant à une torpille connue. — On suit donc l'ennemi avec cette lunette, et un autre opérateur presse sur un clavier A la touche portant le numéro indiqué par la queue de la lunette sur le secteur.

Le diagramme ci-contre donne la marche du courant: pôle de la pile, plaque de terre T, plaque de terre de la torpille 1, 2, 3, etc., amorce de celle-ci, conducteur sous-marin, clavier des commutateurs, fil des postes, commutateur du port extérieur E, pôle négatif. On voit que l'œil du poste I suivant le navire pressera en ce moment-ci la pédale nº 1 en continuant à suivre l'ennemi, il pressera bientôt la pédale 2 en abandonnant la pédale 1. Mais à ce moment l'œil du poste I voit le bâtiment sur la ligne, presse son commutateur et le circuit fermé fait sauter 2 seulement.

Le télégraphe qui relie les deux postes servira à bien désigner le navire à suivre pour que les deux guetteurs n'aient qu'un même objectif convenu d'avance.

Cette entente préalable est l'inconvénient du système à deux postes, mais leur position dissimulée, et toujours protégée par un fort, les met à l'abri des projectiles ou d'un coup de main, seul moyen encore connu de paralyser réellement une ligne de torpilles.

L'installation d'un pareil système est une affaire de mouillage et de manœuvres maritimes sans rapport avec le jeu de l'électricité. Il suffit donc de dire que les conducteurs affectés à chaque torpille ont été éprouvés d'abord à terre par les méthodes connues de conductibilité et d'isolement à épreuve forcée (6 couples Leclanché). Un conducteur partant du clavier est soudé dans la torpille de poudre à une plaquette de zinc reliée elle-même à une des branches de l'amorce, l'autre branche de celle-ci est soudée au fil de la plaque de terre au moyen d'un bout de conducteur assez long pour qu'on puisse au besoin élever au-dessus de l'eau la plaque de terre. En traversant la torpille, le conducteur est, bien entendu, luté avec soin dans l'orifice unique servant à son entrée et à sa sortie. Dès lors on peut, une fois les torpilles en place et tout le réseau établi, procéder aux épreuves qui ne seront faites qu'une fois avant d'abandonner tout ce système au fond de l'eau. — Puis, journellement enfin, une partie de ces épreuves pourra se faire sans sortir des postes.

Les Anglais ont adopté la concentration, dans un poste indépendant, des divers appareils que nous venons de mentionner. — Aux postes E et I, ils ne laissent que des lunettes pour suivre le but; mais ces lunettes, par le moyen d'un fil télégraphique, indiquent au poste central tous leurs mouvements sur une planchette où deux aiguilles se meuvent parallèlement aux lunettes qui les actionnent. Quand ces aiguilles récepteurs viennent se croiser sur la carte à l'endroit où gît une torpille, le poste central fait feu en conséquence.

BROSSARD DE CORBIGNY,
Lieutenant de vaisseau.

(*A suivre.*)

Aug 30 1879

Adaptation of Electricity to Useful Purposes.

Until the invention of the electric telegraph it had not been found practicable to apply the power stored up in electricity to useful purposes. Its nature and characteristics had indeed engaged the attention of scientific investigators for many years, and nebulous ideas of the possibility of utilizing it for the service of mankind had occurred to those who were engaged in its study, but without practical result. Finally Cooke in England and Morse in America, neither of whom belonged to the scientific fraternity, succeeded in solving the problem which had so long baffled the most able scientists of the world, and invented systems of electric-telegraphic communication which proved to be practical and successful. It is but justice, however, to concede that their inventions were only possible through the investigations and discoveries of the philosophers who for so many decades previously had made electricity a study.

These inventions have had an importance and a far-reaching effect, which probably was but dimly foreseen, even by the inventors or the enthusiasts whom they succeeded in interesting in their inventions. Within little more than the life-time of a generation they have revolutionized the social and business systems of the world. Year by year the telegraph is more and more indispensable, and has already become so essential that a total suspension of telegraphic communication, even for a day, would be regarded as a public calamity. The crude but effective apparatus at first used has been simplified and improved upon, and the capacity of conductors for electrical transmission has been developed and practically utilized, and these have become so familiar to the public that results which but a short time since would have been regarded as marvelous and scarcely credible, are now looked upon as of no very special note. Inventions which double and quadruple the available capacity of conductors are not regarded as worthy of special notice, and we are looking expectantly for the time when these results shall be notably exceeded, and six, eight, and even a larger number of circuits shall be regularly operated over a single conductor, as six and eight have already been worked in experimental trials.

The speaking telephone opened up a new field of telegraphic experience and research, and although but recently invented, has already been generally adopted for special and private lines. By means of telephone exchanges, which are being established in all parts of the country, a person is placed in direct oral communication with the persons and places of business of those with whom it is desired to confer, and thus business and social intercourse is facilitated and promoted. The number of telephones already manufactured and in use in this country is probably not less than 50,000, and is being increased as rapidly as they can be manufactured. It naturally makes its way more slowly in Europe, but is being extensively introduced there, and the American system of telephone exchanges is beginning to be looked upon with favor.

By the invention of the telephone we are enabled not only to communicate orally over considerable distances, but also to study the utterances of nature. The voices of the volcano and the earthquake, telephonically reported, reveal to us the titanic workings in the great laboratory of the earth. The lightning announces its coming before even the flash is visible. The pulsations of the vital fluid within our veins and arteries convey to the ear of the physician and surgeon valuable information of our physical condition. Daily new uses are found for the telephone and microphone, and it is not likely that these will be soon exhausted.

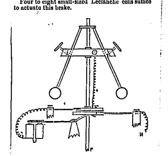
Electricity guards our buildings and property against the spread of conflagrations and the attacks of burglars and thieves; it gives us light rivaling almost the brilliancy of the sun itself; it pierces the hardest rocks and metals, and furnishes the motive power required to run our sewing machines. It traces our pictures, and prepares the plates for the printer; it regulates the movements of our clocks and plows our fields (though not the latter as yet to any considerable extent). It is, in fact, becoming the universal servant and agent of mankind, and it is impossible for us to conceive to what uses it may not yet be put for our convenience and benefit. So much has already been accomplished through electrical agency that the public mind is prepared to credit even the most marvelous achievements which may be claimed for it. It is indeed a wonderful manifestation of a force without doubt co-extensive with the universe itself, and one of the most useful and terrible agencies.—*Journal of the Telegraph.*

A NEW METHOD OF CONTROLLING THE DRIVING-CLOCK OF AN EQUATOREAL.* Eng Mechanic

THIS is a description of an automatic brake to be applied to a rapidly moving part of the mechanism of an ordinary equatoreal driving-clock whenever the normal velocity is exceeded.

As applied to my driving-clock belonging to a 9¼inch reflector, it consists of the following parts:—A frame of brass, slotted so as to inclose, without touching, the centrifugal arms of the governor, is fixed to the upright axis to which these arms are attached, but is insulated from it: in the frame are two brass screws (only one of these need be in use) which can be regulated so as just to be in contact with the arms when the proper speed has been attained. Two metallic wheels are fixed to the lower part of the axis, the upper of which is insulated from it, but connected by a wire with the frame in the upper part, and the lower one is in metallic contact with the axis. Two light springs are in contact with these wheels, and an electro-magnetic brake (as shown by the figure) is balanced so as to press lightly on the base of the lower wheel when no current is passing.

Four to eight small-sized Leclanché cells suffice to actuate this brake.



No current can pass until the weighted arms fly out so as to touch one of the screws in the upper frame; electrical contact is then made, the brake acts instantly, and immediately the arms drop an infinitesimal distance and contact is broken: this intermittent action goes on rapidly, and results in an extremely steady speed, the oscillations being so minute that they are barely perceptible, even with a magnifying power of 500 diameters.

I use a driving-weight of 40lb., and find that when this brake is in action 22lb. can be added without affecting the rate; and I feel sure that by varying the leverage of the brake, or the battery-power, or the size of the electro-magnet, that the weight might just as easily be doubled.

This control was devised in order to obviate the necessity of accurately balancing the telescope (when using a spectroscope, for instance), and to prevent the slackening of the clock's speed, which is frequently caused by a rapid fall in the temperature.

The idea was suggested by a description of a control for machinery invented by Mons. Marcel Deprez (see ENGLISH MECHANIC for March 14, 1879), which, however, is exactly the converse of the plan here described.

Of course I do not intend this simple method to compete with the more perfect, but also more expensive methods devised by Bond and Cooke and Lord Lindsay, but I can confidently recommend it as an excellent and cheap substitute for those who have not very perfect clocks.

* By R. C. JOHNSON, F.R.A.S., in the *Monthly Notices* of the R.A.S.

Electric Clocks

Nature Aug 21 1879

THE various contrivances for electric clocks all depend on producing contacts with the pendulum, which is confessedly undesirable; and they nearly all produce these contacts when the pendulum is at rest at the highest point, which is the worst position.

There seems no reason why a pendulum with a coil-bob traversing over a short permanent magnet, as is usual, should not be independent of contacts. While descending the lower part of the stroke it reaches the magnet, and a current is thus excited in the coil, which is conveyed out at the knife-edges and works a switch; this sends a battery current through the coil for a short period while the pendulum is beginning its ascent, and so drives it forwards by repulsion from the magnet. The same process is repeated in the back stroke. The interval between the production of the excited current and the battery current, and also the duration of the battery current, may be regulated by a small pendulum whose single swing is equal to the interval, and which is liberated by the excited current. The details are so easily arranged that it is scarcely worth while to particularise them. Of course the battery current thus liberated by the excited current could be used for controlling other clocks.

The effect on the pendulum is thus restricted to the quicker parts of its swing; and consists of slightly retarding the descent, and accelerating the ascent, apart from all mechanical friction or contacts. Thus each action is produced at the most suitable time.

Possibly a pendulum cutting off heat rays from a thermopile might thus work a switch, and be even less affected than by producing an excited current in the coil-bob, as proposed above.

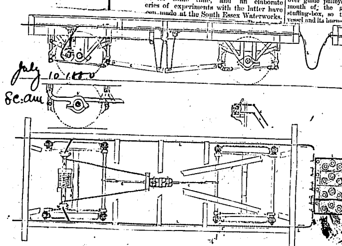
Bromley, Kent W. M. FLINDERS PETRIE

Debray uses wires of German silver in the manufacture of metallic laces. He colors metallic foils for the same purpose by depositing upon them iridescent films of oxide of lead. Litharge is dissolved in caustic alkali, and the resulting solution is decomposed by a current of constant intensity, the positive pole of the battery being in communication with the metallic surface to be coated. Engineering & Mining Sept 20 1879

ELECTRIC BRAKE FOR RAILWAY CARS.

In view of the tremendous speed attained by railway trains, it is a matter of the greatest importance to procure safe, reliable, and powerful brakes, which can be controlled from the engine or any other part of the train. Mr. Achard has invented a new and very ingenious electric brake, which is illustrated in the annexed cut taken from *La Nature*. Two Planté secondary batteries, each charged by three Daniell elements, are arranged on the first car, and two like batteries are provided in the last car. In the engraving the four secondary piles are united, but that does not affect the working of the device.

The current of the secondary batteries is conducted to the brakes of each wheel, the two wires running parallel with the train, with which wires the electro-magnets of the brakes are connected in such a manner that the brake operates when the circuit is closed. The electro-magnet, A, is rigidly mounted on a shaft suspended opposite the axle, B. If the current passes through the electro-magnet it is with great force drawn toward a sleeve, rigidly mounted on the axle, B, and is held against it with sufficient force to cause it to rotate with the axle, thereby winding the brake chains upon the shaft of the electro-magnet. The long arms of the articulated levers, C C, are raised by the winding up of the brake chains, and the brake shoes, D D, connected with the short arms of the levers, C C, are pressed against the tires of the wheels with great force. A brake shoe is provided on each side of the wheel so as not to break the journal box by undue pressure. To release the brakes it is sufficient to break the circuit, upon which the electro-magnet is released from the axle, B, and the chains are unwound. The commutator, H, is used to close or break the circuit, and may be located in the caboose of the engineer, in the last car or at any other convenient part of the train. The brake operates instantaneously, and sometimes produces such shocks that Mr. Achard has found it necessary to interpose resistances in the circuit to weaken the current proportionately. During the experiments made with this brake, on the Northern Railway of France, a train of thirteen cars, with a speed of forty-five and a half miles per hour, was stopped in twenty-one seconds and within a distance of seven hundred and five feet.



July 10 1880 Sc. Am

ELECTRIC BRAKE FOR RAILWAY CARS.

...ment upon it. These two papers were discussed together, and gave rise to a great deal of criticism. It was pointed out that the friction of the cup leathers attached to the pistons of the Foulis regulator was a variable quantity, and that the gun-metal linings of the cylinders were apt to become worn only in that part where the piston travelled most frequently, so that a ridge was formed at each end of its usual travel: hence, when the pistons are made to travel a greater distance than usual they are liable to stick. Both the Foulis and the Barton and West valves have, however, been in use for some time, and an elaborate series of experiments with the latter have been made at the South Essex Waterworks.

...of some size may be used so that it may hold a store of hydrocarbon sufficient for supplying the carburetting vessel for a considerable period. Such feeding tube or vessel communicates with the carburetting vessel by a pipe connecting their bottoms, this pipe being kept sufficiently heated when solid hydrocarbon, such as naphthaline, is used, to enable it to flow to the carburetting vessel. In cases where it is required to charge the carburetting vessel of a high light, such as a sunlight, at or near the ceiling of an apartment, the inventors make the burners and carburetting vessel in one piece, separate from the gas supply pipe in the ceiling, balancing this piece by suitable weights with chains or cords passing over guide pulleys, and they provide at the mouth of the gas-pipe a trumpet-mouthed stuffing-box, so that when the carburetting vessel and its burners are raised to their normal ...ht joint connecting ...e. On shutting off ...vith their carburet- ...rom the pipe and are ...avenient height for ...rocarbon, and after ...ey are again raised ...oming connected to ...oint. Instead of a ...ibed by a stuffing- ...nade as a hydraulic ...d to form the seal. ...emperature of the ...in it or around it ...line solution which ...esponding with the ...arburetting vessel. ...which by convolu- ...present a consider- ...vapour generated ...comes condensed in ...condensation flows ...again evaporated, ...of the carburetting ...ts at or near the

...ill pursuing their investigations in the hope of ...scovering improved means of carburetting gas, ...d as these are applicable to ordinary coal-gas, ...account of their invention may be useful, though the inventors obtained provisional ...otection only. In the article above mentioned, ...e described a method of enriching gas for ...uminating purposes by mixing with it the ...apours of hydrocarbons generated by the heat of ...e flame in carburetting vessels in proximity ...ereto. The present invention relates to the ...nstruction and arrangement of the vessels for ...is purpose in such a manner that they can be ...adily charged with the hydrocarbon even while ...e gas is passing through them, while they ...emain always sealed against escape of gas. For ...is purpose the carburetting vessel is fitted with ...feeding-tube which extends nearly down to the ...ottom of the vessel, or it may extend quite down ...o its bottom, and have small slits or holes ...hrough it close to the bottom. This tube is ...losed at the top by a cap, plug, or stopper, ...which may or may not be an air-tight fit. The ...ydrocarbon is fed into this tube at the top. ...When it is in liquid form it seals the bottom ...penings of the tube against passage of gas ...through them, or if it be in the solid form, such ...as the stick or rod of naphthaline described on ...p. 86, Vol. XXVIII., its lower part, in melting, ...forms the required seal while it is liquid, and ...remains a permanent seal when it becomes solid ...gain by cooling. A portion of liquid hydro- ...arbon, such as paraffin, which does not volatilise ...t the temperature to which the vessel is sub- ...ected, may be in the first place poured into the ...eed tube in order to provide, before the naphtha- ...ine is melted, or when that or the other hydro- ...carbon used is exhausted, the liquid seal required. The feed tube may be external to the carburetting vessel communicating with it at the bottom,

Aug 11 1879

...EZ D'ARROS' ... APPARATUS.

...we illustrate the ...Bellet and Hallez ...ning by means of ...s of writings and ...roduced by litho- ...acid-graving pro- ...coil, arranged in ...ployed. A metal plate is united ... poles by means of a wire, and the other pole is connected to the core of an ordinary blacklead pencil or suitable point by means of a very fine wire. On the metal plate is fastened by means of gum a thin sheet of paper previously dipped in water containing sea-salt. The induction coil is then set in action and the design it is required to reproduce is drawn on the paper attached to the metal plate with the pencil (or point) by which means the two poles are brought together, and the electric sparks dart continuously from the point of the pencil or point, and produce on the thin paper small holes corresponding with the lines of the design. The metal plate should be placed on some insulating substance. The design or writing thus finished, the metal plate is dipped in water and the paper carefully removed. The stencilling thus obtained, it is easy to transfer it to stone by inking a sheet of paper with transfer ink and then placing the stencil thereon and covering it with a sheet of white paper and pressing it sufficiently for the ink to pass through the holes in the stencil. A proof is thus obtained which can be transferred in the ordinary way. The transfer can also be made on zinc, by which a typographical stereotype may be obtained. In order to obtain an engraving or etching on metal it is necessary to proceed as follows:—A well-polished copperplate is covered with a thin layer of varnish. On this varnish a sheet of thin paper or suitable material is pressed, and upon executing the writing or design thereon with the electric pencil (or point) the electric spark will penetrate the paper and varnish at the same time and leave the metal bare at all parts touched by the pencil or point. The plate is then dipped in a nitric acid bath of 20deg.; the acid will attack the metal where not covered with varnish, and after two or three

112

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SIR WILLIAM FOTHERGILL COOKE.

WILLIAM FOTHERGILL COOKE was born at Ealing, in the county of Middlesex, in the year 1806. His father, W. Cooke, was a doctor of medicine in Durham; and after a school education at that town he was sent to Edinburgh University to complete his studies. Like most of the famous electricians of that day, and even of our own day, he was not bred to the study of electrical science.

It was while engaged in a course of surgical training at Heidelberg that one day in March, 1836, he happened to witness an electrical experiment exhibited by Professor Moncke to his class, which greatly interested him, and planted the seed of inventive thought, which speedily grew into the first practical telegraph. The telegraph, like every other invention, including even the phonograph, was not entirely the work of any one man, but was led up to step by step by a number of different thinkers and experimenters. In 1820 Oersted discovered the fact that a current circulating in a wire has power to deflect a magnetic needle freely poised in its neighborhood; and Gauss and Weber subsequently applied this fact in devising and erecting a short private line of telegraph between the physical cabinet of the University and the Observatory of Göttingen. It was a similar contrivance to this which Professor Moncke showed to his students on that day when Mr. W. F. Cooke was present. It consisted of a battery, a conducting circuit of wire extending from one room to another, and a pair of rude galvanometers or coils of wire encircling suspended magnets. With this elementary apparatus Professor Moncke succeeded in exchanging visible signals between the two rooms by means of the electric current. Probably no other student in the room but the young Englishman saw the immense practical importance of such an arrangement. This side of the experiment struck Mr. Cooke so forcibly, that from that day he gave himself entirely up to scheming and pondering over the subject, and within three weeks after he had devised a practical working telegraph on the basis of the Moncke, or rather the Gauss and Weber apparatus. The plan involved the use of six wires, forming three separate circuits, for as yet Steinheil's great discovery that the earth itself would act as a return wire was not known; and each circuit operated a separate needle galvanometer. The alphabet or code comprised 26 signals, and he employed three keys to make and break the circuit, together with a rudimentary switch to alter the connections from "send" to "receive," or contrarily. In 1836 he also designed a mechanical telegraph on the musical box principle, in which the current passing through an electro-magnet attracted an armature which released a detent, and thereby permitted a barrel, studded with projecting pins, to revolve until one of the pins came into contact with a tangential lever, which broke the circuit, leaving an indicating dial, with the proper signal letter or figure exposed.

Cooke tried to get his new invention introduced on the Liverpool and Manchester Railway in the latter part of the same year, but the directors viewed the novelty with small favor, and condemned it as too complicated for their requirements, which was to transmit train signals along a tunnel. He therefore set himself to simplify his apparatus, and succeeded in doing so early in 1837, but by this time a pneumatic contrivance had been resorted to by the directors. Nothing daunted by this failure to get his schemes practically tested, Mr. Cooke continued to perfect his apparatus. He engaged in experiments to ascertain at what distance an electric current would excite temporary magnetism in the electro-magnet employed to move the detent of his mechanical telegraph; and consulted Faraday, Dr. Royet, and Professor Wheatstone on the point. It was on the 27th of February, 1837, that he first met Wheatstone, who had before that time been engaged in researches into the velocity of electric waves in solid conductors.

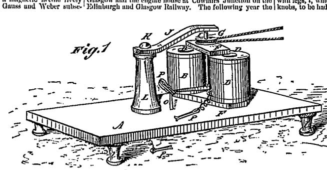
Cooke recognized that Wheatstone's knowledge and genius would be serviceable to him, and early in May, 1837, they entered into a partnership together with Mr. J. L. Ricardo, M.P., combining their ideas in a patent dated June 12 of that year. This patent described an improved form of Cooke's original invention, with five vertical galvanometer coils and astatic needles instead of horizontal ones, and having a diamond-shaped vertical face on which the five needles were pivoted, so that their relative positions could be seen at a glance. There were five separate circuits corresponding to the five needles, with one return wire common to them all. These five circuits were operated by five keys, and each signal was indicated by the relative motions of any two out of the five needles. This apparatus, since known as the "five-needle instrument," was first tried on the London and Birmingham and Great Western Railways, but was found expensive on account of the number of wires used, and subsequently abandoned. Nevertheless the "five-needle instrument," working in 1838-9, between the Paddington and West Drayton stations of the Great Western Railway, a distance of about 13 miles, was the first public telegraph in the United Kingdom, if not in the world. The original Paddington instrument now forms the chief relic of the Postal Telegraph Historical Department, and it is still to be seen on the occasion of every telegraphic fête of importance in London.

In the year 1840 Cooke established the Cooke & Wheatstone system on the Blackwall Railway, and in 1841 on a short line through the tunnel between the Queen Station at Glasgow and the engine house at Cowlairs Junction on the Edinburgh and Glasgow Railway. The following year the telegraph line from Paddington to West Drayton was continued to Slough near Windsor, and a great public interest in it was soon after excited by the clever capture of a Quaker named Tawell, who had committed a daring murder near Slough, and escaped by rail to Paddington, where, thanks to the original five-needle instrument, two detectives were waiting for him as the train drew up to the platform. In 1843 two more short lines were erected, one in Ireland and one in England, and worked by the Cooke and Wheatstone apparatus. In 1844 a line of considerable length, from London to Portsmouth, was also opened for traffic on this system.

Mr. Cooke was rewarded for his great public services in establishing the telegraph by receiving the fourth Albert gold medal in 1863, his name being preceded on the list of recipients by that of the immortal Faraday; and on November 11, 1869, Her Majesty conferred upon him the order of knighthood in recognition of his great and special services in connection with the practical introduction of the electric telegraph. In 1871 he was granted a civil list pension of £100 per annum.

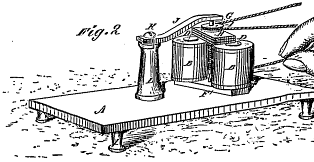
The last two years of his long and prominent career were spent in great privacy until his death, on June 25, at Farnham, in the seventy-third year of his age, after he had lived to see the inventions which his sagacity forced upon civilization develop extraordinary powers and gradually spread itself over the whole world.—*Engineering.*

Fig. 1



ELECTRIC ENGINE.

Fig. 2



MAGNETO MACHINE.

APPARATUS MADE FROM PARTS OF THE ELECTRICAL CABINET.

AN ELECTRICAL CABINET.

By GEO. M. HOPKINS.

THE number of persons who are interested in electrical matters at the present time is enormous, owing to the impetus given to the electrical science by the invention of the telephone and the recent improvements in electric lighting. Many amateurs have taken up the subject as a pleasant field for experiment and study, with a prospect of a possible reward for the discovery of a really practical novelty.

To assist this class of experimenters, especially the younger ones, I have devised what I will call an electrical cabinet, containing a few parts which may be combined to form several different pieces of apparatus, and which, with slight additions, may be employed in performing a great variety of experiments.

The first engraving shows in detail, full size, the several pieces required. There should be two bed pieces, A, with holes exactly as they are shown in the drawing, and provided with legs, *l*, which are the ordinary black carriage curtain knobs, to be had for a penny or so at any hardware store.

The following articles, which may be easily made, will be required: Two helixes, B, which consist of a thin wooden spool wound with 8 layers of No. 20 silk-covered copper wire. Two helixes, C, wound with about ¾ oz. of No. 34 silk-covered copper wire. Two soft iron cores, D, ⅜ in. diameter, a little longer than the helix, B, and having a threaded stem, *m*, of sufficient length to reach through the bed piece, A, and receive the nuts, E, two of the latter being required. The yoke, F, of soft iron, is drilled to receive the stems, *m*, of the cores, D, and having a small conical hole, *n*, in the center. F' is a soft iron armature, having a central aperture, *o*, for receiving the spindle, G. A compound bar magnet, H, is also fitted to the mandrel, G. The milled nut, I, which binds the armature, F', or the magnet, H, upon the spindle is grooved around its periphery for receiving a cord or belt. The mandrel, G, has a small hole bored through it near the shoulder, and is flattened at *p* by filing on diametrically opposite sides so as to remove a little more than a quarter of the circumference on each side. J is a curved piece of brass, having a small conical hole, *q*, drilled in it for receiving the upper end of the spindle, G. It has also a hole through the opposite end for receiving the bolt, K. The pillars, L, of brass or wood are *drilled longitudinally to receive the bolt, K. The latter is provided with a nut, N. The spring, O, is bent into the form represented and flattened at both ends. Twelve or fourteen wire loops, P, and two wires, Q, bent into the form shown, and threaded at the lower end, are required.* R is a vibrator consisting of a small armature, *r*, soldered to a spring, *s*, which is drilled to receive the bolt, K. A small hole is drilled in the end of the armature to receive the wire of the bell hammer, S. U is a strip of brass bent into the shape shown, and having near one end a small hole, *t*, for receiving a screw. For the sake of convenience I have placed above each cut a figure representing the number of pieces of each required.

With these simple parts, which may be made without further description, a great variety of experiments may be tried.

Simplest among the pieces of apparatus that may be made is the sounder, shown in Fig. 3. There is material in the cabinet sufficient for two instruments.

The pillar, L, is placed over the hole, *a*, and the spring, R, is secured to it by means of the bolt, K. The stem, *m*, of the magnet core, D, is secured in the hole, *b*, and the helix, B, placed on the core. The wire, Q, is screwed into the hole, *d*, so that the end touches the top of the spring, R, while the armature, *r*, is a short distance from the core, D. The key, U, is fastened to the bed by a small screw passing through the hole, *t*, into the hole, *h*, in the bed. Under the key a round-headed screw is placed in the hole, *g*, forming a contact point for the key. This screw is connected with the brass clip, *u*, by a wire. One terminal of the coil, B, is connected with the key, U, the other with another similar instrument. The clip, *u*, is connected with the battery,* the ground, or the return wire.

When these instruments are used on a closed circuit, the

* A suitable battery for this apparatus may be found among those described in SUPPLEMENTS 157, 158, and 159. Perhaps the Tom Thumb will answer as well as any home made battery.

UN JOUET SCIENTIFIQUE

L'ÉLECTROPHORE-PEIFFER.

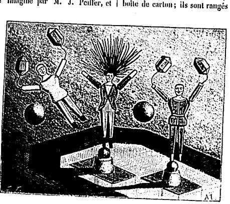
La Nature 20 Dec 1879

Au moment de l'approche des étrennes, il nous paraît intéressant de signaler à nos lecteurs un charmant petit jouet, qui obtient un très grand succès auprès des enfants, et, qui a le mérite incontestable de les initier de bonne heure à tous les principaux phénomènes de l'électricité statique, de leur apprendre la physique en s'amusant. C'est un petit électrophore imaginé par M. J. Peiffer, et réduit à un tel degré de simplicité, qu'il consiste uniquement en une mince plaque d'ébonite, de 1 millimètre d'épaisseur, et de la grandeur d'une page de *La Nature*. Le disque de bois étamé de l'électrophore classique qui se trouve décrit dans tous les traités de physique, est remplacé par une petite feuille d'étain de la dimension d'une carte à jouer, et collée sur une des faces de la plaque d'ébonite.

L'électrophore d'ébonite, produit l'électricité avec une remarquable facilité. Vous le posez à plat sur une table de bois, vous le frottez successivement sur ses deux faces avec la main bien ouverte; si vous le soulevez en le tenant de la main gauche, et si vous approchez la main droite de la feuille d'étain collée sur une de ses faces, vous en ferez jaillir une étincelle de 1 à 2 centimètres de long.

L'électrophore d'ébonite est complété par une série de petits accessoires construits avec beaucoup de goût. Ce sont des petits pantins de sureau, qui permettent de manifester d'une façon très amusante, les phénomènes d'attraction ou de répulsion électriques. Électrisez le plateau d'ébonite, placez sur sa feuille d'étain les trois petits pantins de sureau qui se joignent à l'appareil, soulevez le plateau pour l'isoler de son appui. Voici un petit personnage qui lève les bras vers le ciel, en voici un second, dont les cheveux de soie se hérissent, en voilà un troisième plus léger que les autres qui s'élance comme un clown et qui s'échappe en voltigeant, avec les deux petites balles de sureau qui ont été également placées à côté de lui. Nous avons groupé en une seule figure les trois petits personnages, mais on les fait habituellement fonctionner isolément.

M. Peiffer a réuni dans une boîte, tous les accessoires connus d'une machine électrique: une petite bouteille de Leyde en miniature, un carillon électrique, le pistolet de Volta, le carreau étincelant, un tube de Geissler, etc.; toutes ces expériences sont réduites à leur plus simple expression et les appareils qu'elles nécessitent, tiennent dans une boîte de carton; ils sont rangés à côté de l'électrophore d'ébonite qui se trouve ainsi remplacer une machine électrique encombrante et d'un fonctionnement délicat.



Les pantins de sureau de l'électrophore d'ébonite de M. J. Peiffer.

M. J. Peiffer complète enfin son petit cabinet portatif de physique électrique par une brochure très substantielle qui sert de guide au jeune physicien et lui enseigne les premières notions de la science.

« Il est facile de comprendre, dit M. Peiffer dans sa préface, combien on peut et combien on doit, pour l'instruction de l'enfant, tirer parti de ses facultés naissantes. Voulez-vous les utiliser fructueusement? Mettez lui entre les mains, les jouets qui sous une forme attrayante, le familiarisent de bonne heure et sans fatigue avec des sciences dont plus tard la connaissance lui sera absolument indispensable, et cela en l'amusant bien plus qu'avec des joujoux qui depuis si longtemps sont toujours les mêmes. »

Voilà de bonnes et saines paroles auxquelles nous nous associons pleinement. Oui, la science bien comprise, bien enseignée, peut être mise à la portée de l'enfance, elle doit animer les jouets, et servir à la culture des jeunes intelligences, comme plus tard elle contribue à assurer le développement des travaux de l'homme fait.

GASTON TISSANDIER.

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in two years of 360*l*. 18s. 6d. In addition to the foregoing 49*l*. 16s. 7d. was granted to other trades and unemployed members.

The remaining portion of the expenditure is thus accounted for:

	£	s.	d.
Rent of club rooms and general office, including fuel and gas ...	173	16	0
Salaries:			
Eighty-five branch secretaries, and general secretary ...	407	17	1
Eighty-five branch treasurers	96	18	7
Eighty-five branch sick stewards	68	11	0
Eighty-five branch and other branch officers	119	1	3
Eighty-five branch auditors, and trustees' banking expenses	61	19	5
Printing and stationery, including annual and monthly reports, emblems, &c.	266	9	3
Postage, parcels, telegrams, money orders, deficiency in currency, &c.	107	3	5
Council and committee meetings, delegations, and loss of time ...	217	15	0
Total amount so expended...	1519	11	0

Of this sum 115*l*. 10s. 8d. must be deducted and placed to income account, inasmuch as the sale of reports, &c., realised that sum, which leaves 1404*l*. 0s. 4d. as the total cost of management, or about 14 per cent.

The balance in hand at the end of the year was 13,938*l*. 10s. 4d.; in 1877 it was 16,464*l*. 7s., being a decrease in the year of 2525*l*. 16s. 8d. The amount owing as arrears was 615*l*. 16s. 5d., making the total worth of the society, at the date of the report, 14,554*l*. 6s. 9d.

The income and expenditure of the executive council, although included in the general accounts, are separately given; the former amounted to 809*l*. 17s. 8d., the latter to 820*l*. 6s. Among the disbursements are: General secretary's salary and office assistance, 148*l*. 4s.; rent of office and residence of secretary, coal, gas, rates, &c., 56*l*. 19s. 5d.; council meetings, revision of the laws, deputations, auditing the council's accounts, &c., 86*l*. 0s. 7d.; and superannuation of the late secretary disabled through age and infirmity, 104*l*. The balance was for printing, grants from the benevolent fund, and miscellaneous items, all of which are embraced in the general accounts previously given.

The tables are only made up for 12½ years, dating from 1867. The total income for that period was 95,809*l*. 14s. 5s., the expenditure 89,292*l*. 0s. 3d. The disbursements during the same time have been as follows: Out of work benefit, 26,238*l*. 19s. 5d.; travelling relief, 2078*l*. 18s. 6d; sick benefit, 20,636*l*. 16s. 3d.; accident benefit, 3300*l*.; superannuation, 6204*l*. 11s. 4d.; funeral allowance, 6808*l*. 10s. 10d., making a total of 65,267*l*. 16s. 4d. The cost of strikes is not given, but that it has not been large is proven by the fact that the whole of the balance of expenditure only amounted to 15,836*l*. 10s. 6d., including benevolent grants, salaries, printing, and stationery, postage, grants to other trades, rents of offices and club rooms, strikes, and all incidental expenses for 12½ years.

The average number receiving out of work benefit throughout the year was about 234, the number on the sick list during the year was 916, the number of deaths was 76, and of accidents 5. Consumption again was the fatal enemy as in all the other iron trades.

Some half a dozen pages of the report are devoted to a discussion of the two most prominent topics of the day, depression in trade and foreign competition, but the matter, for the most part, is too general to be quoted. Briefly put, the conclusions drawn may be summed up in two phrases, over-production and over-speculation. The report says: "Striking instances of over-production can be pointed to in the coal, iron, or cotton trade, which may be termed the staple trades of this country." As evidence of over-speculation the active promotion of public companies during the few years following 1871 is referred to, and the enormous prices paid as purchase money, and otherwise, are alleged to have been the true causes of the present slackness in trade. "Only a legitimate and honest system of trading will secure us a return to prosperity," says the report. With reference to the question of foreign competition the following remarks occur: "Our own trade being competed with we do not hear of, only on rare occasions is it uttered, but so far as we can see, hear, read, or learn the nearest approach to competition in engines or machinery is from the American people, for France makes little of that class, and Germany if she does must be subsidised, whilst Belgium is more in the manufacturing of iron itself." Speaking of the alleged importation of cotton goods from America the report says, "The bubble burst when it was found to be the old statement. Ready cash was wanted, and knowing the British failings, they imported here a limited quantity, but the experiment was not repeated."

The report as a whole is interesting and valuable, furnishing as it does an insight into the inner workings of trades societies. It is more full of minute details than the others examined, but the numerous particulars are chiefly interesting to the members themselves. So exact and precise is the information given that every member of the union can be his own auditor.

The following summary of the four great societies in the iron trades may be found useful. Number of branches, 768; number of members, 80,859; income, 217,032*l*. 19s. 11d.; expenditure, 272,545*l*. 18s. 6d.; cash balance, 331,066*l*. 19s. 3d.; arrears due, 21,270*l*. 6s. 6d.; total worth, 354,797*l*. 5s. 10d. Payments made during the year: Out of work, 141,001*l*. 9s. 10d.; benevolent grants, 5390*l*. 3s. 6d.; sick benefit, 56,401*l*. 5s. 11d; accidents, 5419*l*. 14s.; funerals, 14,560*l*. 3s. 3d.; superannuation, 21,453*l*. 15s. 1d.; grants to other trades, 820*l*. 6s. 7d.; total for benevolent purposes in one year, 225,046*l*. 18s. 2d.; total for strikes, 10,147*l*. 0s. 6d., quite one-half of which was left as a legacy from 1877 arising out of the strike and lock-out on the Clyde.

Engineering 29/8/79

THE BRITISH ASSOCIATION.

In our notice of last week we dealt chiefly with the proceedings of the sections of Thursday the 21st instant, we now continue our notice of the meeting on the next and following days.

The business in Section A commenced on Friday, by Professor W. G. Adams, F.R.S., reading the Report of the Committee for procuring Reports on the Progress of Mathematics and Physics. This was merely a formal report, Professor Adams stating that, in consequence of the serious illness of Professor G. Carey Foster, F.R.S., the committee had been able to hold only one meeting during the year. The report contained two communications to the Committee, the one from Professor Clerk-Maxwell, F.R.S., and the other from Professor Stokes, F.R.S., giving their opinions on the questions with which the Committee has to deal, and the report concluded with the announcement that Professor Stokes had promised to draw up the plan of a Report upon Physical Optics, especially in reference to the Theories of Reflection, of Dispersion, and of Fluorescence and Phosphorescence. The Committee had also to announce that Professor Balfour Stewart had undertaken, in conjunction with J. Allan Broun, to draw up a Report upon Terrestrial Magnetism.

UNDERGROUND TEMPERATURE.

Professor J. D. Everett, F.R.S., next read the twelfth Report of the Committee on Underground Temperature, which was appointed to investigate the laws regulating the temperature of the earth at various depths below its surface, and to find out what is called the "temperature gradient" for various localities, which is the rate of increase of underground temperature as the depth is increased. Various methods of taking underground temperatures are recorded in the report, one of which is the lowering of maximum thermometers into deep bore holes filled with water. Another mode is to take observations in mines and collieries of the readings of very slow-acting thermometers. These instruments are constructed with bulbs of very thick glass so as to be very slow in absorbing heat from surrounding objects, and as slow in parting with it. The object of the thickening of the bulbs is to avoid the reading of the instrument altering to any noticeable extent while it is being drawn to the surface. Sometimes, instead of thick bulbs being employed, ordinary thermometers are used having their bulbs covered with a thick mass of tallow or other substance having a low conducting power for heat. The report goes on to refer to the experiments of Dr. Stapff, made in the St. Gothard Tunnel, in which a mean temperature gradient for the whole length of the tunnel (about nine miles), was found to be 1 deg. Fahr. for every 88 ft., but Dr. Stapff found that where the surface of the upper ground is a steep ridge the temperature gradient is less rapid than that, which is quite consistent with the hypothesis that the earth was at one time very much hotter than it is now, and that it is undergoing a process of cooling down. Experiments had also been made for the Committee by Mr. G. F. Deacon, the engineer to the borough of Liverpool, in a well-boring 24 in. in diameter, being made in connexion with the Liverpool Water Works at Bootle, and the temperature at a depth of 1302 ft. was found to be 59 deg. Fahr.—which is moderate compared with the temperature at the same depth in other localities. Another series of experiments had been conducted by Mr. E. Wethered, of Weston, near Bath, in a colliery in that neighbourhood, and in which the following temperatures were ascertained:

Depth	Temperature Fahr.
at surface	48.7 deg.
402 ft.	54.7 „
1232 „	66.7 „
1367 „	68.15 „
1439 „	69.7 „
1769 „	74.7 „

which figures give a temperature gradient of 1 deg. Fahr. for every 68 ft. Mr. G. J. Symons, taking temperatures in a well at Kentish Town, had experienced a difficulty in consequence of the stretching of the wires by which the thermometers were suspended, the effect of which was to lower the instruments at the rate of from 2 ft. to 14 ft. per month, thereby causing them to descend into warmer strata; but, as the temperature gradient for that locality is known, the correct readings were computed without difficulty. Experiments in connexion with this subject had also been made at a depth of 4500 ft. in the Comstock Lode Mine, in Nevada. At the conclusion of the reading of the report, Mr. G. Johnstone Stoney, who presided on the section, announced that the underground temperature Committee had been reappointed.

ATMOSPHERIC ELECTRICITY.

Dr. Michael Grabham next read a report of his experiments made in the island of Maderia for the Committee on Atmospheric Electricity, in which it appeared that in certain atmospheric conditions, and especially during the prevalence of certain winds, there was no atmospheric electricity that could be detected by the instruments which he employed, while he had found at other times that such electricity was at its maximum from 11.30 A.M. to 2.30 P.M.

Mr. McAlister, in proposing a vote of thanks to Dr. Grabham, stated that he had, from cases coming under his notice in St. Bartholomew's Hospital, observed a connexion between the prevalence of asthma and the frequency of positive atmospheric electricity, and he thought that a consideration of this aspect of the case might be of great importance with respect to the sending of asthmatic patients to Madeira. Professor Atkinson in seconding the vote of thanks referred to the report as a very valuable communication, and expressed the hope that it would be printed *in extenso* in the annual report.

TELEPHONIC PHENOMENA.

The next communication was one by Dr. Silvanus P. Thompson, "On the Retardation of Phase of Vibrations transmitted by the Telephone." In this paper, a full abstract of which we published last week,* the author commenced by a reference to the theoretical prediction of Dubois-Raymond and the more recent experimental demonstration by Koenig, that when two Bell telephones are connected together, the one as a transmitting instrument and the other as a receiver, the vibrations of

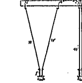


Fig. 1.

the latter take place a certain time after those of the former, which time is equal to that occupied by a quarter of a complete vibration, a retardation equal to that amount taking place in the ultimate transmission. In order to demonstrate this fact the author devised the following experiment. The magnets and coils of two telephones A A, Fig. 1,

* See ENGINEERING, page 169 ante.

le public sans cesse déçu par l'annonce trop souvent répétée de nouveaux progrès dont on n'entend plus parler.

Ce qui n'est pas moins nuisible au développement de la vraie science, c'est la manie trop répandue de déserter prématurément des appareils excellents, mais qui ont le tort irrémédiable, aux yeux de certaines gens, de ne pas être nouveaux, de ne pas avoir été inventés par des Anglais ou des Allemands, et, par-dessus toutes choses, d'être d'une grande simplicité.

Nous sommes heureux de voir qu'une des sommités de la science électrique proteste contre un travers si préjudiciable, et contre lequel nous nous sommes élevés tant de fois.

Nous profiterons de cette occasion pour déclarer de nouveau que les appareils scientifiques et surtout ~~les appareils électriques doivent~~ être créés à l'usage de la nature qu'ils sont appelés à étudier. Le *Ne quid nimis* du poète doit s'y appliquer de la façon la plus rigoureuse.

Les savants qui accumulent formules sur formules et bobine sur électro-aimant rencontrent rarement la vérité, qui n'aime pas à sortir de son puits si grotesquement affublée.

Electricite

L'ÉLECTRICITÉ A L'EXPOSITION DE BERLIN

5 July 1879

Si l'on voulait avoir une idée approchée de l'état de l'électricité à l'Exposition de Berlin, il suffirait de décrire l'exposition de la maison Siemens, dont nos lecteurs connaissent la majeure partie, malgré l'abstention mémorable de l'empire allemand. En effet, la maison Siemens, de Londres, qui nous avait envoyé une collection si nombreuse d'objets de toute nature, n'est guère moins importante que celle de Berlin. C'est même dans ses ateliers, à Woolwich, que l'on construit en ce moment le câble transatlantique français (1).

Dans l'exposition de M. Siemens à l'Exposition de Berlin se trouvent un grand nombre d'objets plus ou moins analogues à ceux qui ont figuré à l'Exposition du Champ-de-Mars, et sur lesquels il n'y a pas, par conséquent, lieu de donner de nouvelles explications à nos lecteurs. Nous devons cependant noter l'*unité de résistance*, qui, comme on le sait, est une colonne de mercure d'un millimètre de section et d'un mètre de longueur. En effet, cette unité est certainement la plus facile à reproduire rigoureusement. A cause de sa grande facilité à distiller, le mercure est de toutes les substances métalliques celle qui peut le plus facilement être obtenue à l'état de pureté absolue. En outre, sa fluidité et sa conductibilité propres lui permettent de recevoir la température ambiante d'une façon très-uniforme et très-rapide. Cette unité de résistance est donc bien préférable à toutes les autres.

(1) La maison Siemens a établi une succursale à Paris, une à Saint-Pétersbourg et une autre à Tiflis. L'établissement de Paris et de Saint-Pétersbourg sont plus particulièrement consacrés aux machines à lumière, et l'établissement de Tiflis à la métallurgie du cuivre et du cobalt. Une autre succursale a été également établie à Charlottenbourg.

NOUVEAU PENDULE ÉLECTRIQUE

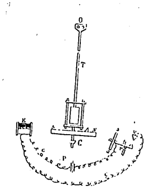
Electricite 20 July 1879

Parmi les applications nouvelles de l'électricité, il en est une très-intéressante, qui a été imaginée par M. V. de Sauty, électricien de l'Eastern Telegraph Company, à Gibraltar, et qui consiste à entretenir électriquement le mouvement d'un pendule battant la seconde. Sauf le point de suspension, il n'y a aucune espèce de contact, ce qui a l'avantage de supprimer les frottements; la construction d'ailleurs en est très-simple. Le dessin ci-contre représente la disposition des différentes pièces.

La tige du pendule, T, fixée en O, à l'aide d'une lame-ressort, porte à sa partie inférieure une lentille B, pouvant contenir une petite quantité de mercure et une vis curseur C, facilitant le réglage. A est un aimant aplati, ayant environ 18 centimètres de longueur; les pôles sont représentés par N et S.

E est un électro-aimant ordinaire, dont r hélices magnétisantes sont formées de fils en cuivre recouvert de soie, n° 36, et présentent une résistance électrique de 320 unités Ohms (environ 32 kilomètres de fil télégraphique de 4 m/m de diamètre). Le petit aimant *a*, mobile sur un axe, porte un bras de levier *b*, qui peut venir s'appuyer sur une vis butoir *v*; le ressort *r* le ramène sur la vis inférieure, formant arrêt. *c*, *c* indique le circuit comprenant deux éléments Minotto, l'électro-aimant, l'axe de l'aimant *a*, et la vis butoir *v*.

Lorsque le pendule oscille à droite, l'aimant A attire le pôle de nom contraire de *a*, et celui-ci, tournant sur son axe, ferme le circuit de la pile. Le courant circule dans l'électro aimant, de façon à déterminer une polarité convenable et les noyaux de fer doux, et le pendule attiré oscille vers la gauche. Le circuit reste fermé jusqu'à ce que la tige atteigne la verticale, ce qu'on obtient facilement par le réglage de l'aimant *a*. En ce point, aucune force attractive n'agit sur l'aimant, et le pendule, en vertu de la vitesse acquise, achève son oscillation, puis revient à droite pour attirer de nouveau le petit aimant.



Pour éviter autant que possible l'influence des perturbations magnétiques, il convient de placer l'aimant principal dans le plan du méridien magnétique. Le fil de l'électro-aimant pourrait être plus gros, mais on comprendra facilement qu'en augmentant la résistance du circuit, les variations de courant, qui se produisent infailliblement, auront moins d'action, et par suite la force attractive restera sensiblement constante.

D'après M. de Sauty, ce pendule fonctionne régulièrement depuis le mois de novembre dernier avec deux éléments, et il pourrait servir à la transmission électrique de l'heure à distance.

MAITRE JEAN.

[37809.]—**Electric Vibrating Beam.**—Presuming that the beam is balanced, if you decrease the force employed to make it vibrate, you will decrease the velocity of its motion; consequently, it will make fewer vibrations per second. If you are using an electro-magnet and counteracting spring applied to one arm of the beam, remove the magnet a little further from its armature and decrease the tension on the spring, to suit the decreased attraction of the magnet; or perhaps you could make the beam longer, when it would vibrate more slowly. If neither plan will do send further details of the apparatus, and say what it is for.—J. BROWN, Belfast. Eng Mechanic Sept 12 1879

Iron Sept 27 1879

ELECTRICITY & TELEGRAPHY

23 ELECTRO-MAGNETIC STOPPING-MOTION FOR SPINNING FRAMES.—In the Augsburge Kammgarnspinnerei there is now working an ingenious contrivance, in which a current of electricity is employed to effect the stopping of the spinning frames. The apparatus consists of an arrangement for closing an electric circuit, in connection with special mechanism attached to the driving power of the frame, and which, upon the breaking or failing of a thread, either on entering or leaving the frame, automatically stops the latter. The stopping-motion consists of an arrangement of disengaging-gear, acting directly on the driving-band of the frame; of a series of thread-guides which act as circuit-closers at the entrance of the yarn into the frame, with similar guides or circuit-closers at the issue of the doubled yarn, before it is wound on the spools; and of a brake for the immediate stopping of the frame.—*Electrician.*

MILITARY TELEGRAPHY IN AUSTRIA.—Since 1873 the regiment of Pioneers has been charged with the duty of training and providing men who will form special railway and telegraph detachments. So long as the army is on the peace footing the men who are destined to form the telegraph detachments remain attached to their respective battalions of the Pioneer regiment. They are trained and exercised in all the ordinary duties of the pioneer soldier, and once a year they have a course of special training and exercise in field telegraphy. In case of war all these specially-trained men can be withdrawn from the Pioneer service and formed into a special corps. Each Pioneer battalion is required to be able to furnish eleven telegraph detachments. This would give a total of fifty-five detachments, who with their *matériel* and appliances would at once constitute a telegraph network 119 (440 English) miles long and embracing 220 stations. The yearly exercise of the detachments stationed in the neighbourhood of Vienna was held at the close of last month. The headquarters were fixed in the Prater, where a quantity of reserve materials was collected. The strength of the detachment consisted of four field telegraph officials, who must be ready to act both as operators and clerks, one superintendent, twenty-three artificers of all kinds (from mere field labourers for setting up the poles to men competent to repair machinery), two wagons to serve as stations, and four wagons for the transport of materials. The station wagons resemble a wooden house; they are divided into compartments and thoroughly fitted up for the reception of the instruments, &c. Two complete sets of instruments and other necessary furniture are allotted for each station, so as to be as independent as possible of accidents, and an abundant supply of stationery, &c. The wagons for materials contain two (eight English) miles of copper wire, and a corresponding quantity of telegraph cable to be employed in marshy places or in crossing rivers, and a sufficient number of poles for supporting the wire at average distances of fifty paces. These poles are to be long enough to allow of the wire being carried at an average height of four metres (about 13 ft.) above the ground.

ELECTRICITY AND HEAT.—In a series of experiments recently described to the Vienna Academy, Prof. von Waltenhofen has sought to deduce from a direct measurement of the work done in induction of an electric current in a closed circuit of given resistance, the mechanical equivalent of heat. For induction, a magneto-electric machine was used, whose electromotive force was ascertained to be proportional to the number of revolutions. A dynamometric handle of the newest construction was attached, and it was furnished with an arrangement for receiving the work-diagrams. The induced currents were measured by means of a tangent galvanometer. The results were found to be in satisfactory agreement with Joule's equivalent.

AN IMPROVEMENT IN THE SIEMENS ARMATURE.

Electrician July 17 1880

When we get the dynamic diagram of a Siemens bobbin, by making it operate through an entire revolution between the two poles of the electro-magnets which act upon it, we see that the work is almost *nil* during two considerable portions of the rotation. These two periods correspond to the times during which the cylindrical poles of the bobbin, having attained the poles of the magnet, defile before them. During these two fractions of a revolution, which are each about 30°, the magnetic surfaces destined to react upon each other, remain at the same distance. The bobbin is not then urged to turn, when it is being driven by the transmitted current from a second machine, and the result is a notable loss of work done.

These indifferent periods have, however, been suppressed by M. G. Trouvé, the well-known French electrician, and the usefulness of the machine thereby much improved. This has been effected by modifying the bobbin in the following manner:—The polar faces, instead of being portions of a cylinder of which the axis coincides with that of the system, are in the form of a *limaçon* or "snail," so that in turning they approach gradually their surfaces to those of the magnet until the moment when the posterior edge escapes from the pole. The action of repulsion then commences, so that a "dead point" is practically avoided.

The importance of this improvement has been shown by a very simple experiment. Two Siemens bobbins of the same diameter have been constructed, of the same length and wind, one only being modified in the way described. These have been successively tested by substituting them for one another in an electric motor, and it has been proved that with the same battery power the modified bobbin gives a considerable increase of work over the other.

The bobbin can act in presence of a permanent magnet, but M. Trouvé prefers to employ as a fixed magnetic reacter an electro-magnet placed in the same circuit, which permits the energy of the current to be varied between far-apart limits without the respective magnetic intensities of the fixed and movable organs ceasing to exist in the relation desired.

At a recent meeting of the French Academy M. Trouvé exhibited a small motor constructed upon this principle, and a single cell of Regnier's battery (described in our issue for July 10) put it into rapid rotation and drove a sewing machine; in fact, the instrument with the cell formed a promising little household motor; moreover, it is reversible in its action, and can be made a generator of electricity.

ELECTRIC JEWELRY.

Among the specialties for which the French are noted there is nothing more curious than the electric jewelry, several specimens of which are shown in the accompanying cuts, which we take from *La Nature.*

The scarf pin represented in the left-hand figure consists of a small golden rabbit holding a liliputian mallet in each paw, with which it beats a roll on a small golden gong. The right-hand figure represents a golden skull, with movable diamond eyes and an articulated jaw. This is also a scarf pin, and its eyes and jaw are made to move in a singular manner. The bird shown in the center of the engraving is an ornament for the head dress. It is of gold, thickly studded with diamonds.

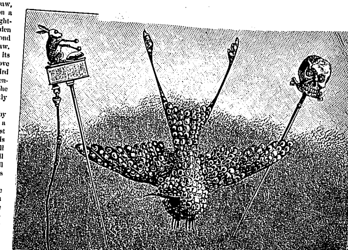


Fig. 1.—FRENCH ELECTRIC JEWELRY.

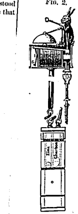
Sc Am Oct 25 1879

These pieces are connected by a fine concealed wire with a small battery carried in the vest pocket. When the battery is made to operate, the rabbit will strike the gong, the bird will move its wings, and the skull will roll its eyes and gnash its teeth.

The battery consists of a zinc and carbon couple contained in a hermetically closed vulcanite case, the zinc and carbon occupying the upper half of and the exciting fluid the lower half of the case. When the case is in a vertical position the exciting fluid does not touch the zinc or carbon, but when it is inverted or placed horizontally, the fluid comes into contact with the zinc and carbon, and the current traverses the coils of the diminutive magnets, which operate the mechanism of the pieces. The arrangement of the internal parts of both battery and scarf pin will be understood by reference to Fig. 2. The mechanism is much like that of an ordinary vibratory electrical bell.

Messrs. Charles
Deadwood, Dakota

FIG. 2.



ELECTRICITY & TELEGRAPHY

from Feb 20 1879

THE NEW CAPE CABLE.—Information reached the officers of the Eastern Telegraph Company, on Wednesday, that the steamship *Seine* had arrived at Aden, having laid down the section of the new Cape cable between Mozambique and Delagoa Bay, which thus far completes the line of telegraphic communication from Natal to Mozambique. It is believed that the other section from Mozambique to Zanzibar will be finished by the 20th inst., and South Africa thus brought into direct communication with Zanzibar. From there it will take about nine days to bring news by ship from South Africa. In the course of time the entire route is to be completed.

CABLE BETWEEN ALGERIA AND FRANCE.—The first section of the cable which is to connect Algeria and Marseilles has been laid with perfect success, and the immersion of the remainder of the cable is being proceeded with. The Governor-General of Algiers, accompanied by several generals and civil officials, paid a visit to the steamer *Dacia*, which is engaged in the work of laying the cable, and partook of a lunch offered to them by the captain and officers of the vessel, during which toasts were drunk to the health of her Majesty the Queen and the President of the French Republic.

THE ELECTRIC LIGHT AT ST. ENOCH STATION, GLASGOW.—On Tuesday night the Glasgow and South-Western Railway Company tested the electric light as a means of illuminating their magnificent station at St. Enoch Square, Glasgow, with a view to adopting this mode permanently if found to work satisfactorily. Four lights were used, doing away with 460 gas-burners, and giving four times the illuminating power. The effect was very fine, the whole of the station being flooded by the brilliant light. Mr. Joshua Horton, agent for the British Electric Light Company, had charge of the arrangements, and was in attendance on Tuesday night to give explanations as to the working of the system. The cost of the four lamps will be about 1s. 4d. per hour, and the light afforded is equal to that given by 24,000 standard candles.

TELEPHONES IN HOSPITALS.—The use of telephonic communication is gradually being extended, and, although we have not yet obtained telephonic exchanges for commercial purposes, the system is becoming more and more popular. Quite recently, the Children's Hospital at Pendlebury, near Manchester, has beet fitted with a system of telephones. The lady-superintendent's room is thus connected with each of the six wards, the kitchen, and the pantry. As the hospital consists of six pavilions opening into a long corridor, the most distant pavilion being about 120 yards from the administrative block, it is obvious that much time and labour in running to and fro are saved by this convenient method of communication. It is especially convenient in communicating with the fever ward thus avoiding the risk of conveying infection to other parts of the hospital. The instruments were the gift of Mr. W. P. Henderson, jun., and Mr. G. P. Dewhurst, of Manchester. They are in constant use, and give great satisfaction.—*The Electrician.*

THE ELECTRIC LIGHT AT A DISTANCE.—An interesting experiment to test the extent of the illuminating powers of the Maxim electric light was recently made one evening at Saratoga Springs, New York. The light was put in operation on the tower of the Grand Union Hotel. An open parabolic reflector was used—no lenses—and care was taken by Mr. Maxim to set the points of the carbons a little on one side of each other and to adjust them exactly to the focus of the reflector. This having been accomplished, the light was turned towards a spot in Ballston Spa, New York, 7½ miles distant, where, by previous arrangement, a group of several hundred persons were assembled to witness the experiment. The place was instantly illuminated in such a way that ordinary printing could be read, the time seen on watches, &c. The night was clear, still, and dark. The experiment was made at 9·30 p.m. This is believed to be the greatest distance at which illumination of equal degree has been accomplished.

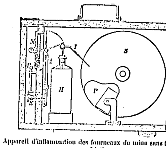
ELECTRICITY APPLIED TO BEE-REARING.—A Correspondent of the *Deutsche Presse* describes a method which he has adopted with success of overcoming the obstacles frequently presented to the rearer of bees by the self-will of those interesting and profitable insects. This is no other than giving them an electric s.ock. Every one interested in bees knows the difficulties and dangers involved in hiving a swarm. One is often seen on a hot day in June in the top branches of a tree not to be climbed, and another in some inaccessible place seems to be preparing to set out on its wanderings. If the beemaster venture to approach, all his dexterity and experience will often not prevent him from being seriously stung. There are, indeed, several cases on record of death supervening from the stings inflicted on such occasions. Herr Freiwith, the correspondent referred to, hit upon the idea of employing the electric force to stupefy the bees. Trials on large and small clusters, and even on single insects, answered perfectly; the bees coming in contact with the conducting wires felled stunned and motionless to the ground. They were then sorted and marked, according to the strength of the current applied. The time required for their recovery varying from ten minutes to eight hours, was proportionate to the strength of the shock, but all came out of their trance safe and sound. Encouraged by the result of this experiment, Herr Freiwith resolved so try it on a larger scale, namely, on bees in the hive. To this end he introduced the ends of two conducting wires into a fully occupied honeycomb, and turned on the current for a moment; the bees soon lay on the ground, and it was half an hour before they resumed activity. Herr Freiwith then constructed an apparatus in a small box, 6 inches each way, which, similar to a cartridge pouch, he wore with a strap round his body. The two wires of the apparatus were, when required to be used, fastened to rods of a suitable length, the wires of course always projecting over the ends of the rods. These ends were then applied to the swarm, a knob similar to that employed for a room-telegraph being attached to the apparatus, that the current might be turned on at the proper time. Every one is, of course, not skilful enough to construct such an apparatus, though none are precluded from doing so, as Herr Freiwith has not patented it.

Journal of the Telegraph, Aug. 1881.

Appareil électrique à-inflammation.

Electricity 9th Sept 1879

Beaucoup de praticiens, même intelligents, ont le tort immense de supposer qu'il est nécessaire d'employer l'électricité dynamique pour tous les grands effets de l'industrie moderne. Il n'est point hors de propos de montrer que l'électricité de friction peut être utilement employée dans beaucoup de cas et que les travaux des anciens électriciens, ces pères d'une science si belle et si progresive, n'ont pas été mis hors de service par les progrès les plus merveilleux que l'histoire ait à enregistrer. Le mode le plus commode de donner le feu aux fourneaux de mine dans lesquels on emploie la dynamite Nobel est exploité par M. Viau, 12, rue Condorcet. Cet appareil se compose de deux disques en résine, auxquels on donne un mouvement de rotation à l'aide d'une manivelle. Ces disques S, dans leur mouvement de rotation, frottent entre des tampons ou coussinets revêtus d'une peau de chat.



Appareil d'inflammation des fourneaux de mine sans tube et par friction.

L'électricité, ainsi développée, s'écoule par la pointe I qui communique avec l'intérieur d'une bouteille de Leyde servant de condensateur. L'armature extérieure H de la bouteille est en communication avec la pointe située à une distance quelconque où se produit l'étincelle. Mais une difficulté se présente dans l'emploi de cet appareil:

Presque jamais, la décharge qui se produit n'est complète, il reste, sur les deux surfaces de la bouteille de Leyde, ce que l'on nomme une charge résiduelle. La partie placée à gauche de la figure compose le déchargeur, dont le jeu consiste à faire éclater une étincelle entre la partie métallique B et la partie métallique M. Ce résultat s'obtient en poussant sur le bouton K, de telle manière que le levier mobile qui termine la partie A vienne toucher le bouton de la bouteille de Leyde.

An Electrical Speech Recorder.

A curious piece of apparatus, not likely to be of practical use, but showing considerable ingenuity, has been devised by M. Amadeo Gentilli, of Leipsic, for the purpose of giving an intelligible record of speech. The natural movements of the mouth in speaking are employed to produce through delicate levers a series of electric contacts, and thereby sundry combinations of signs on a moving band of paper, similar to those of the Morse alphabet. The transmitting portion of the apparatus is based on a careful study of the motion of lips and tongue in speaking with an object held between the teeth. The working parts are mainly arranged on an ebonite plate, from one end of which projects a piece to be taken between the teeth, whereupon the mouth-levers come into position. The nasal puff in sounding *m* and *n* affects a special delicate organ. There are eight electro-magnets in the receiver, each of which, when actuated by a current, causes a line to be formed on the paper. It is mentioned by M. Guerout (who describes the apparatus in *La Lum ere Electrique*) that the letters *g* and *k*, *d* and *t*, *b* and *p*, *f*, *v* and *w*, which are produced by movements very slightly different, are represented by the same signs. Thus of those letters the alphabet comprises only *g*, *t*, *b*, and *f*. Further, *c*, *z*, and *x* are represented by *ts* and *gs*. The apparatus will, perhaps, be shown at the forthcoming exhibition in Paris.

Le Correspondant [illegible] 2 [illegible] 1876

L'HYGIÈNE ET L'ÉLECTRICITÉ

Dans l'une de ses dernières causeries scientifiques, le spirituel chroniqueur du *Temps* M. Lereboulet, rapporte les curieuses observations d'un ancien capitaine amputé d'une jambe. Ce personnage a eu la patience de marquer les heures pendant lesquelles il souffrait du membre qui lui manquait, et de comparer la coïncidence qui existait entre l'époque de ses douleurs et la manifestation des orages, troubles atmosphériques, tempêtes, tous renseignements fournis par le Bureau météorologique central des Etats-Unis (Signal). Il a constaté ainsi que ses souffrances étaient plus accentuées lorsque la pluie approchait que lorsqu'elle tombait, pouvant ainsi prévoir et connaître l'arrivée d'une averse tombant à quelques kilomètres de sa résidence. Bien entendu il ne pouvait dire si la pluie atteindrait sa station, ou si elle passerait au large, mais cette approche de la pluie n'échappait pas à la sensation particulière qu'il éprouvait dans cette jambe privée par le fait de toute innervation réelle.

Quelque bizarre que puisse paraître l'idée du capitaine américain, je crois devoir rappeler ici des observations que j'ai faites moi-même sur une femme déjà âgée, foudroyée dans sa jeunesse, et qui est affectée depuis lors d'un torticolis dont aucun traitement médical n'a triomphé.

Chaque fois que la pluie est imminente, elle éprouve des douleurs assez vives qui ne se calment que lorsque l'averse est tombée. Il serait à désirer qu'on pût noter avec soin les impressions de cette femme, en les comparant avec les phénomènes atmosphériques du moment; mais nos observatoires français ne sont pas assez bien organisés pour permettre la vérification scientifique de faits de ce genre.

Le critique du *Temps* croit émettre un spirituel paradoxe en conseillant aux directeurs des bureaux météorologiques de s'adjoindre, pour leurs prévisions, un détachement de vieux mutilés. Il pense même que ces établissements scientifiques seraient fort heureusement placés au voisinage d'un hospice ou d'un hôtel des invalides!

Toujours est-il qu'il est très logique de supposer que l'arrivée des pluies produise des courants électriques, dont les organismes exceptionnellement sensibles, par suite de lésions internes ou de dispositions morbides, ressentent malheureusement la présence par des douleurs très vives et très variées.

N'a-t-on pas constaté depuis longtemps que l'atmosphère n'est parcourue par des courants électriques qu'au moment où la foudre éclate dans le voisinage de nos demeures? Alors, en effet les personnes les mieux portantes ressentent des commotions dont elles ne sauraient ignorer la nature.

Il n'est pas surprenant que les personnes malades ou souffreteuses éprouvent des effets analogues, alors que les courants naturels de l'électricité atmosphérique n'agissent pas sur l'individu bien portant.

Les belles expériences de M. Palmieri ne nous montrent-elles pas que l'atmosphère est parcourue par des courants électriques, alors qu'il n'y a pas d'orage proprement dit à l'horizon, alors que l'on pourrait supposer que l'électricité naturelle est en plein repos.

Trente années d'observations consécutives lui ont démontré qu'aucune pluie ne peut s'approcher de son ermitage du Vésuve sans que l'électroscope n'en décèle immédiatement la présence; et les nerfs affaiblis de personnes maladives ne sont-ils pas des électroscopes plus sensibles que les appareils du savant météorogistes?

Personne n'ignore que les indications fournies par les sens dépassent en délicatesse les instruments les plus sensibles.

Le sens du goût révèle, sans aucune espèce d'hésitation, des traces d'acide sulfurique qui échappent à l'analyse spectrale elle-même.

La membrane olfactive de l'homme est douée de la perspicacité, presque magique, de reconnaître le musc renfermé dans une molécule d'air.

Les considérations qui précèdent, et d'autres qu'il serait facile d'énumérer, démontrent l'utilité que le Bureau de météorologie pourrait tirer de pareils auxiliaires.

Examinons actuellement les moyens à employer pour garantir ces infortunés névrosiques contre les souffrances qui troublent si cruellement leur vie.

En les plaçant dans l'intérieur d'une chambre complétement garantie contre les mouvements de l'électricité, comme la célèbre cage de Faraday, par exemple, ne serait-on pas à même de faire cesser les névralgies, les névroses, et autres troubles morbides sous la dépendance du fluide électrique?

De pareilles expériences présenteraient un grand intérêt, surtout si elles étaient accompagnées d'observations recueillies dans un district ou périmètre d'une certaine étendue, et si la chute de toutes les quantités de pluie pouvait être enregistrée avec soin et précision.

Cette étude, aussi intéressante pour la physiologie que pour la médecine, aurait été possible à Paris si l'on avait adopté la création des observatoires municipaux, succursales de l'observatoire central de Montsouris.

Effectivement, si l'on parvient à constater que les mouvements de l'électricité atmosphérique agissent d'une façon si puissante sur l'organisme malade, il sera difficile de ne pas reconnaître entre le fluide électrique et l'influx nerveux une analogie plus intime qu'on ne le suppose ordinairement.

Si l'on ne trouve aucune différence, il faudra de toute nécessité chercher dans d'autres causes efficientes l'origine des susdites souffrances!

Jusqu'à preuve du contraire, nous considérerons l'organisme comme une source d'électricité, en même temps que de chaleur, et dans cet ordre d'idées, nous conseillerons de protéger les malades non-seulement contre les variations de la température, mais encore contre celles de l'état électrique.

Les courants continus, soit directs, soit inverses, ne paraissent agir que faiblement sur l'organisme tant qu'ils conservent une même intensité; c'est lorsqu'ils commencent ou s'interrompent, lorsqu'ils augmentent ou diminuent, qu'ils produisent les mouvements des muscles de la grenouille, qui, avec quelque soin qu'elle ait été préparée, ne saurait acquérir la sensibilité de l'être humain dont le système nerveux est ébranlé.

Or, lorsque l'électrisation de l'air varie, il faut de toute nécessité que l'état électrique de l'individu soumis à ces changements d'influence soit modifié, car on ne saurait admettre que son épiderme possède une puissance isolante assez marquée pour le soustraire aux perturbations du milieu ambiant.

Comment ces modifications pourraient-elles se produire sans que des courants, plus ou moins intenses, ne parcourent en ce moment les fils télégraphiques de la motilité et de la sensibilité?

Qui sait si ces courants spontanés ne sont pas assez énergiques pour engendrer des effets analogues à ceux des courants voltaïques qui, on le sait, donnent lieu à des sensations acides quand ils parcourent les nerfs linguaux, à des bruits quand on les fait agir sur les nerfs acoustiques, enfin à des phosphorescences quand ils cessent d'exciter les nerfs de la vision?

Nous appelons volontiers sur ces faits l'étude et le contrôle de l'observation clinique.

Wilfrid de Fonvielle.

(*Le Journal d'hygiène.*)

ELECTRIC TIME-BALL APPARATUS FOR INDIA.

oct 31 1879

A VERY complete set of electrical time-ball apparatus has recently been manufactured for the Indian Government, and will in due course be erected at Fort William, Calcutta. The apparatus has been designed by Mr. S. Alfred Varley, whose name is well known in connection with this and similar electrical apparatus, and it has been manufactured at the works of Messrs. Siebe and Gorman, Mason Street, Westminster Bridge Road, where we recently had an opportunity of inspecting its working. The apparatus includes a time-ball, a clock or regulator for giving the time, a commutator for closing the electric circuits, an electric lock, on which the ball hangs until the moment of discharge, and an apparatus for firing a time-gun. The ball, which is 5 feet 6 inches in diameter, and weighs with its attachments about 5 cwt., is wound up a mast by means of a rack and pinion, and falls, when released, through a space of 10 feet. A rod, furnished with a piston at its lower end, is attached to the ball, and after the latter has fallen through a space of 4 feet, the piston enters a pneumatic cylinder, producing a cushion of compressed air, which arrests the descent of the ball without any shock or concussion being experienced. This ball, as regards the size and the space through which it falls, is similar to those which were erected at Charing Cross and Liverpool in 1853 and 1854, at the suggestion of the Astronomer Royal, to whom we are indebted for the idea of utilising electricity for discharging time-balls. Improvements have, however, been effected by Mr. Varley in connection with the pneumatic cylinder, as well as in the discharging apparatus. In the former a pressure-relieving valve has been introduced, which, by preventing any rebound on the part of the ball, gives greater distinctness to the signal. In the latter, greater rapidity and certainty of action are secured by the special mechanical and electrical arrangements we are about to describe.

There are certain dangers to be guarded against in time-ball apparatus, and it is clearly very important that time-signals should be absolutely reliable. The only way to ensure correctness in the working of the time-signal is that the arrangements be such as shall enable the operator at the Observatory, whence the time emanates, to see what is taking place at the time-signal station. This result is obtained by making the time-ball send back a return signal at the moment of its release. The actual force of the electric current employed is very small, whilst the weight of the ball and its attachments, is considerable; the discharge is therefore effected by constructing the lock by which the ball is retained and released of a series of levers, the lightest of which is set in action by the electric current. A greater or less time is occupied by these levers in falling, and the loss due to this cause is, in many of the electric locks, very appreciable; in the Liverpool lock, which was more active in its action than some which have been constructed at a later date, the loss of time amounted to 3-10ths second. In the present apparatus the loss of time due to this cause is only 1-20th of a second. An interval of a few minutes elapses after the ball has been wound up, before the time-signal is sent, during which time the ball is resting upon the electric lock, and there is the danger of the lock being discharged by a false current, before the proper current arrives; such false current may be caused either from the time-wire being accidentally in contact with another circuit, or from meteorological causes.

The greatest possible reliability in the working of the Fort William apparatus is attained in the following way: It the first place, the electric lock is constructed on the polarised system, *i.e.*, to work with opposite electrical currents, the current of one direction more securely locking it, and the current of the opposite direction releasing the lock. The time-ball is discharged at 1 p.m. daily, and the locking current is sent some few minutes before. The discharging apparatus therefore remains firmly locked by an electrical current more powerful than any accidental current is likely to be, until the very moment of discharge. In the next place, the release of the electrical lock divides the electrical circuit, and sends back a return signal, just after the ball has commenced to fall. The attendant at the observatory whence the time is sent sees the interval which elapses between the sending of the time-current and the receiving the return signal, recording the fall of the ball. It is, therefore, made clear to him that the current has done its work efficiently. Again, the loss of time in the lock itself has been reduced to 1-20 second, as before stated, and should any hanging fire occur in the electric lock, it is indicated both at the sending and at the time-ball stations. The gun is fired by means of an induction coil and a local battery, which is set in action by the time-current. In connection with this apparatus, there is also an electric lock, which prevents the gun being put in circuit until it is protected from any false current by the preparatory signal, which remains from a few minutes before 1 p.m. until the moment of discharge. The first time-ball apparatus constructed on the polarized system was designed by Mr. S. A. Varley, at the instance of the late Sir Thomas Maclear, Astronomer Royal at the Cape of Good Hope, for the Port Elizabeth time-ball, which was inaugurated in August, 1865, and gives time to the shipping in Algoa Bay. This ball is discharged from the Cape Town Observatory, which is distant 500 miles, and the return signal, recording the falling of the ball, was stated by Sir Thomas Maclear to have been received 1-15th of a second after the time-current was sent. The time-ball over Messrs. Dent's, at Charing Cross, and which has been daily discharged by Greenwich current for the last six years, is also constructed on the polarized system, but only one current is used, and no return signal has been provided for, as it is not deemed necessary. The apparatus we have been describing was inspected on Tuesday last by General Hyde and Mr. W. F. Batho, C.E., on behalf of the Indian Government. Its working was found to be perfectly satisfactory, and it will shortly leave the manufacturers' works for its destination.

La nature 25 oct 1879

LE DRESSAGE DES CHEVAUX

PAR L'ÉLECTRICITÉ

MORS ET STICK ÉLECTRIQUES.

On a souvent proposé des moyens divers pour arrêter et maîtriser les chevaux emportés ou rétifs, il n'en est pas de plus ingénieux et de plus efficace que celui qui a été imaginé par M. Defoy et dont M. Bella, administrateur de la Compagnie des Omnibus, a récemment apprécié les avantages devant la Société d'encouragement[1].

M. Defoy exécute chaque jour de remarquables expériences que nous croyons devoir signaler à nos lecteurs. Disons d'abord en quoi consiste le système employé. C'est simplement un petit appareil de Clark renfermé dans une boîte qui peut facilement être placée sous la main du cocher ou du cavalier. Les rennes du cheval contiennent intérieurement un fil métallique conducteur qui aboutit au mors d'une part, et à l'appareil magnéto-électrique d'autre part. En tournant la manivelle de l'électro-aimant, on détermine la formation d'un courant électrique qui agit dans la bouche du cheval, et lui cause une telle surprise qu'il s'arrête et reste immobile. En joignant à l'action de l'électricité la douceur et

Cheval lancé au galop, instantanément arrêté par l'action d'un mors électrique. (D'après nature.)

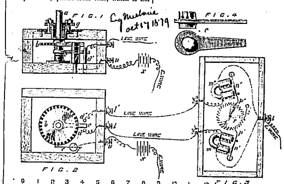
les caresses, le cheval le plus dangereux est rapidement maîtrisé.

M. Bella rapporte que M. Defoy a expérimenté son appareil sous ses yeux, au dépôt de la Compagnie générale des Omnibus, où se trouvent réunis les chevaux les plus méchants et les plus dangereux. Un cheval hongre très difficile à ferrer fut amené à la forge où il se montra extrêmement méchant, on le munit de la guide conductrice du courant : au bout de quelques minutes d'expérimentation, le cheval se laissa caresser l'encolure et le dos, puis toucher les jambes, et finalement relever les pieds de derrière, toujours les plus difficiles à aborder et à relever. « On frappa sur le fer sans qu'il se révoltât, dit M. Bella, et on lui changea ses fers, sans qu'il fût entravé et sans qu'il recommençât ses dangereuses défenses. »

Le directeur de la Compagnie parisienne des Petites Voitures a récemment aussi constaté l'efficacité de ce procédé. « L'expérimentation, dit M. Camille, dans un rapport que nous avons sous les yeux, a eu lieu sur plusieurs chevaux qu'il avait été jusqu'alors impossible de ferrer, tous sans exception ont cédé à l'influence de l'appareil. Un cheval qu'il s'agissait de ferrer allait jusqu'à se rouler à terre, se débattant, se défendant et luttant contre tout, rien ne pouvait le dompter. J'eus recours à l'appareil de M. Defoy; à la première expérience, on leva, à mon grand étonnement, sans de grandes difficultés,

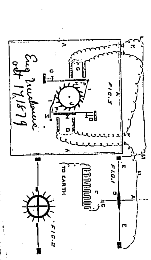
[1] *Société d'Encouragement*, séance du 25 avril 1879.

[38216.]—Electric Vane.—If the editor can understand my rough sketch to engrave it, I think "F. W. W." will see my plan of trying to do what he requires. A, spindle from vane, which is not



shown; B is a wheel soldered to spindle; the wheel will require say 16 projections (as in sketch), tipped inside with platinum, as shown at Fig. 2, so that as it revolves the projections will come in contact with two steel springs, E, E, which at their ends must be tipped with platinum on, say, front side and ebony the other: the spindle, A, terminates in a small cup of mercury, C, which is connected to one pole of battery F, the other pole is connected to earth, therefore if the wheel B is turned to the left a current will be sent through the left spring, E; if turned in the opposite way the current will travel through the other spring, as the contact will be broken on the left side by the tip of ebony on side of springs. Two line wires, M, M, will have to be connected to springs, E, E, and carried to where the indicator is fixed. Fig. 3, inside of indicator; the front of it and pointer are not shown; K, K, are binding screws, line wires to be connected to one of them on each side; G, G, magnets; H, armature; O, screws for regulating springs; P, are studs to keep armatures from springing too far back; I, I, are ratchets fixed with a pivot on the top of armatures; the lower one will require a spring, as shown at S, to prevent it from falling from the wheel, J, which must have same number of cogs as the wheel B (Fig. 1) has projections; on the spindle of the wheel J is fixed the pointer. The action is as follows: Suppose the vane turns the wheel B to the right, a current is sent through the magnet on the right side, which draws its armature forward and turns the wheel J and pointer one notch every time the projections on wheel B come in contact with spring E; when turned back it causes the current to be sent through the other magnet, which will work the wheel J and pointer in the opposite direction; the circuit is completed by the wires L being connected to earth. By having 32 projections on wheel B and same number of cogs on J, the indicator should show all points of the compass. What is Mr. Lancaster's opinion of the arrangement?—G. T. Bursnell.

[38216.]—Electric Vane.—In reply to "F. W. W.," I send drawing of a piece of apparatus which I designed for this purpose some years ago. It is still in a crude form, and needs working out as regards details, but it may give "F. W. W." an idea. Fig. 1 is a sectional elevation of the transmitter; Fig. 2 a sectional plan of ditto; Fig. 3 plan showing interior of receiving instrument or indicating dial; Fig. 4 an enlarged view of the arm *c* in Figs. 1 and 2. *a* is the spindle of weathercock, the movements of which are to be transmitted to the house. It passes through a stuffing-box, or any other device to keep the rain out, into a strongly-made box containing the following mechanism:—A wheel, *b*, is rigidly secured to this axle, so as to revolve with it. The periphery of this wheel is divided into, say, 32 teeth, corresponding to as many points of the compass. The number of these may be increased or decreased, the sensitiveness of the receiver being increased or decreased accordingly; the spaces between these teeth to be filled with ebonite, hard wood, or other insulating substance, and the rim turned smooth and true. *e* is a spring fixed to a brass pillar *f*, and armed at its tip with a piece of platinum, which rubs against the edge of wheel, and which must not be wider than one tooth of the wheel, though it may with advantage be somewhat less. The pillar *f* is connected, through *u*, with a battery *x*, the other pole of which is connected with the earth. Just below the wheel, and sliding on the same spindle, is a brass arm *c* (shown enlarged in Fig. 4). This arm fits sufficiently tightly to be carried round with the spindle when nothing opposes its motion, but not so tightly as to hamper the movements of the latter when it—the arm—is stopped by either of the brass pins *d' d''*. For the sake of clearness, I have shown these pins further apart than they should be. In the actual thing they should be as close to the arm as they can be without simultaneously touching it. Now let us examine the action of this transmitter. Suppose the wheel *b* revolves in the direction of the hands of a watch; the arm *c* is carried round until it touches *d'*, where it maintains contact, while *b* is at liberty to keep on revolving: as it does so the teeth on its edge rub, one after the other, against the platinum tip of *e*, and are thus, one after another, connected with the battery. As the ebonite pieces pass beneath the spring this connection is broken and the current ceases. Thus, for every tooth which passes beneath *e* a current or pulsation is sent into *b*, thence into *c*, and through *d'* to *l'*, and along the line-wire attached thereto. If the wheel be turned in a contrary direction the same series of pulsations will be sent, but this time through *d''* and *l''* to the other line-wire. The mechanism of the receiver is represented by Fig. III. Enough is given to show the principle, but the details (the pawls *p' p''* for instance) require working out. On the outside of the box is fixed a dial (not shown), marked with 32 points of the compass. In the centre of this dial is a spindle, carrying a pointer, the movements of which correspond with those of the weathercock. On this spindle is a toothed wheel, *r*, having the same number of teeth as *b* (in this case 32). An electro-magnet on either side is so fixed that by attracting an armature attached to a spring a pawl, *p*, at the end of the latter pushes the wheel *r* one tooth round. It is clear that while *m'* will turn it in one direction, *m''* will move it in the other. A light spring, *s*, drops between the teeth so as to prevent accidental movements of the wheel. These electro-magnets are connected one to each of the line wires. It is obvious therefore that a current sent through either wire will turn the wheel, *r*, in one direction one tooth, two impulses will move it two teeth, and so on. Currents through the other line wire turn *r* in the reverse direction. One end of the wire on each magnet is connected to one of the line wires, the other end to earth.—Clatton.



E. L. 0471

Travaux de l'Etat-major

L'Electricité

On lit dans l'*Akhbar*, d'Alger, numéro du 26 juillet :

Dans un projet de loi demandant ouverture de différents crédits supplémentaires sur l'exercice 1879, nous relevons, à propos du budget de la guerre, une demande de crédit de vingt mille francs pour le chapitre 3, « Dépôt de la guerre ». Les motifs de cette dépense sont assez curieux pour que nous les relations.

Voici les explications fournies par le gouvernement dans son exposé des motifs :

A la suite d'une entente avec le gouvernement espagnol, il a été décidé que les opérations relatives à la jonction trigonométrique de l'Algérie avec l'Espagne, par-dessus la Méditerranée, seraient exécutées en 1879.

Ce projet est le plus grandiose que la géodésie moderne ait été appelée à réaliser. Il s'agit, en effet, de mesurer des triangles dont la longueur des côtés dépasse trois cents kilomètres ; l'opération terminée, l'Algérie et la France seront reliées entre elles par une chaîne ininterrompue de triangles.

La méridienne de France s'étendra alors, sans solution de continuité, depuis les îles Shetland jusqu'aux confins du Sahara algérien, par une amplitude de trente degrés environ.

En raison de l'énorme distance qui sépare les sommets de la Sierra Nevada, en Espagne, des cimes de l'Atlas algérien, les appareils employés aux opérations ordinaires de la triangulation sont insuffisants pour assurer la visibilité réciproque des points du réseau hispano-algérien ; il est, par suite, nécessaire de recourir à des moyens d'illumination plus puissants que ceux que l'on obtient avec les appareils actuels. Après des recherches préalables, faites avec le concours des ingénieurs les plus éminents, il a été reconnu que l'électricité seule pouvait fournir une source de lumière assez puissante pour être perceptible à l'énorme distance de trois cents kilomètres.

Dans ces conditions, le Dépôt de la guerre est conduit à demander l'acquisition d'un matériel nouveau, qui comprendrait :

1° Six miroirs héliotropes de trente centimètres de côté ;

2° Six appareils réflecteurs de 0 mètre 50, pour les observations de nuit ;

3° Six lampes électriques à incandescence ;

4° Six machines Gramme, petit modèle, pour la production de la lumière électrique ;

5° Quatre moteurs ou locomobiles, de la force de deux chevaux-vapeur, pour actionner les machines électriques, chaque machine Gramme devant faire quinze cents tours par minute.

6° Un matériel secondaire, comprenant des courroies de transmission, des charbons, des lunettes de repère, des microscopes, etc.

Enfin, il y a lieu de prévoir la construction, fort dispendieuse en pays de montagnes, de baraques d'observation, de piliers et de colimateurs.

La dépense totale peut être évaluée à trente mille francs.

Mais, dans le matériel dont il s'agit, se trouvent des machines Gramme et des moteurs qui resteront acquis au Dépôt de la guerre après la fin des travaux, et pourront alors être utilement employés dans les ateliers, pour lesquels on se proposait déjà d'en effectuer l'acquisition.

Il en résulte que la dépense relative aux opérations géodésiques peut être considérée comme diminuée d'une somme de dix mille francs, qui serait prélevée sur le budget normal du Dépôt de la guerre.

Le crédit supplémentaire demandé se réduit en conséquence à vingt mille francs.

On voit que la grande opération géodésique dont nous avons été les premiers à annoncer la prochaine exécution, va être tentée très-prochainement. Grâce au pouvoir lumineux de l'électricité, des mesures qui eussent été presque impossibles seront, très-sûrement, très-simplement terminées.

Pour se rendre compte des progrès accomplis grâce à l'électricité, il n'est pas inopportun de copier dans les Mémoires d'Arago les passages relatifs aux difficultés que l'illustre astronome a éprouvées à saisir les signaux qui lui étaient envoyés pour une opération analogue, la prolongation jusqu'aux Baléares de la méridienne de Paris :

« Nous partîmes de Paris, M. Biot et moi, et le commissaire espagnol Rodriguez au commencement de 1805.

« Nous visitâmes chemin faisant les stations indiquées par Méchain ; nous fîmes à la triangulation proposée quelques modifications importantes et nous nous mîmes à l'œuvre

« Une direction inexacte donnée aux réverbères établis à Iviza, sur la montagne Campvey, rendit les observations faites sur le continent excessivement difficiles. La lumière du signal de Campvey se voyait très-difficilement, et je fus, *pendant six mois*, au Desierto de los Palmas, *sans l'apercevoir*, tandis que plus tard la lumière établie au Desierto, mais bien dirigée, se voyait tous les soirs de Campvey.

« On concevra facilement quel ennui devait éprouver un astronome actif et jeune, confiné sur un pic élevé, n'ayant pour promenade qu'un espace de vingt mètres carrés, et pour distraction que la conversation de deux chartreux dont le couvent était au pied de la montagne, et qui venaient en cachette enfreindre la règle de leur ordre. »

Nous avons pleine confiance dans le zèle et l'habileté des officiers d'état-major commandés par M. Perrier. Mais nous avouons ne pas comprendre pourquoi les lumières électriques à incandescence ont eu l'honneur d'être préférées à celles beaucoup plus puissantes que donnent les régulateurs Serrain, et nous serions fort aises d'être éclairés à ce sujet.

Nous ajouterons que, suivant nous, comme nous l'avons indiqué il y a déjà plus de deux ans, le meilleur emploi de l'électricité pour résoudre le grand problème de la figure de la Terre serait de se transporter dans les îles Pomotou et d'y mesurer un arc, à l'aide de triangulations à grande portée.

En effet, dans cet archipel lointain qui appartient désormais à la France dans son intégralité, les terres ne sont ni assez hautes, ni assez nombreuses pour défigurer la surface d'équilibre des eaux, et les anomalies locales au milieu desquelles se noient (même à sec, au milieu des continents) les météorologistes sont complétement éliminées.

the Atlantic lines reflects to some extent on holders in this Company, but it is far from being a vital question. It is by no means probable that the whole revenue of the English Atlantic Companies will be absorbed in the fight, it is far more probable that some arrangements will almost immediately be made. Hence we trust the supposititious case of the Atlantic Companies' dividends being *nil* presented by the chairman will never become a real case.

We have, then, briefly shown that cable property is increasing in value, that a company like the Globe Telegraph and Trust Company is non speculative, and gives the average instead of the individual dividend, thereby incurring less risk and greater certainty of continuous payments. Although we have so far mentioned only one Trust Company, our remarks do not necessarily apply to this alone; in fact, there was held on the same day the meeting of another Company—the Submarine Cables Trust—the report of which was very satisfactory. These reports will shadow forth to intending investors the exact position of such Companies, and no doubt will be found full of valuable information to many who have not hitherto devoted much attention to Companies of this character.

THE TELEGRAPHIC CABLE ACROSS THE CASPIAN SEA.*

Manufacture, Transport, and Submersion.

The eastern coast of the Caspian Sea, where the Russian regiments and colonies of Krasnovodsk are located, was without any telegraphic communication with the Caucasus, notwithstanding that the Transcaucasian military administration is subordinated to the superior administration of the Caucasus.

The continued increase, especially within the last few years, of the intercourse with Krasnovodsk caused the necessity for establishing direct communication to be more and more felt. This being the case, the superior administration of the Caucasus, which for several years past had been considering the question of connecting the transcaucasian military circle with the opposite shore by means of a submarine cable, thought it expedient to hasten the solution of this question, so that the proposed connection might be effected that same year.

Terminal stations having been selected in the direction of Bakou (east coast) and Krasnovodsk (west coast), the carrying out of the undertaking was entrusted to the Telegraph Department, and was to be completed before the autumn, at which season the tempestuous weather might have prevented any operations in this direction.

The distance between the locality for laying and that of the manufacture, together with the difficulties of transport across the continent, rendered the conditions of contract difficult to draw up. Thus, in order to gain time, it was considered necessary to draft the same without waiting for special data, and simply on information obtained from the map of the Caspain sea brought out by the hydrographic department. The calculation of the length of the cable, which was to serve as a basis for estimating the total cost of the undertaking, preceded therefore the selection of a definite line for the laying of the cable.

To determine the direction of this line, whilst bearing in mind the usual precautions, that is to say whilst avoiding dangerous localities, precipitous rocks and sea-bottoms, where the cable might be exposed to a destructive action, and, at the same time, seeking the shortest route, it was decided to take the peninsula of Apchéron, near Cape Gourgane, where the anchoring of the fleet would not injure the cable, as the starting-point in laying. The line, taking thence a direction towards the eastern coast of the Caspian Sea, was to lie in the same latitude as Krasnovodsk, leaving to the north the island of Gelavo, and the *naphtha rocks*, and to pass at some distance from the submarine ridge which divides the Caspian sea into two basins.

The length, as the crow flies, of the line thus indicated is 125 nautical miles (of 1,852 metres). It was provided that there should be an additional 16 miles of reserve cable to meet various contingencies. The total length of cable to be ordered was thus 141 nautical miles. There remained to be specified the construction of the cable and the deviations to be made in laying it. It was necessary not to lose sight of the importance of this line in time of war, the difficulty of repairing it, and the impossibility of counting upon the assistance of special vessels; and it was important to make the cable of great strength throughout its whole length, but especially near the coasts, to enable it to stand the ground swell which is so frequent in this locality. Two types of cable were therefore determined upon—one for the coast and shore ends, and the other for deep-water cable.

The following were the conditions for the construction:—

The metallic sheathing was to consist of ten galvanised iron wires of diameters (*a*) 7·6 millimetres or 297 *mils*, *i.e.*, No. 1 of the Birmingham wire gauge, for the shore-ends; and (*b*) 5·2 millimetres or 208 *mils*, *i.e.*, No. 6 B.W.G., for the deep-sea cable. Each sheathing wire was to be of strength sufficient to support 42 kilog. per square millimeter, and the sheathing was to be coated with two layers of tarred hemp.

The lengths of cable ordered were 24 naut. miles of shore-end, and 117 of deep-sea cable; forming a total of 141 naut. miles, inclusive of the reserve cable.

The measures, diameters, construction, &c., which were indicated by the telegraph department corresponded to those which the French Government had selected for the Corsica cable laid in 1878; and it was resolved to adopt as a basis, generally, the electrical conditions established by the French administration.

The outer diameter of the insulating sheath was fixed at 7 millim. or 275 *mils*; the weight of gutta-percha being not less than 63 kilog., or 138·8lb. English, per naut. mile.

The conductor (*l'âme*)* consists of a stand formed of 7 copper wires, ·7 mm. in diameter, twisted in such manner that one of the wires is central throughout the whole length. The diameter of the strand is not less than 2·2mm. or 86 mils.; its weight is 48 kilog. per mile.

The electrical resistance of the conductor, at the temperature of 24° C., is not higher than 12 ohms† (12·28 Siemens' units).

The inductive or electrostatic capacity of the core is not greater than ·4 microfarad per naut. mile.

The battery employed for testing the insulation has a minimum electromotive force of 100 Daniell cells.

Since the Caspian sea, during 3 or 4 months in the year, presents a very low temperature, the minimum insulation was to be 600 megohms per naut. mile, no temperature being specified.

The conditions of the construction of the cable being laid down, there remained to be considered the questions of manufacturing, transporting and laying the cable. The difficulties in the way of carrying out, by the agency of its own staff, the two operations of transport and laying, necessitating special appliances, induced the Department to entrust the whole of the operations to a single firm, which, in addition to the pecuniary guarantee specified in the conditions of contract, should be considered competent to carry out the three operations of manufacture, transport and laying, and to assume, consequently, the entire responsibility.

In accordance with these considerations, conditions of contract were drawn up on the above-mentioned basis, and on March 24, 1879, were communicated to all the foreign cable manufacturers, as well as to persons known to have been specially engaged in similar enterprises. The contract was submitted to public tender on April 24 following. The major portion of the firms offered their services for the manufacture of the cable, but regretted that they could not undertake the transport to so great a distance across the Continent. Thus two competitors were alone in presence, viz.:—Dr. Siemens, of Berlin, and M. Palliesen, the representative in Russia of the great company of northern telegraphs. They offered to take the whole contract, the former for £62,000, and the latter for £59,500; this contractor stating that the cable would be manufactured at the works of the India Rubber and Gutta Percha Company, near London. The undertaking was therefore awarded to M. Palliesen.

On its part, the Department of Telegraphs had sent out a principal mechanician and several functionaries to study finally and theoretically the questions involved. Their labours allowed of a route for the line being definitively determined. Starting from the Peninsular of Apchéron, and passing about six miles to the south of the island of Gelaro and of the naptha rocks, the cable was to be laid to the town of Krasnovodsk itself, on the opposite shore. By reason of this modification of the route, the cable was to be 147 miles in length, inclusive of the reserve, being composed of 24 miles of shore-end, and 123 of deep sea cable, or an increase of six miles above the length originally estimated.

The manufacture at the works was superintended by several electricians sent by the contractor and belonging to the great company of the North. These electricians were to take note day by day of the work done. On the other hand, the Imperial Department of Telegraphs was represented in London by an Inspec-

* Translated from the *Journal Télégraphique*.

* The word is here improperly used; the expression *l'âme du cable* corresponding to the English term *core of the cable*.—Ed. E.

† *Per knot.*—Ed. E.

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vement d'horlogerie atteint les deux limites extrêmes de sa

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Journal universel d'Électricité

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SOMMAIRE

RÉGULATEURS ÉLECTRIQUES

DE LA PRESSION DU GAZ

Parmi les applications industrielles utiles de l'électricité, l'une des plus importantes est celle qui se rapporte à la régularisation de la pression du gaz d'éclairage dans les tuyaux de distribution. Cette question est étudiée depuis longtemps, et plusieurs systèmes plus ou moins complets ont été mis au jour; mais, jusqu'à présent, les applications que l'on en a faites ont été très-limitées. Cependant quelques-uns de ces systèmes fournissent des résultats satisfaisants, comme nous allons le voir.

Le gaz d'éclairage, comme on le sait, s'écoule à travers les tuyaux de distribution sous l'influence d'une pression exercée à l'usine par les gazomètres, et qui est réglée sur la moyenne de la consommation. Cette pression restant la même, il arrive nécessairement que la force avec laquelle le gaz s'échappe des tuyaux de distribution est d'autant plus grande que le nombre des orifices d'écoulement est moins grand. Or, comme ce nombre peut varier, soit qu'un certain nombre d'établissements qui consomment du gaz allument ou n'allument pas, soit qu'il se déclare dans un quartier des fuites ou que les compteurs fonctionnent mal, soit même qu'il y ait irrégularité dans le service de l'éclairage public dans les différents quartiers d'une ville, il peut en résulter, pour le consommateur et même pour la compagnie du gaz, de nombreux inconvénients dont le moindre est une dépense de gaz inutile (1). On comprend en effet que si, ayant réglé une première fois l'ouverture des becs, de manière à obtenir une bonne lumière, la pression vient à augmenter, le gaz qui s'échappe en trop grande abondance brûle imparfaitement, et, en se répandant dans les appartements, non-seulement les enfume, mais encore peut occasionner la détérioration des marchandises qui y sont déposées, altérer la santé de ceux qui les habitent et provoquer même des accidents les plus déplorables. D'après le témoignage des hommes compétents, il paraîtrait que plusieurs incendies, entre autres ceux des Deux Magots, des magasins de Pygmalion, du Grand Opéra, de la rue Monge, de la filature de MM. Vilmot père et fils, et un grand nombre d'explosions de magasins, auraient eu pour origine la cause dont nous parlons, et on y rapporte même la mort du frère de l'école de Saint-Nicolas qui, d'après les constatations médicales, aurait été asphyxié par le gaz.

Ce qui est le plus fâcheux, c'est que souvent on ne se rend pas compte de cet accroissement de pression, car la lumière, au lieu de devenir plus brillante, s'assombrit, et l'on serait plutôt tenté d'ouvrir davantage le robinet d'alimentation des becs que de le fermer. On comprend qu'en présence de ces inconvénients, on pouvait désirer l'invention d'un révélateur et d'un régulateur automatique de la pression du gaz, et, comme je le disais, depuis une vingtaine d'années, plusieurs solutions ont été proposées par MM. Servier, Giroud, Launay, Raupp, Chardin et Prayer, etc.

Le système de MM. Giroud et Breguet, breveté en 1855, avait, non-seulement pour effet d'indiquer les variations de pression qui peuvent survenir dans les tuyaux de distribution du gaz, mais encore de régler automatiquement cette pression en ouvrant ou en fermant plus ou moins, à l'aide d'une

(1) Dans un article intéressant publié par M. Servier dans le Journal *le Gaz* du 20 Mars 1859, on montre que sur 100 mètres cubes qui sont envoyés de l'usine, il n'y en a que 80 ou 90 d'utilisés, ce qui rend le prix de revient du gaz au lieu de consommation de 10 à 20 o/o plus élevé qu'aux gazomètres.

1² 130

Sc Am Feb 14 1880

A SYSTEM OF ELECTRICAL STORAGE.

By Profs. Edwin J. Houston and Elihu Thomson.

The various suggestions which have hitherto been made for the storage of electrical energy, in such manner as to readily permit its after recovery in the form of electrical current, have failed when attempted to be carried into practice, either on account of their inherent impracticability, or by reason of the serious inconveniences and losses due chiefly to the following:

1st. The extent of conducting surface of the storage apparatus required to be acted on rendering it cumbrous.

2d. The loss of energy due to evolution of gas during the operation of charging.

3d. Lack of constancy and duration in the currents evolved after charging.

4th. The limited capacity for storage due to the proportion of active material being but a fraction of that present.

The well-known Planté secondary battery is open to all of the above inconveniences, and though admirable in its conception as a piece of scientific apparatus, yet lacks markedly the requisites of an economical reservoir for electrical action. In the secondary battery, as is well known, the duration of action is chiefly dependent upon the amount of surface of the lead plates employed; the action of the current used to charge it being practically limited to the surfaces of the plates, and the charge received may therefore be designated as due chiefly to polarization. Moreover, the charge received is necessarily limited on account of the evolution of gas.

Fig.1.

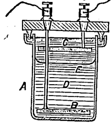
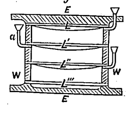


Fig.2.



It is manifest that a Smee cell, or cell with vertical plates, in an acid solution, could not be used in the process, for the only effect would be the evolution of the gases hydrogen and oxygen from the decomposition of water.

In the system of electrical storage devised by us, the duration of action and consequent capacity for storage is independent of extent of surface and dependent on the mass of material to be acted upon.

In our method we employ a saturated solution of zinc sulphate, inclosed in a suitable vessel, at the bottom of which is placed a plate of copper, to which is connected an insulated conducting wire. At or near the top of the vessel, and immersed in the solution contained therein, is placed a second copper plate, or plate of hard carbon, or metal unchanged by contact with zinc sulphate solution, and less positive than metallic zinc. This is also connected to a wire. The storage cell so constituted is then ready for charging, which is effected by the passage through the cell of a current, whose direction is from the lower to the upper plate. The current employed is that obtained from a dynamo-electric machine, and the result produced is the deposition of metallic zinc on the upper plate, and the formation of a dense solution of copper sulphate overlying the under plate. The duration of the charging action is of course limited only by the amount of zinc sulphate and the thickness of the lower plate. The cell, after charging, constitutes in fact a gravity cell, and continues a source of electrical current until a reconversion of all the copper sulphate into zinc sulphate has been effected, metallic copper being deposited on the lower plate, and the deposit of metallic zinc being removed from the upper. *It thus may be allowed to regain its original condition.* The recharging, however, may be effected at any time, either before or after the cell has become inactive. The cell may be covered or sealed to prevent evaporation; and since no addition of new material is needed, a restoration to an active condition is at any time possible.

It is not necessary to employ zinc sulphate as the material to be decomposed, since other metallic salts may serve the same end, the only other requisite being that the lower plate shall yield to the solution a metal capable of redeposition, and the solution of which is denser than the solution employed in the cell, and that the upper plate be capable of receiving a metallic deposit and of retaining its form unchanged during prolonged use.

A, Fig. 1, represents a cell of glass, or other suitable material, furnished with two metallic plates, B and C connected separately by conducting wires to the binding posts, *b* and *c*, the wire from the lower plate being insulated. A porous diaphragm, E, is placed below the upper plate, C, to prevent fragments of deposited zinc from falling on the lower plate, which may occur should the charging current be too intense.

In charging, the arrangement of the cells in multiple arc or in series may be adapted to suit the electromotive force of the dynamo-electric machine employed. The arrangement of the cells in charging may be different from that in discharging, according to the purpose for which the current is designed. Diffusive action of the solutions may be prevented by any of the well-known means used in gravity cells.

It may be objected that the economical results obtained in the storage of electricity as above described will necessarily be low, as but a fraction of the electrical energy in charging will be expended in overcoming counter electromotive force, or in effecting electrolysis, compared with that which overcomes the resistance of the liquid, and therefore lost in heat production. But this objection is readily met by so connecting the cells as to make their counter action or counter electromotive force the chief resistance to its passage. Economical results necessarily follow, the economy attained being measured by the relative cost of the fuel required to drive the dynamo-electric machine and that of the zinc and chemicals used for charging a battery of equal power to that of the storage battery used.

The resistance of the liquid between the plates of a storage cell may be lowered either by broadening the cell or by bringing the plates nearer together. In charging, economical results are obtained by using the plates comparatively near to each other, and separating them during discharge, and thereby avoiding loss by diffusion.

A convenient form of storage battery, designed for rapid charging and discharging, is shown in Fig. 2, where L, L', L'', L''' are horizontal plates of copper separated by insulating rings, W, W, the spaces between the plates, L, L', etc., being filled with a saturated solution of zinc sulphate. Lateral tubes, *a*, are provided to compensate for the expansion of the liquid due to changes of temperature, and also to provide for filling the cells. The cells are held between plates, E, E, by bolts which pass from one to the other. In this arrangement, the plates, L' and L'', serve as upper and lower plates, accumulating copper sulphate on their upper surfaces and receiving metallic zinc on their under surfaces. The series may of course be extended.

When a number of cells are connected in series, several of them may be charging, while the remainder are used as a source of active current.

The most obvious application of a storage battery furnishing a constant and lasting current, is to replace the ordinary telegraphic batteries; the objections to the direct use of the dynamo-electric machine being mainly the necessity for continually sustaining the driving power and preventing variations or intermissions therein; to adapt the current generated to the work to be done; and to sustain a uniform electro-motive force in said current. By the use of a storage battery, the dynamo-electric machine may be run at suitable intervals to produce and sustain the charge of said battery. The economy and convenience of this arrangement will, we believe, be vastly greater than with the ordinary batteries in use.

In lighthouses, a dynamo-electric machine can be run by suitable power at intervals during the day to furnish an unfailing and reliable source of current for lighting purposes.

The purposes for which the storage batteries may be applied are so numerous that mention need not be made of them, the feasibility of each being decided by the question of its economy.

In domestic economy it would be feasible to provide storage batteries to be charged by dynamo-electric machines from convenient central locations, the energy of said batteries to be used in the operation of burglar and fire alarm systems, or for light driving power.

It is practicable in good forms of dynamo-electric machines to realize in external work from 50 to 60 per cent. of the power used in driving them. Of this we believe it possible to store and recover 50 per cent., or even more. Therefore 25 per cent. of the original power may be given out secondarily as electrical current. If it be assumed that in the best steam engines it is possible that 20 per cent. of the heat energy of the coal be utilized, then about 5 per cent. of the heat energy might, we think, be recovered after storage as electrical current. Notwithstanding this small percentage, the economy would be much superior to the employment of zinc and other materials used in the ordinary battery in the production of current.—*Franklin Journal.*

Electricity as a Remedial Agent.

There are two methods by which electricity can be used as a remedial agent. One method is the temporary application of a strong current; the other is the constant application of gentle and scarcely perceptible currents. The strong currents referred to are furnished by the various electro-magnetic machines, manufactured for special medical purposes, or by regular voltaic batteries, as used in electric baths, while the gentle currents are obtained by the application to the body of peculiar arrangements based on the principle of the voltaic pile, and in which the natural perspiration of the skin, with its acid or alkaline reactions, takes the place of the acids or salt solutions used in the ordinary voltaic pile, and aided by the heat of the body, evolves a constant current which may be made to assist the vital energies, by its special action on the nerves, which are, as is well known, eminently good conductors of electricity, as they are of the nervous force. Notwithstanding the most recent researches have demonstrated that nervous force is not identical with electricity, they have proved the close relation of these two forces, by showing how electric currents act on the nervous system, and how muscular contraction induced by the nerves of volition can actually produce demonstrable electric currents, acting on the galvanometer in an identical way as in the case with the electric appliances, which are the principal subject of this article.

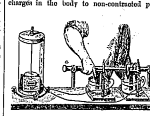
It was especially Dubois Raymond, who has made himself meritorious by investigating the capability of the muscles and nerves of volition to generate electric currents, and consequently the inverse operation. He saved animal electricity from the disrepute into which it had been brought by Mesmer, who as is now well known, acted only upon the highly wrought imagination and sensibilities of his patients, while his appliances were so absurd as not to stand the critical test of even a merely superficial scientific examination.

We consider the experiments of Dubois Raymond so important in connection with the subject of this article, that we give a short description of one of his experiments, proving that the generation of electricity by the nerves of volition, does not only belong to electric fishes, or to the animalculæ which produce the luminosity of seawater, in our summer nights, but also to man himself; from which follows necessarily that similar electric currents as can be produced by the nerves and muscles, will react on them and all the tissues of the body, and when properly applied may exert a most beneficial influence.

The method by which Du Bois Raymond proves that electric currents are generated by the contraction of the muscles, induced by the nerves of volition, consists in connecting with the ends of the coils of a sufficiently sensitive galvanometer, the two metallic handles of an ordinary small medical electric machine; they are grasped with the moistened hands, the needle will then come in motion by irregular currents developed, but after some oscillations come to rest. If now the muscles of one arm and hand are contracted, the needle will deviate to one side, for some 10 or 20 degrees; if then these muscles are relaxed and those of the other hand and arm contracted, the needle will at once deviate to the other side, and may be made to deviate more, and so by alternate contraction and relaxtions of the muscles of both arms at the right time, deviations of the needle of 40 to 50 degrees may be produced, provided the galvanometer coil contains from 3000 to 4000 windings of fine wire.

The adjoined figure represents a modification of the experiment which Du Bois Raymond made later:

In two seperate glass vessels containing salt water, two strips of platinum are plunged connected with the terminal wires of a very sensitive galvanometer with astatic needles, suspended in a coil of 24,000 convolutions. A wooden rod *ab* is over the vessels and so near to it, that while grasping it, a finger of each hand can be immersed in the liquid. When now the bar is squeezed with one hand, and the muscles of the corresponding arm are contracted, taking care not to move the fingers immersed in the liquid, the needle will deviate, and this in such a direction as to indicate that the current runs from the arm which is not contracted, through the salt water in one vessel, the galvanometer coil and the salt water in the other vessel, to the arm of which the muscles are being contracted. It is evident therefore that as the current moves in a closed circuit, it will run in the body from the contracted to the non-contracted member, and that contraction evolves positive electricity, which discharges in the body to non-contracted parts,



ELECTRICITY DEVELOPED BY MUSCULAR CONTRACTION.

which can therefore give out positive electricity, which will be absorbed from the outside by the contracting parts, if they are in contact with conducting substances.

It is curious that experiments have proved that if frogs' legs are thus connected, and caused to contract, the current runs in the opposite direction, it shows a difference in the relative arrangement of muscles and nerves in frog and in man. Or it may be that there is a difference in the current when muscles are contracted by volition as is the case when man thus experiments, while with the frog, they can only be caused to contract by the reflex action, produced by stimulating the parts we wish the animal to contract.

It has been suggested that these currents are developed by the heat evolved in contraction, by sanguine congestion or by the increased perspiration of the contracting member, but Raymond proved directly by studying the subject practically, that if these causes produce currents they run in opposite directions, as the currents evolved by voluntary contraction.

These gentle electric currents continually circulating in the human body are confined to the interior by the epidermis (upper skin) which is a bad conductor of electricity, and their presence can only be demonstrated by special arrangements. Du Bois Raymond proved this also, when he blistered the surface of the parts in contact with the salt water or better with the pl[illegible]num plates attached to the galvanometer; wh[illegible] with the epidermis he obtained a deveation [illegible] only 2° to 3°, he obtained as much as 60° or 7[illegible] when the contact was made after removal of t[illegible] epidermis by blisters.

It is to be hoped that the field opened by him will be taken up by other equally able hand[illegible] and our knowledge of one of the most influenti[illegible] secret and subtile agencies of living organisms [illegible] as far extended as possible, and as the subje[illegible] so fully deserves. Surely the fact that muscul[illegible] contractions produce electric currents, as [illegible] that electric currents cause muscular c[illegible]tions, is a most important and suggestiv[illegible] which some day will lead to important d[illegible]ies.

Mining & Scientific Press
May 21, 1881.

AN ELECTRIC SOLDERING IRON.—Mr. Ball, of Philadelphia, has patented a soldering-iron capable of melting the hardest solders, as those of gold and silver, by electricity. The electrodes pass through and project beyond the handle, and are connected with a ball of platinum; this, when battery connection is complete, becomes heated to any required degree, and the desired soldering is readily affected.

Telegraphic Journal

THE ELECTRIC DISTANCE MEASURER OF M. G. LE GOARANT DE TROMELIN.

April 1880

THE question of the rapid measurement of the distance separating a moving object from a point of observation, has often been considered by various inventors. The problem resolves itself into this: There being two given points of observation, O O′, separated by a distance of say 1,200 metres, to find immediately, and without calculation, the distance of a movable point, N (see fig. 1), from the observatory, O. If O O′ represents the base of 1,200 metres, and O A the distance separating the limit, L, of the centre of rotation of the pointer, A *a*, it is evident that if A *a* is parallel to O′ N, the triangles, O *n* A and O N O′, being similar, *n* O will represent on the table, T T, the distance of O from N on the same scale that O A bears to O O′.

This being granted, suppose that from the two observatories, O O′, the telescopes, L and L′, are turned towards the point, N; then if by electrical means we cause the pointer, A *a*, to move always parallel to the telescope, L′, the two similar triangles, of which we spoke, will always be automatically formed, and the point of intersection of the pointer, A *a*, with the graduations, R, engraved on the telescope, L, and which are graduated to the scale of $\frac{OA}{OO'}$ will give at once, by a direct reading, the distance, O N, which is required.

In order to obtain parallelism between the telescope, L′, and the pointer, A *a*, let us suppose a toothed sector, S, to be fixed to L′, and made movable by means of a tangent screw, V, turned by a handle, M.

The telescope, L, and the pointer, A *a*, are set parallel once for all when the instrument is adjusted. A wheel, P, fixed to the axis, *b b*, of the tangent screw, and provided with an interrupter, I, can produce a number of interrupted currents, so that the escapement of a receiver, regulated by the wheel P, causes the pointer, A *a*, to follow the angular movements of the telescope, L′.

This principle has been effected by various persons; the object aimed at has been the same, but the means by which they have been arrived at are very different.

M. Siemens, well-known by his electrical inventions, has employed the armature which bears his name to effect this result.

On the axis, *b b*, he placed a multiplier wheel, connected with his armature, which turned between the poles of a powerful magnet.

By making the sector, S, turn, he produced at the same time a rotation, more or less rapid, of the armature, which produced reversed induced currents at each half revolution. These currents, transmitted to the receiver, O, constituted a motive force which caused the movement of the needle, A *a*, by means of a system of propelments, driven by an armature oscillating between the branches of an electro-magnet, polarised by a magnet in V.

This system was, as is evident, the application of the *transmission* of force to a distance by the magneto-electric machine which M. Siemens had invented.

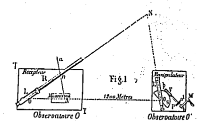
Although ingenious, this system possessed a great defect; in fact, it was impossible to produce a sufficient current without exerting considerable manual exertion, and this was aggravated by the multiplying power of the wheel work. If the manipulator was turned slowly, the currents induced had not sufficient power to move the pointer, which was nearly a metre in length. If the apparatus was turned too quickly, the number of currents transmitted was so considerable that the propelments did not respond at all in consequence of the inertia of the long pointer, A *a*. In any case the motive force was so slight that the wind alone was sufficient to prevent the pointer moving, and consequently parallelism from being preserved.

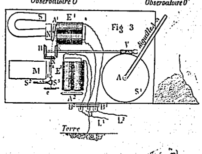
This system was tried for some time at Brest, and had to be given up.

We have spoken at some length about this *telemeter*, because it is one of the first applications of the transmission of force to a distance, and because it was in France that it was first applied; in fact, because it had features distinct from similar forms of apparatus.

The inconveniences which we have pointed out do not exist in the telemeter of M. de Tromelin. The electricity being only used for regulating an escapement driven by clockwork, it is evident that the motive force can be sufficiently considerable to effect the object aimed at. The problem to be solved is that of the movement of the pointer, A *a*, in the two directions. It is necessary that the observer, having followed a particular point with the pointer in one direction, shall be able to follow any other point by using the pointer in the reverse direction.

Description.—The manipulator is made as shown by fig. 1; fig. 2 shows details of the same. As can be seen, the wheel, P, has 8 cams, which, by raising the jockey wheel, *g*, during the rotation of the former, produces at *d* interruptions of the current given out by the battery, F, and which flows to line, B. The spring, *r*, is sufficiently strong to cause the jockey wheel, *g*, to lie in the hollow of the cam wheel when the handle which turns the wheel round is left to itself. A reverser, I, mounted friction tight on the axis, *b*, allows either the positive





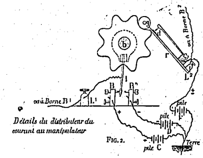
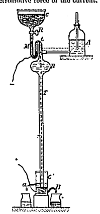


FIG. 2.

way as to show to the astronomers of Mars...

DEBRUN'S ELECTRO-CAPILLARY GENERATOR.

THE most sensitive of all electrometers hitherto invented is that known as Lippmann's capillary electrometer. It is based on the principle discovered by Herr Lippmann, that if by mechanical means we deform a mercury surface, that deformation produces a disengagement of electricity which tends to arrest the movement of the mercury. The electrometer is based on the converse of this principle and the electricity to be measured is caused to produce a mechanical movement in a mercury surface confined in a capillary tube, and this movement is measured by means of a very fine scale. In the actual electrometer, as now manufactured and sold in Germany, the mercury appears as a column in the capillary tube, and the upper surface of the column is in contact with a superposed column of dilute sulphuric acid. When, therefore, one pole of the battery to be measured is connected to the mercury and the other to the acid, there is a movement of the upper surface of the mercury within the tube, either up or down according to the "sign" of the poles, and to a degree corresponding to the electromotive force of the current.



It follows, of course, that if such a movement could be communicated to the mercury surface mechanically an equivalent electromotive force would be produced, and hence it would be possible to construct a generator of electricity on this principle. M. Debrun, preparer to the Faculty of Sciences, Bourdeaux, has in fact devised such a capillary battery, and his arrangement is represented in the figure. In a tapering capillary tube T he causes mercury to fall drop by drop in such a manner as to form a string of capillary beads or globules having acidulated water (dilute sulphuric acid) interposed between each pair of globules. The mass of mercury M which forms the first globule is in communication with a platinum wire electrode, as shown, and therefore takes its polarity, which following the figure is negative. Similarly the mass of mercury C' forming the final globule is connected to another platinum wire which is marked positive in the figure. The fountain-head of mercury is contained in a reservoir C, and its flow into the capillary tube is regulated by the stop-cock R. The water, acidulated by one-sixteenth, is drawn out of the globular reservoir B by the passage of the mercury drops, and a Mariott flask A is employed to maintain its level constant. At the lower end a Florence receiver permits the acidulated water to escape by the nozzle *a* and the mercury by the nozzle B into separate receptacles. The extremity of the tube should be immersed in the mercury C', or else the dilatation of the globules at the extremity will tend to generate a current in a contrary direction to that developed by the descending globules.

The tube used by M. Debrun has at its upper end a diameter of $2\frac{1}{2}$ millimetres dwindling to 1 millimetre at its lower end. It should be arranged to give a height of 0.30 metres and to contain at least twenty globules of mercury and not more than thirty-five. In these conditions the electromotive force obtained as measured by the mercury elect- meter of Herr Lippmann, is about 1.4 volts, whicl is sufficient to decompose water by means o Wollaston points. The energy absorbed by th apparatus in generating the current is representec by 2 kilogrammes of mercury falling a quarter of metre per hour. Nevertheless M. Debrun has beer able, in making the generator operate during twenty-four hours, to strongly silverise a five centime piece and from this data he has been able to compute tha while the work absorbed was 0.5 kilogram-metre per hour, the work done amounted to 0.4 kilogram-metres.

If the two poles of the apparatus are separated, the mercury flows gently and with difficulty, if on the other hand they are united, the mercury flows rapidly; and its motion can even be arrested by opposing a Bunsen element to the capillary battery.

The electrician will readily understand that in order to test the current a galvanometer of high resistance is necessary owing to the great resistance of the capillary column.

MINERAL WEALTH OF EUROPEAN

LE NOUVEAU FREIN ÉLECTRIQUE

DE M. ACHARD

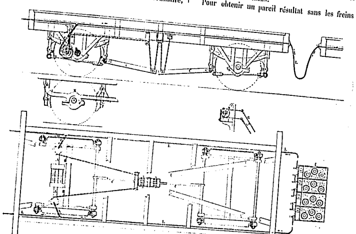
La Nature mars 1880

Avec les vitesses effrayantes des trains des chemins de fer actuels, vitesses qui dépassent quelquefois 100 kilomètres à l'heure, — 28 mètres par seconde — il est indispensable de disposer de moyens d'arrêts puissants, rapides et sûrs.

L'arrêt instantané, tel que le rêvent encore certains inventeurs ignorants, étant une chimère, comme le mouvement perpétuel, on se contente d'agir, faute de mieux, par la méthode ordinaire, qui consiste à venir appliquer des sabots sur les roues des voitures pour enrayer leur mouvement. Si le principe est resté le même, les méthodes d'application ont du moins beaucoup varié, et c'est une solution très élégante et aujourd'hui très perfectionnée de la question des freins continus que nous voulons faire connaître aux lecteurs de *la Nature*.

On obtient un arrêt rapide *en agissant sur toutes les roues d'un train à la fois;* les appareils qui permettent de réaliser cette condition prennent le nom de *freins continus*.

Pour obtenir un pareil résultat sans les freins



Frein électrique de M. Achard. — Disposition nouvelle du chemin de fer de l'Est (1879). — I, batteries secondaires avec piles Daniell pour les charger; L, L, conducteurs; A A, électro-aimant tubulaire; B B, essieu qui entraîne l'électro-aimant, en fonction lorsque le courant passe; C, C, leviers mouflés soulevés par les chaînes au moment du serrage; D, D, sabots de serrage en fonte; H, commutateur disposé sur le fourgon de tête; G, G', cordes allant du fourgon de tête à la locomotive. En tirant G', le mécanicien produit le serrage, et le desserrage en tirant G. On manœuvre le frein sur le fourgon d'arrière en agissant sur une manette analogue à celle du commutateur H.

continus, on serait obligé d'employer un garde-frein par voiture, condition irréalisable dans la pratique.

A côté de la question de continuité d'action se place l'instantanéité d'action; on devine sans peine l'importance de ce facteur, chaque seconde perdue rapprochant l'obstacle de tout le chemin parcouru par le train, dans le même temps. L'action instantanée de l'électricité donne au frein Achard cette propriété qui ne se retrouve qu'à un moindre degré dans tous les autres systèmes, — vide ou air comprimé — aussi peut-on, avec le frein électrique, obtenir des arrêts aussi rapides et aussi puissants qu'avec aucun autre.

Reste la question de sécurité d'action. Il est très important, à ce point de vue, de disposer d'un appareil toujours en état de bon fonctionnement, et nous avertissant lui-même de ses dérangements, s'il en arrivait. L'insuccès des freins exceptionnels, dits *freins de détresse*, destinés à produire des arrêts rapides en cas de danger imminent, tient à ce qu'ils n'étaient jamais en état de fonctionner au moment même où on réclamait leurs services; les freins doivent donc être utilisés en service courant; et, d'autre part, avertir s'il leur arrive un accident de nature à compromettre leur bon fonctionnement.

Les appareils qui satisfont à cette dernière condition sont dits *automatiques*.

STATISTIQUE. — *Prix Montyon* accordé à M. V. de Saint-Genis. La Commission accorde en outre : à M. Borius, le rappel du prix qu'il a obtenu en 1875 ; un encouragement de la valeur de 400 francs à M. G. Le Bon et une mention très honorable à M. Bonnange.

CHIMIE. — Le *prix Jecker* est partagé de la manière suivante : M. Riban obtient 4000 francs, M. Bourgouin 4000 francs et M. Crafts 2000 francs. — *Prix Lacaze*, décerné à M. Lecoq de Boisbaudran.

GÉOLOGIE. — Le *grand prix des sciences physiques*, dont le sujet était l'étude approfondie des ossements fossiles de l'un des dépôts tertiaires situés en France, est décerné à M. Filhol. Une récompense de 1000 francs est accordée à M. Lemoine.

BOTANIQUE. — Le *prix Barbier* n'est pas accordé, mai un encouragement de 1000 francs est attribué à M. le docteur Manouvriez. — Sur le *prix Desmazières*, deux encouragements de 750 francs chacun sont accordés, l'un à M. Crié, l'autre à M. le docteur Leudiger-Fortmorel.

ANATOMIE ET ZOOLOGIE. — Le *prix Thore* est décerné à M. Eduart Brandt.

MÉDECINE ET CHIRURGIE. — *Prix Montyon.* — La Commission décerne trois prix : à MM. Dujardin-Beaumetz et Audigné, à M. Tillaux et à M. Auguste Voisin. Elle accorde trois mentions honorables : à M. Bochefontaine, à M. Lécorché, à M. Simonin, et cite honorablement dans le rapport : MM. Azam, G. Delaunay, Grasset, Gréhant, Poncet, Parak, Riembault. — *Prix Bréant.* Un prix de 5000 francs est décerné à M. Toussaint. — *Prix Godard.* La Commission décerne deux prix, de 1000 francs chacun, à MM. Alph. Guérin et Ledouble. — *Prix Chaussier.* Le prix est décerné à feu M. Ambroise Tardieu.

PHYSIOLOGIE. — *Prix Montyon : physiologie expérimentale.* — Le prix est décerné à M. François Franck. — Le *prix Lacaze* est décerné à M. le docteur Davaine.

PRIX GÉNÉRAUX. *Prix Montyon : arts insalubres.* — Le prix est décerné à MM. Boutmy et Faucher. Un encouragement de 1500 francs est accordé à M. le docteur Haro. — *Prix Cuvier*, décerné à M. Studer. — *Prix Trémont*, à M. Thollon. — *Prix Gegner*, à M. Gaugain. — *Prix Laplace*, à M. C. M. Walckenaer, sorti le premier en 1879 de l'École Polytechnique.

Un prix de 5000 francs est accordé à M. William Crookes, pour l'ensemble de ses expériences.

STANISLAS MEUNIER.

La Nature. March 6 188

TÉLÉMÈTRE ÉLECTRIQUE

DE M. G. LE GOARANT DE TROMELIN

Enseigne de vaisseau

Le nouveau télémètre que nous allons décrire, en reproduisant les dessins de *La Lumière électrique* est une solution très élégante du problème suivant :

Déterminer, par une simple lecture, exactement, rapidement et à chaque instant, la distance d'un objet mobile, éloigné et inaccessible.

Le principe de l'appareil est représenté fig. 1.

On vise de deux observatoires O,O' placés à une distance connue, 1200 mètres, par exemple, le point N, dont on veut connaître la distance à l'observatoire O. Si, par un procédé quelconque, nous obligeons une droite *Aa*, tournant autour du point A, à rester *toujours parallèle* à l'axe de la lunette O'L' de l'observatoire O', nous formerons deux triangles semblables OA*n* et OO'N. Si la distance OA est de $1^m,20$, le côté OO' ayant 1200 mètres, il en résultera que chaque *millimètre* sur le côté O*n* correspondra à une longueur de *un mètre* sur le côté ON et que, en lisant la distance O*n* exprimée en millimètres sur une règle graduée R, ce nombre sera l'expression *en mètres* de la distance ON. Maintenir toujours le parallélisme entre la droite *Aa*, et l'axe de la lunette O'L', tel est le rôle de l'électricité dans le télémètre de M. de Tromelin.

L'appareil se compose donc de deux parties distinctes, un *manipulateur* placé en O' ; il a pour effet de distribuer des courants électriques qui dépendent du mouvement de la lunette L', et d'un *récepteur*, qui utilise ces courants pour faire mouvoir l'aiguille *Aa*. L'ensemble constitue une sorte de télégraphe à deux fils.

Manipulateur. Il se compose d'une lunette L' (fig. 1), portant un secteur denté S mis en mouvement par une vis tangente V. reliée à une manivelle M. En tournant cette manivelle dans un sens ou dans l'autre, on fait tourner la lunette à droite ou à gauche, ce qui permet de suivre l'objet mobile.

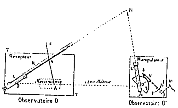


Fig. 1. Mode d'emploi du télémètre électrique.

Sur l'axe de la vis tangente est placé le *distributeur de courants*, représenté figure 2, et dont nous allons étudier la fonction.

Une roue à 8 cames est fixée sur l'axe de la vis Un galet *g*, relié à une tige *r* formant ressort, s'appuie constamment sur cette roue.

Lorsque le galet est dans un creux, le ressort *r* ne touche pas la pointe *d* et le courant venant de la pile F ne passe pas dans le fil relié à la borne B'' du récepteur. Si on tourne la manivelle de droite à gauche, le plateau tournera ; il y aura un contact en *d*, et par suite une émission de courant, chaque fois qu'une des cames du plateau sera en face du galet *g*.

Pour chaque tour de la vis sans fin il y aura *huit* émissions de courant, le récepteur recevra huit fois le courant électrique, l'aiguille *Aa* se mouvera sous l'influence de ces courants, comme no verrons tout à l'heure.

Relativement à l'opinion de la commission sur la nécessité de s'affranchir à tout prix des crues du Chagres, les auteurs du projet ont pensé que l'on pouvait résoudre la difficulté, en réglant l'écoulement des eaux de cette rivière dans le canal, à l'aide d'un barrage à déversoir régulateur, d'une longueur de 1.500 mètres, et d'une hauteur maximum de 38 mètres ; ou encore de construire un lit mineur pour le Chagres. Ces solutions, qui peuvent être modiées par des études plus approfondies, entraineraient de grandes dépenses, et porteraient les frais de construction, d'après la commission, à 1 milliard 70 millions et la durée des travaux à douze années. En tout cas, la commission préférerait voir adopter la dérivation complète du Chagres, en lui creusant un chenal artificiel, pour mener ses eaux à la mer.

Au cours des travaux de la commission, un nouveau projet, variante des deux précédents, a été proposé.

Les dispositions de ce projet sont les suivantes :

Les deux chaînes entre lesquelles se trouve comprise la vallée du Chagres formant, en certains points, d'étroits défilés, on en profite pour barrer la vallée en un de ses points, et relever le niveau des eaux du fleuve ; on crée ainsi un lac artificiel, une sorte de lac Nicaragua, à la cote de 24 mètres, auquel on donne, en des endroits convenables, un écoulement dans les vallées latérales, pour le trop-plein des eaux du fleuve, qui s'écoule vers la mer par cinq écluses accolées au barrage. Du côté du Pacifique, la même disposition serait adoptée pour le Rio-Grande.

Ce nouveau projet, dans la pensée de ses auteurs, permet d'éviter les travaux à faire pour creuser au Chagres un nouveau lit ; de diminuer les terrassements, et, par suite, de réduire en proportion le chiffre des dépenses.

Avec cette modification, le Canal deviendrait un canal à écluses et il en nécessiterait 13.

Une remarque qui s'applique aux trois projets par l'isthme de Panama, c'est que les mouvements volcaniques sont arrêtés depuis longtemps dans cette région de l'isthme américain, ce qui, au point de vue des tremblements de terre, est un gage de grande sécurité pour l'avenir.

TRACÉ PAR L'ISTHME DE SAN-BLAS. — La nature du terrain ne comporte dans ce projet qu'un canal à niveau. Il a son origine dans la baie de San-Blas, non loin de l'embouchure du Necarlegua, et aboutit, comme le précédent, dans la baie de Panama.

La commission n'a eu pour l'examen du projet que des renseignements insuffisants ; cependant elle a apprécié que les travaux à exécuter pour emprunter une portion du Bayano seraient très-coûteux et très-aléatoires ; le tracé comporte, en outre, un souterrain de 16 kilomètres de longueur, qui ne permettrait pas de livrer le Canal avant une douzaine d'années. La dépense de construction a été évaluée à environ 1 milliard 270 millions. De pareilles conditions n'ont pas semblé de nature à recommander le projet, qui n'a pas été pris en considération.

TRACÉ PAR L'ATRATO-NAPIPI. — Le canal partirait de l'embouchure de l'Atrato, dans la baie d'Uraba, emprunterait le cours de cette rivière, presque au confluent du Napipi, et aboutirait non loin de la baie de Cupica. Deux projets ont été présentés, l'un d'un canal à écluses, l'autre d'un canal à niveau, comportant chacun un tunnel. Pour les deux, la longueur serait de 290 kilomètres environ et la durée du passage de trois jours.

Nous ne nous occuperons que du canal à niveau, le projet de canal à écluses ayant été abandonné par son auteur avant que le Congrès se fût prononcé définitivement.

Le projet à niveau a paru présenter plusieurs difficultés techniques des plus sérieuses. L'une de ces difficultés réside dans les travaux considérables qu'il y aurait à faire à l'embouchure de l'Atrato, pour obtenir sur la barre et y entretenir plus tard une profondeur constante de 8 mètres 50. Au prix de sacrifices énormes on a pu arriver à 7 mètres 50, à l'embouchure du Mississipi, dans la passe sud ; mais on était aidé par les grands courants de la mer : ce qui ne se présenterait pas pour l'Atrato, placé au fond d'un golfe profond. Il faudrait, de plus, recevoir dans le canal la totalité des eaux de la Vallée du Napipi, et la commission a vu dans cette nécessité la production probable de courants très-nuisibles à la navigation.

Outre les difficultés techniques qui viennent d'être signalées, il y a lieu de tenir compte encore de ce fait, que la contrée est la plus humide de tout l'isthme américain, qu'elle est dépourvue de matériaux de construction, à l'exception du bois, qu'elle n'a qu'une très-faible population, et qu'enfin elle est alternativement si montueuse et si marécageuse qu'il faudrait un travail énorme pour y établir les chemins de service indispensables.

En conséquence, la commission a estimé que le projet par l'Atrato-Napipi ne présentait pas de bonnes conditions techniques.

La durée d'exécution serait probablement de 10 à 12 ans, et la dépense de construction d'environ 1 milliard.

Il restait à la commission à se prononcer sur les cinq grands tracés qui lui avaient été soumis, et sur les projets divers présentés pour chaque tracé.

En présence des avantages et des inconvénients de chacun, la commission a émis l'avis que le canal à construire devait être dirigé à travers l'isthme de Panama par la baie de Limon et Panama, en se réservant de faire son choix entre le canal à niveau et le canal à écluses. Une seule chose pouvait faire pencher la balance en faveur du canal à écluses, c'était l'évaluation des dépenses d'établissement qui n'ont été portées par la commission qu'à la somme de 570 millions environ, tandis que le canal à niveau ne pourra être construit à moins de 1 milliard 70 millions environ, à moins de circonstances exceptionnellement favorables.

La commission a pensé que l'on ne devait pas s'arrêter devant cette grande différence des chiffres d'estimation des dépenses, que, même avec le chiffre de 1 milliard 70 millions, le canal à niveau sera rémunérateur, en prenant pour base le passage de 4 millions de tonnes (chiffre inférieur aux évaluations statistiques), au prix de 15 francs par tonne, et finalement elle a recommandé le canal maritime à niveau devant être dirigé du golfe de Limon à la baie de Panama.

Conformément aux conclusions concordantes des rapports de ses différentes commissions, le Congrès international, dans sa séance générale de clôture du 29 mai 1879, a pris la décision suivante :

Le Congrès estime que le percement d'un canal interocéanique à niveau constant, si désirable dans l'intérêt du commerce et de la navigation, est possible ; et que ce canal maritime, pour répondre aux facilités indispensables d'accès et d'utilisation que doit offrir, avant tout, un passage de ce genre, devra être dirigé du golfe de Limon à la baie de Panama.

(*La fin au prochain numéro.*)

B. LUNEL.

ERRATUM. — Une faute d'impression s'est glissée dans la légende de la carte de l'isthme, que nous avons publiée dans notre dernier numéro. Ce n'est pas à 570 millions, mais bien à 1 milliard 70 millions que s'élèveraient les dépenses du canal à niveau constant par le Limon et Panama, ainsi que nous l'indiquons dans l'article ci-dessus.

Menlo Park Scrapbook, Cat. 1057

No. 40A. "Various Electrical Appliances"

This scrapbook covers the years 1880-1886 and contains clippings about electrical appliances, electrical medical technology, aerial navigation, and military technology. There are 144 numbered pages.

Blank pages not filmed: 50-144.

1057

Various Electrical Appliances

40

1

2

3

New Patents—1880.

Telegraphic april 15 1880

1286. "Telephones." J. H. JOHNSON. (Communicated by E. Marx, F. Aklem, J. Kayzer, and L. Davis.) Dated March 27.

1295. "Insulating electrical conductors." E. M. ALLEN. (Communicated by A. A. Knudson and F. L. Kane.) Dated March 30.

1328. "Improvements in and relating to telegraphic and telephonic apparatus." W. R. LAKE. (Communicated by E. Davis and P. A. Dowd.) Dated March 31.

1333. "Improvements in or applicable to machinery or apparatus for the manufacture of engine-packing, insulated telegraph wires, or other similar manufactures." G. F. JAMES. Dated March 31.

1339. "A new or improved rotary induction or electric motor." J. C. MEWBURN. (Communicated by W. de Fonvielle.) Dated April 1.

1343. "Improvements in apparatus for the production and application of electricity and of magnetism." J. L. PULVERMACHER. Dated April 1.

1385. "Dynamo-magneto electric machines and electric motors." T. A. EDISON. Dated April 5.

1392. "Improvements in and relating to dynamo-electric machines." W. R. LAKE. (Communicated by H. S. Maxim.) Dated April 5.

1397. "Improvements in electric lamps and in solenoids applicable for their regulation." C. D. ABEL. (Communicated by F. Krizik and L. Piette.) Dated April 6.

1407. "Improvements in electrical conductors and in the arrangement and manner of using conductors for telephonic and telegraphic purposes." O. HEAVISIDE. Dated April 6.

ELECTRIC INDICATOR FOR STEAM BOILERS.—It is said an electric boiler indicator has been brought out in France, by means of which the water level in a boiler may be ascertained at any distance from the boiler. A tablet is connected with the electric indicator, which is fixed at the top of a vertical tube above the boiler, by two electric conducting wires. An index, a battery and a bell complete the apparatus.

Engineering ELECTRICITY. July 31 1880

The Commonwealth Electric Lighting and Manufac-
turing Company of Philadelphia is a corporation which
came into legal existence on the 22d, by the granting of
a charter by the State Department at Harrisburg. The
objects of the company, as set forth in its application,
are to manufacture and supply electricity for illuminat-
ing purposes, and also lamps, burners and other neces-
sary appliances for the same.

The life of a submarine telegraph cable is from ten to
twelve years. If a cable breaks in deep water after it
is ten years of age it cannot be lifted for repairs, as it
will break of its own weight, and cable companies are
compelled to put aside a large reserve fund in order that
they may be prepared to replace their cables every ten
years. The action of the sea-water eats the iron-wire
completely away, and it crumbles into dust, while the
core of the cable may be perfect. The breakages of ca-
bles are very costly, and it is a very difficult matter to
repair them in comparison with land lines. A
ship has to be chartered at an expense of
\$500 a day for two or three weeks in fixing
the locality and in avoiding bad weather, as cables
can only be repaired in the calmest seasons. One
break alone in the Direct Company's cable cost
\$100,000 to repair, and the last chance left to the com-
pany was to make an agreement with the Anglo-Ameri-
can, so that they should be protected and have the use
of that company's line when their own was stopped.

Electricity in the Human Body.

Druggists circular

Most people are familiar with the "sparks" which may be produced under certain conditions by stroking the fur of a cat; and travellers in Canada and other cold, dry countries have witnessed the still more remarkable phenomenon of the human body being turned into a conductor of electricity, and the possibility of lighting the gas by merely placing one's finger—given the necessary conditions of electrical excitement—near the gas get, without any other agency. Mr. A. W. Mitchinson, the African traveller, who is engaged in writing a narrative of his exploring expeditions in West Central Africa, gives some still more startling facts. He states that one evening, when striking an African native, in a moment of anger, with a cowhide whip, he was astonished to see sparks produced, and still more surprised to find the natives themselves were quite accustomed to the phenomenon. He subsequently found that a very light touch, repeated several times, under certain conditions of bodily excitement, and in certain states of the atmosphere, would produce a succession of sparks from the bodies of native men as well as native cattle. A lazy nigger, it seems, yielded none of these signs of electricity—a rather unfortunate circumstance for his more active brethren, who may possibly come in for a share of undeserved flogging from the hands of future travellers in search of electrical phenomena among the human race. We are not aware that these facts have been recorded by other travellers, but they certainly deserve thorough sifting by competent observers.—*Lancet.*

CORRESPONDENCE.

Electrician

GALVANOMETERS.

Av July 24 1880

TO THE EDITOR OF THE ELECTRICIAN.

SIR: While reading the article on the Deprez galvanometer in *The Electrician* of June 5th, received a few days ago, my attention was engaged by the following paragraph, which I quote for the purpose of making a few comments, which I hope will not encroach too heavily on your space:—"If the current from a powerful battery be passed through the coils of a large electro-magnet, and studied by means of this galvanometer, the intensity of the current may be seen to vary and to increase during a considerable period of time, which under special conditions may extend to a minute, that is to say, the production of the magnetic effect is not completed until the end of this period, during the whole of which the inductive reaction of the electro-magnet is appreciable and continuously decreasing. This remarkable phenomena, discovered, so to speak, *en passant*, by M. Marcel Deprez, shows what services may be rendered by the instrument we have described."

We see from this quotation that the Deprez galvanometer
shows an inductive effect of the magnet on the coils during the
first period of time the current is passing through the coils.
It must be, therefore, that during magnetisation there is a
motion of the lines of force in such a direction as to tend to the
production of an opposing electromotive force when the coils cut
them as they pass by. On the other hand, the second series of
researches of Lord Elphinstone and C. W. Vincent, F.R.S.E.,
demonstrates plainly that the electromotive force produced in
the helices by demagnetisation of electro-magnets is in the same
direction as the original current; whence, it appears that in this
case the motion of lines of force must be contrary in direction
to that in M. Deprez's experiment.

Now, these two experiments just noted may seem to have no
apparent connection with each other; but I will endeavour to
show that they become interestingly related as a founda-
tion of actual proof to one of Faraday's most beautiful
conceptions of lines of magnetic force. Faraday, it is
known, imagined lines of force to spring out around con-
ductors and expand concentrically around them as centres,
just as the ripples produced by a pebble falling in the
water; and that they increased outwards, as new lines originated
at the centre, until this outside tension balanced the producing
current in the conductor; that when the current was interrupted
these lines shortened upon themselves or contracted back to-
wards the centre. But this explanation of Faraday has not gone
far beyond the hypothetical state in the opinion of many
scientists, especially those whose confidence still lingers in
Ampère's doctrines, because a palpable demonstration of the
theory has been lacking. With isolated linear conductors, or
with helices, the experimental observation of this motion of lines
of force has always been totally unsatisfactory, on account of
its extremely short duration under those circumstances; but
when we call to our assistance a paramagnetic body like iron, as
in electro-magnets, then we have a retardation in the process,
due to the coercive force of the iron—a magnetic inertia which
consumes time and delays the action sufficiently to permit its
observation. Therefore, investigation with magnets would seem
to be more promising than with currents alone. About a
year and a half ago, while studying the effects of arma-
tures of various kinds on the distribution of the force
in U magnets, I detected an unmistakable motion of lines of
force, which I subsequently investigated and verified fully. I
found that on approaching an armature to the poles of the
magnet, those lines which cross to the other pole at points on
the sides (supposing the poles turned upwards) followed the
substance of the magnet upward further, and crossed to the other
arm at a point much nearer the poles, and thus crept up, nearer
and nearer the poles, until the armature arrived at contact.
With the recession of the armature from the poles, the lines fell
down the sides from the poles and crossed over at lower points
until their original place was resumed. It may be said here
incidentally that these motions of the lines of force can account
satisfactorily for the currents produced by motions of the arma-
tures of electro-magnets observed by Lord Elphinstone and
Professor Vincent.

From these observations, and from other facts which I had
previously studied out, I concluded that when a magnet is de-
magnetising, the lines of force fall down the sides (in U magnets)
and contract to the base. When the first paper of Lord Elphin-
stone and Professor Vincent was received in America, I saw the
application of this theory as an explaining factor, and in a
letter (December 15th, 1879) to an eminent American scien-
tist, I mentioned it as an argument bearing on a dis-
cussion then open between us. A partial quotation will be
of interest in this connection. "As to the reason why the mag-
netic force disappears so rapidly without the armature, my
opinion is this—when the armature is removed sufficiently away
to overcome the existing tension, by breaking the circuit, the
lines of force rebound back in the manner explained in my paper,
and undergo a reconstructive process—*i.e.*, the lines of force
which went up to the end of one pole through the armature
down the other pole now spring out from all points, and endea-
vour by a circuitous route to re-establish circular connection,
and then takes place that *passive* action of shortening which has
so often been mistaken for the *active* process, precisely in the
same manner that the magnetic field around a linear conductor
disappears on breaking the current. The reason why the
(ethereal?) medium does not perform the same function as the
armature is that, being *diamagnetic*, it possesses no coercive
power at all; and instead of gathering the lines of force together,
tends to part them, or make them self-repellent, while *paramag-
netic* substances like iron concentrate lines of force. As a prac-
tical fact it is notable that the size and surface contact of an
armature modify considerably its keeping powers on a permanent
U magnet."

Boston Jour. Chem
4 May 1. 1881

110

ELECTRIC SPARKS.

ELECTRICITY FOR LIGHTING AND EXTINGUISHING LAMPS. — A French journal describes two new and ingenious pieces of electrical apparatus for lighting and extinguishing lamps. In one of them (M. Margret's system) the oil-lamp stands on a base in which is a horizontal electro-magnet. From the armature of this rise two parallel curved rods of copper, joined at the top by a platinum spiral, which is rendered incandescent by a battery current, and brought in that state to the wick, when the armature is attracted. In this movement towards the wick, a small bellows is compressed, giving a puff of air through a tube rebounding on the wick. In the case of lighting the lamp, this puff has no effect, but when the lamp has been burning, and is to be extinguished, the puff produced by a momentary passage of the current blows the flame out, and there is not time for the spiral to relight the lamp. In the other system (that of M. Ranque), a platinum spiral is brought to the wick, much in the same way, but the lamp is put out by an extinguisher at the end of a curved and pivoted wire. The contrivance is such that the extinguisher is brought down to the wick, or raised from it (through attraction of the armature), according as the flame is to be put out or lighted.

AN ELECTRICAL ELEVATOR. — Dr. Siemens, who appears to be indefatigable in seeking to extend the sphere of usefulness of electricity, has brought out an electric elevator, which he has been exhibiting at Mannheim, Germany. Its construction appears to be simple, and suggests an easy method of putting in safety brakes. The cage is carried by wire ropes, having counter-weights, so that the cage, when loaded, is practically in equilibrium. The current generator at the base is electrically connected to the dynamo-machine in the cage, and the latter actuates two toothed wheels, taking into a metal rack running up the centre of the passage-way of the lift.

ELECTRICITY IN SURGERY. — Trouvé's utilization of electricity in combination with surgical instruments is bearing fruit. A case is recorded from Vienna in which a doctor has succeeded in curing a cancer in the stomach, mainly by the assistance rendered by the polyscope. The electric probe, which rings a bell when a ball or any metallic substance imbedded in the muscles is reached, is highly prized by army surgeons, and an application of the same principle to surgical forceps has enabled a Berlin oculist to save the eye of a workman, which was damaged by the intrusion of a spark of steel. This case had become so urgent that it was necessary to extract the piece of metal without delay, or to excise the eye; but Dr. Hirschberg, by inserting a soft iron probe, and subsequently converting it into an electro-magnet, withdrew the particle of metal,

6

adduce consists in a comparison between the prices of two watches manufactured by machinery in America, where, as is generally admitted, its use has been pushed as far as anywhere. They are movements of the same size; the cheaper, approximately adjusted for heat and cold, costs about £12, and the other, more highly finished and adjusted, is quoted at nearly £50, more than four times the price of the first, and yet, to an ordinary observer, such difference as there is would be of comparatively little moment. One may safely assume then that at least half the price of the higher class watch has been on account of skilled labour. Thus we have no present need to complain that any system has proved itself to be superior to that adopted in this country, so far as regards the best work, and what is now principally needed is that the number of competent workmen should be augmented. Machine work need not, then, degrade the manual skill of our artisans, and the fear that it will necessarily cause the English watch to become less artistic than at present is equally unfounded. The fact that a particular machine does not produce artistic work is, of itself, no evidence against machinery being able to do so, and there are abundant specimens on the table to show that graceful forms can be secured by such means. Moreover, in the cheapest watch, what is wanted is soundness and good timekeeping, and, if needful, hand labour might be relied on for modifying the form according to taste in the higher grades. But the rapid growth of the production of foreign countries, as compared with our own, if it means anything, must be taken as evidence that the English system of manufacture is not adapted to the cheaper class of watch. If it were, it would be simply impossible that more than a quarter of a million of foreign-made watches should be annually required to satisfy the demands of the home market.

But how to popularise the use of machinery is a very difficult question. The factory system would certainly not be welcomed in Clerkenwell. And it may well be doubted whether its introduction would be advisable; the English system has so long consisted in a certain degree of isolation of various branches that efforts should rather be directed towards the improvement of this system, and the setting of it on a more satisfactory footing. Let Prescot retain the movement-making, Coventry the case-making, in addition to its own individual trade of watchmaking, Clerkenwell the finishing, escapement-making, &c., but if the trade is to continue a trade, these several branches must work more into each others' hands. It is absurd that one man should systematically be called upon to undo the work of his predecessor, when by proper organisation all such contradiction might easily be avoided. In a watch factory each man, of course, works to a template, and it is surprising that there should be any occasion to advocate its use at the present day, in any of the mechanical arts that involve the production of a number of identical pieces. It is difficult to see why a common standard should not be introduced in the watch trade, and its adoption would constitute a very important step in adapting the English system of manufacture to modern requirements.

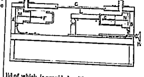
ELECTRO-MASSAGE.

A LARGE portion of electrical treatment that hitherto could only be carried out by specialists by using elaborate apparatus, by the proper use of a new mode of treatment, by employing the apparatus shown in the engraving, can be

intrusted to the hands of those who are not so skilled. By means of this simple machine the manipulator transfers the mechanical motion used in rubbing the patient into an electrical current, and the current as it is generated is transmitted through the part while being rubbed, and it fulfils the requirements of a treatment including rubbing, kneading, pounding, flexing, etc., combined with the application of the electric current. The instrument consists of a metallic roller covered with chamois leather or other suitable material, an electro-magnet, and a permanent magnet set in a strong frame, which holds the instrument together. The roller, besides acting as the driving-wheel of the machine, is so arranged that it also acts as one of the electrodes by which the current is transmitted, and is connected by gearing with the electro-magnet so as to cause the poles of the latter to revolve opposite those of the permanent magnet which forms the handle of the instrument. Each revolution of the roller produces twenty-five revolutions of the electro-magnet, which is magnetised and demagnetised at each revolution, and thus induces a current of electricity which is ample for all purposes for which it is intended. The circuit is completed by connecting any required electrode by the binding-post at the side of the instrument, the roller acting as the other electrode; both are brought into contact with the surface of the body of the patient, and as the roller is moved about over the surface, the current is established and transmitted through the part over which the roller is made to revolve. This machine includes in itself an electric generator, a rubber, kneader, a manipulator, and a set of electrodes, all in one. Any person ordinary intelligence can be taught to use it under the direction of the attending physician. It is portable, being quite capable of being carried in an overcoat pocket. The inventor finds in practice that it has far exceeded his expectations, inasmuch as by its use he gets greater tonic effects than from the employment of both faradism and massage separately. It fulfils most of the requirements of the induction current in general practice and every-day cases. As the current is generated by motion, no acids or liquids of any kind are necessary. The instrument is at all times ready for use, a matter that will be appreciated by all who use electricity. This treatment has been used with great success in cases of nervous exhaustion, debility, neuralgia, rheumatism, paralysis, etc., and we are informed that it is recommended by the medical profession generally. This invention has recently been patented by Dr. John Butler, of New York City.—*Scientific American.*

LIVEING'S INSTRUMENT FOR DETECTING INFLAMMABLE GAS IN MINES.

THE following description of Mr. Liveing's instrument for detecting and measuring inflammable gas in mines is taken from the pamphlet issued by the author, which can be had of Messrs. Clark, Muirhead, and Co., Regency-street, Westminster. The principle on which the instrument is based may be thus described:—A mixture of marsh-gas (fire-damp) and air in which the marsh-gas forms less than five per cent. by volume, is not explosive*, or capable of continuing its own combustion (starting at ordinary temperatures and pressures), simply because the heating-value of the marsh-gas is insufficient to raise the large excess of atmospheric air to the necessary ignition-temperature. If, however, such a mixture is exposed to some sufficiently heated object, especially if that object is platinum, it will burn in its immediate contact and neighbourhood, and in so doing add materially to the temperature of the object, and the more so the larger the percentage of gas present. To apply this principle to the detection and measurement of gas in mines, the arrangement shown in the sectional diagram is employed. A B is a narrow box of wood about 8in. in length, the



lid of which is provided with a narrow glass window, C, and also with two short entrance tubes, D and E. At each end of this box is arranged a fine spiral of platinum wire, F and G; through these a current from a small magneto-electrical machine, contained in the base of the instrument, is made to circulate; both wires being in the same circuit, and offering equal resistances to the current and cooling surfaces, become equally heated on turning the machine. One of these spirals is inclosed in a small tube having a glass end and containing pure air; the other is exposed within a small cylinder of wire gauze (also with a glass end) to whatever gaseous mixture is drawn within the instrument for examination. So long as the air examined is free from combustible gas or matter, the two spirals glow with an equal brilliancy, but if the air contain any amount above 1-400 of its volume of marsh-gas, the exposed spiral increases in brilliancy, and the more so the nearer the percentage approaches the explosive proportion; and this difference of brilliancy becomes a very delicate test of the presence of gas, as well as a means of determining the percentage present.

To measure the difference of brilliancy, a simple form of photometer is provided, consisting of a small wedge-shaped screen, H, the two surfaces of which are illuminated, the one by the covered platinum spiral, and the other by the exposed one. The two surfaces are viewed through the window C in the lid, and when the instrument is employed for measuring purposes the screen is moved towards the covered spiral by the slide-rod, K, until its surfaces appear equally illuminated in the particular gaseous mixture under examination. Within the box, in close proximity to the sliding screen, is placed a scale, L, which gives at once the percentage of gas due to any given position of the screen. This scale is rendered visible by the light from the platinum spirals, which is found sufficient for the purpose. The following table shows the difference of brilliancy due to stated percentages of marsh-gas:—

Percentage of CH_4.	Relative Illuminating Power of Spirals.	
	Covered Spiral.	Exposed Spiral.
Pure Air	1	1·
¼ per cent. marsh-gas	1	1·21
½ ” ”	1	1·65
1 ” ”	1	2·78
2 ” ”	1	5·1
3 ” ”	1	22·0
4 ” ”	1	64·0

This table will give some idea of the delicacy and striking character of the test; for it will be seen that in the presence of two per cent. of gas (the limit detectable with the lamp), the exposed spiral is five times as bright as the covered one, and that before the explosive proportion is reached it becomes sixty to seventy times as brilliant.

In considering the above table it should be borne in mind that the actual results depend much upon the size of the wire, the proportion of the spiral, and other conditions, and can only be determined by actual trial in known mixtures. It is a point worthy of note, that the rate at which the handle is turned within reasonable limits does not sensibly affect the ratio of brilliancy so long as the exposed wire is heated to tolerable redness. Now with regard to the practical use of the instrument. In modern systems of colliery ventilation the main current of air that descends the downcast shaft is soon sub-divided into separate currents or "splits" as they are called; these passing along the principal travelling ways are conveyed to the different districts where the men are working, and after ventilating a certain number of working places and becoming more or less contaminated with the gas that is there evolved from the freshly-exposed surface of the coal, are carried by air-ways known as "returns" to the upcast shaft, often skirting in this part of their course large areas of broken ground (or goaf) where the coal has been more or less perfectly removed.

It is for the examination of the air passing in these different returns that this instrument is particularly valuable, as it at once enables a colliery manager to determine the quantity of gas evolved in the different working districts, and thus to regulate the proportion of his various currents of air, so as to make the best use of the given ventilating power that he has at his disposal, and not have some of his air-ways considerably contaminated with gas whilst others are practically free (a condition by no means unusual). Again, if a regular account of the observed percentages of gas be kept, the quantity of air passing and the barometric pressure being also noted, it will soon become evident within what limits the gas usually varies; and should at any time an abnormal increase be observed, it will be desirable to follow up the return until the source is ascertained and the necessary precautions taken, the effect of the possible presence of coal-dust being always borne in mind.

The instrument thus employed, and the results carefully considered, cannot fail to be of assistance in laying out and regulating the ventilation of collieries. There is, however, another, and perhaps more urgent requirement, which it is hoped this instrument will also meet. In every colliery where gas is liable to be found, the working places and travelling ways leading to them are systematically tested for gas every morning before the men are permitted to go to work; and so also where the hardness of the coal necessitates the use of powder,

* This is not strictly true of some varieties of fire-damp, which appear to possess a greater heating value than ordinary marsh-gas. (See Prof. Abel's report, in which smaller percentages are shown to be explosive).

7

or upwards of 10,000,000 less than the number passed over the wires of this country.

In Germany, with a population of 42,700,000, the number of telegraphic despatches was barely 100,000 more than those of France, or 14,540,000.

The only cases in which the proportionate number of messages is at all larger than in Great Britain are those of Belgium and Switzerland.

In neither of these States does the total number of messages amount to 1 per head of the population, and in Belgium the number forwarded is even closer to the British ratio as compared with population. But both these countries derive an exceptional advantage from the number of foreign telegrams passing through them, and not, as it were, resting within their borders. English messages are not swollen to any appreciable extent from this cause. Switzerland, moreover, has its native business largely increased by the host of locomotive and telegraphing foreigners annually attracted to the playground of Europe. Hence it may be fairly said that England is decidedly ahead of continental Europe in the matter of telegraphic employment.

During the present year arrangements have been made for the erection of over 5,000 miles of new wire, intended to meet the demands upon the system made by the prospect of reviving trade. The cost will not add to capital sunk in telegraphs, but will be all charged to the revenue of the Department.

For two or three years past, owing to the commercial stagnation that has prevailed, the rate at which the use of the telegraph has progressed has been but slight.

As regards railway telegraphs there are at present 14,889 miles of poles, 62,099 miles of wires, 13,128 speaking instruments, 22,411 block instruments, and 11,308 semaphore repeaters. All these being used for working the "block" system.

In the discussion which followed the reading of the paper

Sir Charles Bright, late chief engineer to the British and Irish Magnetic Telegraph Company, said that he considered that the progress that had been made in telegraphy under Government management was highly creditable. As regards Sounders, he pointed out that his Bell system was entirely one of sound, and was exclusively used by the company of which he was engineer. He hoped that at some future date statistics of foreign messages would be forthcoming.

Major Webber pointed out that Mr. Graves' paper was the first of the kind that had been read before the Society; the period chosen was particularly a happy one, inasmuch as it was coincident with the growth of the Society of Telegraph Engineers. He expressed a hope that a 6d. rate for telegrams would shortly be introduced.

Mr. C. E. Spagnoletti, in seconding a vote of thanks, complimented Mr. Graves on the paper he had read, which must have involved a great deal of trouble to get up.

Mr. Robert Gray said that as regards the cheapening of telegrams, the traffic on the Marseilles-Algiers cable, which was formerly transmitted at the rate of 2d. per word, could now be sent for 1d. per word, two cables being used for the purpose. The increase in traffic consequent on the reduced rate had quite paid for the new cable.

The President having made some concluding remarks, the meeting adjourned.

At an extraordinary general meeting of the Society held June 3rd, Mr. W. H. Preece, President, in the

8

The Sun.

TUESDAY, AUGUST 2, 1881.

DISCOVERING THE BULLET.

THE MAGNET PROVING THE CORRECTNESS OF DR. BLISS'S DIAGNOSIS.

Interesting Experiments to Definitely Locate the Bullet in the President's Body—An Electric Apparatus Unerringly Telling the Secret Through a Telephone.

WASHINGTON, Aug. 1.—The magnet has discovered the bullet in the President's body, and the telephone announced that discovery so accurately that Dr. Agnew can, by one quick cut with the lancet, reach the missile. The experiments that resulted in revealing the hiding place of the bullet were made this morning. The President was found to be in good condition for the tests after the morning examination. Prof. Bell and his assistant, Mr. Taintor, were in the consultation room, and when Dr. Agnew told them that they were prepared to begin the search, Prof. Bell made ready his delicate instrument. The coils of wire were charged with the electric current, and the telephonic attachment was applied. Through the mysterious relation that is established between the electro-magnet and metallic substances, as well as the equally mysterious relation that electricity and harmony bear toward each other, it was proposed to fix the spot where lay buried a leaden ball in the flesh of the President. The science of surgery had been unable to locate the ball. The physicians have inclined to the opinion that a black-and-blue spot on the abdomen indicated that the ball lay directly beneath it; but this was only a surmise. It would not be safe, were an operation necessary, to cut into the flesh at this point unless the ball was certainly to be found there. The President was bolstered up in bed, and watched every movement that was made. His eyes were constantly on the instrument. He looked curiously at it. When Mr. Bell took his place a few feet from the bedside and put the telephone to his ear, the President was intently watching him.

That the experiment might be complete, Mr. Bell turned his back to the President, and his assistant began slowly to move the electric apparatus over the abdomen. The theory was that the metal bullet would interrupt the regular humming which the electric apparatus carried through the wire to the telephone. Slowly Mr. Taintor moved the plate about, but without actually touching the skin. At length he approached the black and blue spot. Prof. Bell said nothing. The physicians stood around, watching with the interest which the case itself and which scientific experiment awakened. The President's eyes remained fixed on the telephone that was held to Prof. Bell's ear. The electric plate is at last right over the central portion of the black and blue spot. Prof. Bell hears the telephonic harmony, so to speak, change. "Stop," he says. "There it is!" and he turns to see. The plate is precisely over the spot beneath which Dr. Bliss has said for four weeks the ball was hidden. Dr. Bliss catches the President's inquiring look. "It's where I told you it was, General," he says in response to the patient's mute inquiry.

But they do not propose to fix it with one experiment. Prof. Bell and Mr. Taintor exchange places. Mr. Taintor, with his back to the bed, holding the telephone to his ear, waits while Prof. Bell passes the plate over the abdomen. The telephone hums away until suddenly there is an interruption. Something has stopped the regularity of the humming. It is the influence of the bullet on the magnet. "There it is," Mr. Taintor says, and the plate is found to be precisely where it was when Prof. Bell said "Stop." The experiment is tried again, and with the same results, and at length Mrs. Garfield puts the telephone to her ear, and when she too has heard the signal which the bullet is forced by the power of nature to give, she tells the President that she, too, detects the bullet. No longer does any doubt remain in the minds of the physicians. The bullet is clearly there, buried firmly in the flesh, just above the groin and about three inches to the right of the median line of the body. Only one fact regarding it remains in doubt. It is not less than two nor more than five inches from the surface, but precisely how many inches is the only secret that the bullet keeps. It is where it can do no great harm, in all probability, and where, if danger does threaten, Dr. Agnew's lancet, guided by his unerring fingers, can by two quick cuts make a path for its removal. Dr. Bliss's diagnosis, then, was correct. The physicians did not try to conceal their happiness over the result. The possibility of the coming of a time when the bullet must be reached by the knife has caused anxiety, because, until to-day, they did not know exactly where they would have to apply the knife. The path is cleared for a safe operation if it should be necessary. In the locating of the ball in the body of the President a valuable and remarkable contribution has been made to the history of gunshot wounds.

The President was but little fatigued by the experiments, and he has had a comfortable day. The expected Monday fever did not come on. Prof. Bell was not so wholly occupied with the experiments as not to notice how very weak the President was, and that when he said to Mr. Bell, "I feel a wire touching me," he said it in so weak a voice that it was barely more than a whisper.

The induction balance used by Profs. Bell and Taintor this morning, in its present improved form, consists of two flat coils, about four inches in diameter and one-half an inch in thickness of insulated copper wire; a battery, a condenser, an interrupter or circuit breaker, and a telephone. The ends of the primary or inducing coil are connected with the poles of the battery, and in the same circuit are a condenser and a small interrupter, whose vibrating tongue opens and closes the circuit with great rapidity. The ends of the secondary coil in which the current is to be induced are carried to the binding posts of a Bell telephone. When the connections have all thus been made, the secondary coil is laid on the primary or inducing coil, so that their respective circumferences exactly coincide. The circuit breaker is then set in motion, and the rapidly interrupted current through the primary coil induces another current of higher intensity in the secondary coil, and as it does so a loud musical tone is heard in the telephone, with which the secondary coil is connected. As long as the current is maintained and the circumferences of the two coils are kept in exact coincidence, the musical note in the telephone does not change its pitch or intensity. If, however, the experimenter slides the upper coil along an inch or so upon the lower, so that their circumferences no longer correspond, the intensity of the musical tone is diminished, and just in proportion as the centres of the flat coils are separated by a greater or less distance, the intensity of the musical tone is lessened or increased. When the upper coil has been slidden over the lower so that they simply overlap—the centre of one corresponding nearly with a point on the circumference of the other—the musical tone in the telephone ceases. If the upper coil be pushed a little farther to one side, so that it overlaps still less, the tone is again heard. By delicate manipulation it is possible to adjust the centres of the overlapping coils at such a distance one from the other that a perfect balance is brought about, and when this is the case the telephone makes no sound whatever. The centres of the overlapping coils cannot then be moved either toward or away from one another without causing the telephone to break its silence. When the coils are thus balanced and the telephone is mute it is found that what may be called the area of coincidence, or, in other words, the area of the overlapping parts of the two flat coils, has become highly sensitive to the approach of metal, and manifests its sensitiveness by a low note in the telephone. As long as metal is kept away from this area the telephone remains silent, but if a piece of lead, for example, is brought within a distance of four or five inches from the overlapping parts of the coils, there may be heard in the telephone a faint but clearly perceptible note, which becomes louder and louder as the metal approaches the sensitive surface and throws the coils more and more out of balance. It will readily be seen that under the guidance of the telephone the small area bounded by the intersecting circumferences of the overlapping coils can be placed exactly above a bullet or other piece of metal embedded in the body, provided the metal does not lie at too great a depth. As soon as the balanced coils begin to feel the disturbance caused by their approach to the embedded bullet, the telephone announces the fact by a faint continuous musical note, and this note grows louder and louder until the overlapping parts of the coils are directly above the disturbing metal, when the sound reaches its maximum. For convenience of application to the body, the coils used by Prof. Bell this morning were mounted in a rectangular piece of walnut, about seven inches in length by four in breadth, with screw posts at the corners for the wires and a handle at the back by which it could be held. The following is Prof. Bell's report to the surgeons on to-day's experiments:

VOLTA LABORATORY, 1,221 Connecticut avenue,
WASHINGTON, Aug. 1, 1881.

To the Surgeons in attendance upon President Garfield:

GENTLEMEN: I beg to submit for your information a brief statement of the results obtained with the new form of induction balance in the experiments made this morning for the purpose of locating the bullet in the person of the President. The instrument was tested for sensitiveness several times during the course of the experiments, and it was found to respond well to the presentation of a flattened bullet at a distance of about four inches from the coils. When the exploring coils were passed over that part of the abdomen where a sonorous spot was observed in the experiments made on July 26, a feeble tone was perceived, but the effect was audible a considerable distance around this spot. The sounds were too feeble to be entirely satisfactory, as I had reason to expect from the extreme sensitiveness of the instrument a much more marked effect. In order to ascertain whether similar sounds might not be obtained in other localities, I explored the whole right side and back below the point of entrance of the bullet, but no part gave indications of the presence of metal except an area of about two inches in diameter, containing within it the spot previously found to be sonorous. The experiments were repeated by Mr. Taintor, who obtained exactly corresponding results. We are, therefore, justified in concluding that the ball is located within the above-named area. In our preliminary experiments we found that a bullet like the one in question, when in its normal shape, produced no audible effect beyond a distance of two and a half inches; while the same bullet flattened and presented with its face parallel to the plane of the coils gave indications up to a distance of nearly five inches. The same flattened bullet, held with its face perpendicular to the plane of the coils, produced no sound beyond the distance of one inch. These facts show that in ignorance of the actual shape and mode of presentation of the bullet to the exploring instrument, the depth at which the bullet lies beneath the surface cannot be determined from our experiments. I am, gentlemen, yours truly,

ALEXANDER GRAHAM BELL.

Tribune Aug. 2. 1881.
(See Induction #12.)

Electricity was put to an entirely new purpose yesterday in determining the position of the bullet in President Garfield's body. The instrument called an induction balance, invented by Professors Bell and Taintor, seems to have done its work admirably in the first experiment. The ball is where the surgeons believed it to be, and further experiments will, it is thought, show to a fraction of an inch how far beneath the skin it lies. Its position is such that the wound can heal without danger of internal abscesses. When the patient gains strength there will probably be little trouble in extracting the ball by an incision in the wall of the abdomen. Meanwhile, we have still reason for thankfulness in the fact that the progress of the President toward recovery, though slow, is steady.

Sun. Aug. 8. 1881.

THE LOCATION OF THE BULLET.

Dr. Agnew Says that the Probe, not the Electric Balance, Gave the Information.

PHILADELPHIA, Aug. 7.—Dr. Agnew has given to the *Times* a statement regarding the location of the ball in the President's body. An examination with the probe has resulted in showing that the wound is of a far less serious nature than was for a long time supposed. It has been definitely ascertained that the cavities of the chest and abdomen were not entered, and necessarily the peritoneal membrane was not pierced, nor was the liver torn. The opening of the wound is between the tenth and eleventh ribs, four inches to the right of the spinal column, and the ball took a course almost directly downward. The bullet striking and splintering the eleventh rib, lost considerable force, and, being deflected, passed through the tissue of the muscles which form the soft wall of the abdominal region, and stopped just at the crest of the ilium or broad flaring bone which forms the hip. The precise location is in either the quadratus or the psoas muscle, but which cannot yet be told, as Dr. Agnew did not succeed in touching the ball, although he introduced a probe fully seven inches into the wound. The difference, however, can be but slight, as the muscles are in close contact with each other, and, no matter which it is imbedded in, the bullet cannot be far from the surface of the body.

In speaking of the process by which this definite knowledge of the nature of the wound was obtained, Dr. Agnew said that the electric balance was not of the slightest service. The information was obtained by the ordinary method of probing. It was quite trustworthy, he said—above all, as to the point that none of the great cavities had been entered. The dullness under percussion which had been regarded as a symptom of injury to the liver, and resulting in hemorrhage, he explains on the theory that that organ was slightly bruised by the ball in its passage. He is quite sure that it was not lacerated in the least, and its capsule is now intact. The bruise was of no importance, and would naturally pass off in a few days. Dr. Agnew entirely approves the action of the attending surgeons in refraining from any endeavor to find the ball just after the shooting. He thinks it likely that any such search, whether with the probe or with cutting instruments, especially in the great uncertainty as to the direction taken by the ball, would have had a fatal result. Even now there is little or no expectation of extracting the ball, although there is little or no doubt of the President's ultimate recovery. Dr. Agnew is dissatisfied with his appearance, and his weak digestive powers cause fear that his convalescence will be prolonged. The position of the bullet, however, is such that no permanent inconvenience is anticipated from its staying where it is.

Some thirty years ago the remedial uses of Electricity were almost ignored by the regular Medical Profession, because unfortunately electricity was mostly in the hands of uneducated parties, who applied electric shocks in utter ignorance of the effects they were going to produce. They acted somewhat after the fashion of a surgeon, who in place of performing an operation, with full knowledge of the anatomy of the parts to be operated upon, in his ignorance plunges the knife into the body without knowing what he is going to hit. Fortunately electricity is seldom so dangerous as the knife, otherwise many fatal results would have attended its first application by the ignorant.

We had the satisfaction to furnish twenty five years ago, some of our most eminent physicians, with improved machines, for the production of temporary strong currents; among them we can name the late Dr. Valentine Mott, and Dr. W.H. Van Buren. We called attention to the fact that among other uses such applications are very beneficial in cases of parylysis, to keep up daily involuntary muscular contraction, and so prevent the atrophy of the muscles, which is the unavoidable consequence of not using them. When the cause of the paralysis is finally removed electricity has kept the muscles in good contractile condition and they are found ready for their regular functions,

Great expectations were fostered about the efficiency of Electric baths in extracting injurious substances, such as metallic poisons from the system. Theoretically it must be conceded that those expectations appear well founded, but unfortunately it must be conceded also that the expectations have rarely been realized; probably however simply by the ignorance of most of those applying them.

We say this with emphasis as in several instances, where we visited such institutions, we found the connections the inverse way, they should have been, and the electric current in place of carrying obnoxious bases out of the body and depositing them upon the copper with which the bath tub was lined, or upon the copper electrode plunged in the water, the copper was by reason of improper connections carried toward the body of the patient.

We mention this as a warning to all who use electric baths, that they should be particular not to take them except from parties well ve[rsed in] electrical science.

9

Sun. Sept. 11. 1881.

ELECTRIC AID FOR GOLD SEEKERS.

Edison on the Chances of Finding Kyd's Treasure with an Induction Balance.

A reporter of THE SUN yesterday showed to Mr. Edison the following item:

The value of electrical inventions has received a fresh illustration in the case of the schooner Vermilion, which was wrecked in Lake Erie in 1843. The vessel was loaded with copper ingots of the value of $60,000, but her precise location far down in deep water was for thirty-four years a mystery. It remained for electricity to solve the mystery. With a newly invented electric indicator on board a cruising schooner, evidences of the proximity of submerged metal were at last obtained, and divers have begun the recovery of the valuable cargo.

"I rather think that is a made-up item," said Mr. Edison. "Some fellow has read about the induction balance used in the President's case and has gotten up the item."

"Could the induction balance be made use of for such a purpose?"

"Oh, it is quite possible. When brought near to such a mass of metal as a cargo of copper, it would indicate its presence."

"Even if it were stowed away in the hold and the timbers of the hull separated it from the induction balance?"

"Yes, I think it would."

"Then the induction balance would be a handy thing for seekers after Capt. Kyd's buried treasures to take along, so as to let them know whether they are nearing it or not?"

"Well," said Mr. Edison, laughing, "the trouble is that the induction balance simply indicates the proximity of a good electrical conductor, such as metal. Therefore, in poling around after a submerged vessel or buried object with an induction balance you would only get indications that metal was about. A good deal of metal is used in the construction of vessels, and so you would not really be certain of anything more than that there was something metallic down there. That is the reason why I think the item is an invention. If they knew the locality where the vessel was sunk they would not need to use an induction balance in searching for her exact position. A few days ago I was out at Port Huron, Mich. A vessel had sunk some seven or eight miles from there, and it could be seen plainly enough, although it was forty feet below the surface."

"Can the electric light be made use of for submarine exploration?"

"Oh, yes. I have an electric lamp made for submarine work on exhibition at Paris. The water can be lighted up as well as the air. I could lay a cable from here to Sandy Hook, with lamps about fifty feet apart and light up the whole channel."

"Would it be lighted up so that a pilot could see all the rocks and shoals?"

"Yes. He could pick his way along just as you can along the street.

Mining & Scientific Press.
July 29. 1881.

AN ELECTRICAL BLOWPIPE.—The electrical blowpipe of M. Jamin, consists of a pair of carbon pencils—an electric candle, in fact—surrounded by a coil of insulated copper wire wound a few inches distant from the pencils in the plane of their axes. The current is so led that, in circulating round the coil, it will attract the electric arc formed at the lower end of the carbon pencils, and cause it to flash out almost in the form of a fish-tail gas flame. This spreading out of the arc is the special feature of the action of the apparatus. It facilitates the application of the heat of the electric arc to the fusion of refractory substances, and enables us better to take advantage of this little-used means of producing a very high temperature.

10

40

SEPTEMBER 24, 1881.] Scientific American.

ELECTRIC FLYING MACHINE.

The improvements recently made in electric motors have suggested to the eminent French electrician, M. Gaston Tissandier, the idea of employing these machines to propel air balloons. They can be used in connection with M. Planté's secondary couples, which store a large amount of electric energy and weigh relatively little. Such a motor possesses great advantages. There is no danger of firing the volume of hydrogen above, and it has a constant weight, there being no decrease by combustion.

In making his experiments M. Tissandier employed a small oblong balloon ending in conical points. This balloon, which is like that used by M. Giffard, is 3 m. long by 1·30 m. in diameter, and has a volume of about 2 200 liters. Inflated with pure hydrogen it has an ascensional force of 2 kilogrammes.

It is worked by a small electric motor resembling the Siemens dynamo, and weighing 220 grammes. This works a light propeller 40 inches in diameter. This motor is suspended below the balloon, and will propel the balloon for several miles with a Planté element of 220 grammes, while with a secondary couple weighing 1·300 kilogrammes the duration of its rotation is considerably increased. Under these conditions the armature turns 6·5 times a second, and acts as a propeller, giving the balloon a speed of 1 m. a second during more than 40 minutes. With two secondary elements, a propeller 60 inches in diameter can be used, which will propel the balloon at the rate of 2 m. a second during 10 minutes; and with three elements a speed of 3 m. can be obtained.

These experiments took place in the "Conservatoire des Arts et Metiers," at Paris, in a large hall, where the balloon could move freely, restrained only by a light rope dragging behind it, which served at the same time to guide and to measure its speed.

The working power of the electric motor was measured by the simple method of lifting weights. A secondary element, and afterwards two elements together, were attached to the motor, and it was found that the swiftness of the revolutions varied according to the weight lifted.

This little motor, when developing a maximum of energy with a single element, produced a force of 90 grammes at a speed of 5 revolutions a second. With two elements a speed of 12 revolutions a second was obtained and a power of 420 grammes. With three elements the power was 1 kilogramme.

In working with two elements, if the speed is reduced to 5 or 6 revolutions a second, the power is also reduced, and, on the other hand, if the speed becomes greater than that which corresponds to the maximum power, the working force is correspondingly reduced. For example, if the speed obtained is 14 or 15 revolutions a second, the power is only 375 grammes. The manner this trial balloon acted, and the speed obtained with the propeller, afford a very satisfactory outlook for aerial navigation, as it must be remembered that in balloons the surface does not increase with the volume, consequently the results obtained with larger balloons would be still more favorable.

In working condition an electric motor equal to 6 horse power and weighing 3 0 kilogrammes, with 900 kilogrammes of secondary elements, would easily carry 1,200 kilogrammes when attached to in a hydrogen balloon of 3,000 cubic meters, elongated in shape like those used in 1852 by M. Giffard, and in 1872 by M. Dupuy de Lôme. This balloon would be 40 m. long by 13·50 m. wide across the center, and its ascensional force would be about 3 300 kilogrammes. It would weigh, with all its accessories, 1,200 kilogrammes; so there would remain for the voyagers and for ballast over 1,000 kilogrammes. In calm weather this balloon, worked by an armature of 5 to 6 m. in diameter, would obtain a speed of 20 kilogrammes an hour, and in windy weather would be powerful enough to move out of the direct line of the air current.*

Of course, this balloon could only go for a limited time, but that could easily be decided by experiments, in which results even more favorable might be obtained by making the motor and piles especially light for this purpose.

Until now no balloon has ever been really steered, that is, has never returned to its point of departure after having navigated the atmosphere at the will of its pilot. Necessarily such voyages can only take place in calm air and during a short time; but the essential point is that they have succeeded at all; and no physicist can deny that the electric motor and the secondary piles have solved the problem of aerial navigation.

* Of course the idea of guiding balloons against strong winds belongs to Utopia; but for short voyages, such as escaping from a city during a siege, it would be very valuable to be able to steer the balloon.

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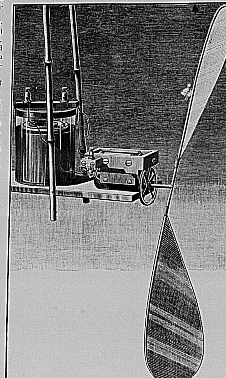
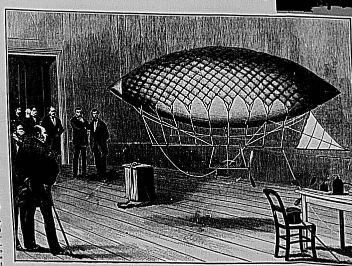


PROPELLER OF ELECTRIC FLYING MACHINE.



ELECTRIC FLYING MACHINE.

Southern New Jersey Sinking.

Professor George H. Cook, State Geologist of New Jersey, concludes that the land in Cape May and Cumberland counties is gradually but certainly sinking. From knowledge now in his possession he estimates that the surface has settled about eight feet during the last hundred years. During a recent visit he declared it his intention to test the matter by placing stone posts in the ground at certain localities, a record of which should be kept so as to insure their being

Mining & Sci. Press Aug 28 1880

33

AN INTENSIFIED ELECTRO-MAGNET.—Dr. Stone recently exhibited before the Physical Society a very interesting electro-magnet of novel construction, and based upon a principle which will probably be applied with advantage in the construction of electro-magnets for dynamo-electric machines and telegraphic apparatus. It is known that electro-magnets enclosed in jackets of soft iron are far more powerful than when the copper coil of wire is unenclosed. The iron jacket has the effect of exalting the magnetic power of the poles. Dr. Stone does not employ a soft iron jacket, but instead of using copper wire to wind the bobbins, he uses best charcoal annealed iron wire about one-fifth of an inch in diameter. Four wires are wound on in parallel circuits, and the current is split up among them in "multiple arc." They are insulated from each other by paraffine wax. By this felicitous arrangement the lifting power of Dr. Stone's large magnet is, with a battery of four or five Bunsen cells, increased fourfold.—*Engineering.*

English Mechanic & World of Science. Aug. 12th 1881.

A patent has lately been taken out in France, by M. Tissandier, for a balloon of elongated shape to be propelled by means of an electric motor and screw. He notices the advantages of the electric motor over a steam-engine for balloon purposes. 1. It has a constant weight, and does not disturb the conditions of equilibrium, whereas a steam-engine is always losing weight, and gas must be let off to compensate. 2. The electric motor works without fire, and so is safer (in presence of the combustible gas). True, there is a spark, but it is localised, and cannot be compared to a fireplace giving out sparks; besides it may be inclosed with metallic sheets. 3. The electric motor has great simplicity, and is easily managed. The balloon (of which M. Tissandier is having a small model made by M. Trouvé) will be worked by a very light dynamo or magneto-machine, the metallic pieces of which will be hollow. The force will be supplied by an electric accumulator made as light as possible (an ebonite or parchment-receiver containing very thin sheets of lead). Under these conditions a considerable force will be at disposal, during a time pretty short indeed, yet of sufficient length to allow of a demonstrative experiment in calm air. Should the model prove a success it will be shown at the exhibition.

Daily Graphic, Oct. 14, 1881.

11 5

AERIAL NAVIGATION.

Mr. F. W. Brearey, a member of the Aeronautical Society, read an interesting paper this week in the Birkbeck Institution, Southampton buildings, on aerial navigation, explaining, with the aid of models, the principles upon which attempts had hitherto and should in the future be made to effect artificial flight. The conclusion at which the Aeronautical Society had arrived was that flight was merely a mechanical action capable of imitation, that it was unassisted by air cells or other contrivances for effecting levity, that the balloon was incapable of being rendered useful to man as a means of locomotion except in the way of waftage, and that this mode of progression in relation to the earth was capable of being materially assisted by some method of raising or lowering the balloon at pleasure without loss of gas or ballast. After pointing out some of the conditions under which a fish moved in the water and a bird in the air, he said he was quite prepared for the discovery of some peculiar conditions attaching to the agitation of this thin medium of which we had no conception. The tenants of the air, great as was the variety in their size and form, resembled one another in possessing three important capacities, the association and proper adjustment of which constituted the property and power of flight, viz., weight, surface and force. The weight of a body was due to the action of gravity, and the problem was how so to retard or regulate the action of gravity as to cause its influence to be infinitesimally distributed. Having explained what he wished to show by projecting some peculiarly-folded pieces of paper across the theatre, he then let fall from a height a bat-shaped model, which soon, taking a curve, shot out in a nearly horizontal direction for a time. Had force, the third great principle of flight, been employed, it would have neutralized the action of gravity so long as it continued, and the flights of the models would have been prolonged. In endeavoring to estimate the proportion of plane surface to weight, so that the one might carry the other by the application of impulsive force, we were not without significant data. So varied were the forms of flight and so widely different the conditions—in some cases a heavy weight being supported by small planes or wings and in others little weights by extensive surfaces—that if ever the subject should be mastered, flight would probably be effected in more ways than one. Great weight and small surface, as the observations of M. de Lucy showed, must be accompanied by great velocity, as in the flight of the common sparrow, while with small weight and great surface, as in the butterfly tribe, a reduced velocity only was requisite. If, therefore, man could construct the necessary surface of strength sufficient to insure safety, he could certainly add, by the aid of engine-power, sufficient velocity to obtain support upon the atmosphere. Showing this by the flight of models with wing surfaces of different forms, which were propelled by the torsion of indiarubber bands, he then gave an account of experiments which had been made within the last thirty years. It was to be regretted that many were working in secret, and thus the causes of failure were not generally known. One reason for this secrecy was the fear of ridicule; another, the state of the patent laws. He had himself turned his attention to the parachute, because it was known that a surface of thirty square yards would bring a man safely to ground, and his efforts had been directed to providing a means of propulsion. He was not without hope, especially since he had held a conversation with Dr. Siemens at York, that in electricity would be found the means of supplying a force which would make it possible to transport a weight of, say, 300 pounds in the air.—*London Times.*

Scientific American Oct. 15th 1881.

Electricity and Ballooning.

Soon after the announcement of Faure's new accumulator of electricity the idea was thrown out by Mr. Martin Tupper in this country that storage batteries could be employed with advantage in propelling balloons. Power and not levitation was, in Mr. Tupper's opinion, the true key to the attainment of aerial travel. French aeronauts have also given their attention to the subject, and at the recent meeting of the French Academy of Sciences M. Gaston Tissandier made a communication on it. The true solution of the problem, if it be feasible at all, appears to us to lie not in the exclusive use of levitation or electric power, but in a proper combination of both principles. This plan is that which M. Tissandier contemplates, and he points out that a propeller driven by electricity possesses advantages over other methods of movement. For example, it requires no fire, which is a dangerous element in a balloon inflated with hydrogen gas; it has a constant weight and gives off no products of combustion, and is readily manipulated.

M. Tissandier prepared a small balloon, pointed at the ends, 11 feet long by about 4½ feet in diameter. Its volume was 484 gallons, and when filled with pure hydrogen gas it had an ascending force of about 4½ pounds. A Trouvé motor of the Siemens type weighing nearly 8 ounces was fixed to the lower part of the balloon and connected to a double-bladed screw of 18 inches diameter. With the aid of a Planté secondary battery weighing nearly 3 pounds, the screw was driven at the rate of 6½ turns per second, and propelled the balloon through the air at a speed of over 8 feet per second during a space of 40 minutes. With two secondary elements weighing 11¼ pounds, and a screw of 21 inches diameter, a speed of 6½ feet per second was maintained during 10 minutes. With three elements the speed was about 10 feet per second. M. Tissandier also measured the work done by the little dynamo-electric motor, and found it to be about 314 foot pounds with a single element and a speed of 5 turns per second; and with three elements it is about 7 foot pounds. He estimates that a dynamo-electric motor of 5 cwt. with 17 cwt. of secondary batteries will yield 6 horse power of work. This weight could be raised by a hydrogen charged balloon of 3,900 cubic yards volume, and similar to that employed in 1852 by M. Giffard, and in 1872 by M. Dupuy de Lôme. It would be 131 feet long by 43 feet in diameter at the middle, and its ascending force would be about 3½ tons. With all its appurtenances it would weigh from 19 cwt. to 22 cwt., and there would remain from 1 ton to 2 tons for ballast and voyagers. In calm weather it would have a speed of from 12 to 15 miles per hour, and it would be able to deviate from the line of a wind.

It is true that this result could only be obtained during a limited time, but the conditions would be greatly improved by lighter batteries and possibly by the use of M. Faure's accumulators. While upon this subject we may also mention that M. Trouvé has tried his electrically propelled boat on the upper lake of the Bois de Boulogne with a Trouvé motor and a four-bladed screw about a foot in diameter. Twelve Bunsen cells of Ruhmkorff's pattern propelled the boat, containing three persons, at a speed of 10 feet per second, but this rate fell off at the end of three hours to about 9 feet per second, and at the end of five hours to 8 feet per second.—*Engineering.*

14

15

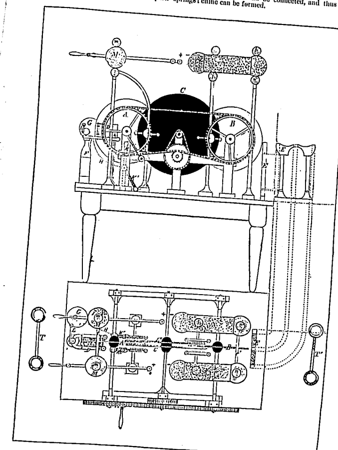
NEW DIELECTRIC MACHINE.

Sept 11 1880 — Sc. Am. Sup. No. 245 — 40

By the ABBE LE DANTEC.

MR. LE DANTEC has invented a dielectric machine which
unites the chief principles of all electric machines hitherto
invented, and is a great improvement upon the latest one,
constructed by Mr. Carré, two of this latter kind being in-
geniously connected in one of Mr. Le Dantec's. The con-
struction of it is as follows:
(1) A plate of gum lac, B, which is rubbed by the hands,
reminds us of the first electric machines invented by Otto
von Guerike and Hawksbee. A rest, E, isolated by two
glass posts, serves as a support for the hands, and if the
person who rubs the gum-lac plate stands upon a glass stool
he is positively electrified.
(2) A glass plate, A, with its rubber, D, and its iron
comb, shaped like a horseshoe, as indicated in our illustra-
tion by K, reminds us of Ramsden's machine. This comb,
K, which is movable around a horizontal axis, can be placed
in the position, K', when it is necessary to set in motion the
whole of the machine. It is connected by means of the
small chain, H, with an isolated copper ball, which serves
as a conductor.
(3) The rubber, D, of the glass plate is carried by a horse-
shoe and isolated by three glass posts in such a manner that
both kinds of electricity can be collected as in the machine
of Nairne. One of the supports, F, of the rubber of the
glass plate is a Leyden jar, which serves for the condensing
of both kinds of electricity, as soon as its outer coating is
connected with the ball, G. The electric spark springs

Dantec: Why should not this part of the plate serve to
transport positive electricity, as the lower part of it serves
to transport negative electricity? This thought led him to
make the following improvements: First, he employed two
caoutchouc plates, C and C', and, secondly, he introduced
between these two plates a plate of gum lac, B, which after
it is electrified by rubbing with the hands, produces on its
part the same effect as the glass plate does on its. The up-
per half, viz., of the two caoutchouc plates, is utilized for
transporting the positive electricity, the action of which is
thus added to that of the glass plate in influencing the
combs of the condensors, M and M', while at the same time
the lower part transports negative electricity, which assists
the gum-lac plate in extracting positive electricity from the
combs of the conductors, N and N'.
When, after having mounted all of the above mentioned
parts (each of which is a separate electrical machine), the
gum-lac plate is added, then the length of the electrical
spark is doubled. We have now in reality two complete
new machines in juxtaposition:
1. An anterior machine composed of the plates, C, and
the conductors, M and N, which utilizes the electricities on
the front sides of the glass and gum-lac plates.
2. A posterior machine composed of the plate, C', and the
conductors, M' and N', which utilizes the electricities on
the other sides of the glass and gum-lac plates. By means
of the brass beams, T and T', the first of which is fastened
to the knobs, m and m', the other to the knobs, n and n', the
two machines can be connected, and thus one grand ma-
chine can be formed.



NEW DIELECTRIC MACHINE.

over between the ball, G, and the bar, L, and this latter is
connected with the outer coating of the Leyden jar, F, when
the isolations of the rubber are no longer needed.
(4) When the glass plate has been several times revolved
by means of a crank, the motion may be arrested, and the
glass plate is then electrified between the two caoutchouc
plates, C C'. In turning these latter plates, the united effect
of two of Bertsch's machines is produced.
Thus, as above mentioned, we find united in this new ap-
paratus the principles of all the chief electric machines
hitherto invented, and Mr. Le Dantec's machine is so con-
structed that these principles may either be used separately
or in connection.
(5) When the glass plate and the caoutchouc plates are
turned at the same time, the effect is that of two of Carré's
machines.
(6) The following are the advantages of Le Dantec's ma-
chine in comparison with Carre's machine. The latter had
two weak points. First, if A represents the glass plate, C
the gum-lac plate, and M and N the conductors of the Carre
machine, then the electricity upon that side of the plate, A,
which is opposite to the caoutchouc plate, C, acts only with
difficulty upon the comb of the conductor, M, from which
it is separated by the thickness of the glass plate, A, and the
caoutchouc plate, C, together. Secondly, the negative elec-
tricity, streaming from the conductor, M, upon the plate, C,
is neutralized by the comb of the conductor, N, in
such a manner that the upper half of the plate, C,
is in a neutral state. Now, the question occurred to Mr. Le

All these details seem more complicated in appearance
than in reality, and permit a great number of interesting com-
binations, which are highly instructive for the study of the
different effects produced by static electricity.

EXPLANATION OF THE FIGURES OF THE ILLUSTRATION.

A, glass plate; B, gum-lac plate; C C', caoutchouc plates;
D, rubber of the glass plate, carried by a horseshoe, which is
isolated by means of three glass supports, one of which is a
Leyden jar. E, rest for the hands, isolated by two glass
supports. F, Leyden jar, the inner coating of which is con-
nected with the rubber, D. G, isolated metal ball, serving
as a conductor for the positive electricity streaming out of
the rakes, K and K', and connected with them by the
little chain, H. K K', rakes, which can either be brought
into a position opposite to the glass plate, as indicated by K,
or inclined downward, as shown by K'. L, movable lever,
which serves for the purpose of bringing the negative elec-
tricity of the rubber, D, in communication with the positive
electricity of the conductor, G. M and N, anterior machine;
M' N', posterior machine; t t', glass beams, which hold the
system of machines together, at the same time permitting a
perfect isolation of the single parts; T T', cross beams of
brass, by which the anterior and the posterior machine can
be united, and the one of which is fastened to the knobs, m
and m', while the other is joined to the knobs, n and n'.

17

copper deposited and depositing the zinc dissolved.

If magneto-electric machines are used for producing the electricity necessary to renew the battery, the renewal is done at the expense of motive power. Economically produced by the aid of powerful machines, the electricity becomes stored up in the liquids, regenerated to the state of energy which is disposable and portable. This indirect transport of electricity generated by machines would be, in most cases, more practicable and more advantageous than the direct transmission by cables.

Actually the renewed liquids are not employed, the new battery offering as it does a notable economy of material and labour over the nitric acid couples. As to the industrial realisation of the process of regeneration, which should render my battery economically applicable to small electric motors and to domestic lighting, it is yet hindered by certain difficulties foreign to the art, which will, I trust, be overcome eventually.—*La Lumière Electrique.*

ELECTRIC MINE EXPLODERS.

SIEMENS' APPARATUS.

The magneto-electric exploder.

This apparatus (fig. 1) consists of a number of powerful *permanent* magnets, between the poles of which there is an ordinary Siemens' armature. When the armature rotates, its magnetism is reversed, and the alternating positive and negative currents generated are reduced to a common direction by means of a commutator, similar to that shown at *c* in fig. 3. One complete revolution of the handle causes the armature to revolve thirteen times, and at each turn of the armature two currents of opposite direction are induced in the wire coil, or a total of twenty-six currents for each revolution of the handle. The apparatus, which consists of an armature (as above described) and six permanent magnets, has been specially designed for blasting operations, in which only a small number of shots are to be exploded. It fires twelve Abel's fuses in single circuit simultaneously and with certainty. The working parts of the exploder are inclosed in a teak-wood case, fitted with straps and two terminals for the leading wires. The terminals are short-circuited by a firing-key, which must be depressed before the current can pass into the line. The handle can be taken off and placed in the side of the case. The outer dimensions are 10" × 7" × 7", the total weight only 22 lbs. The length of spark which this exploder will give is $\frac{13}{3000}$ of an inch. A general view of the apparatus inclosed in its case and connected to fuses placed in the charges in a mass of rock is shown by fig. 2.

A larger form of apparatus, with nine permanent magnets, is of the same construction as the smaller one, but the electro-motive force is higher, the spark being about $\frac{18}{3000}$ of an inch in length. This apparatus fires simultaneously about seventeen Abel's fuses in single circuit. Dimensions, 10" × 8½" × 7". Total weight 29 lbs.

The dynamo-electric mine exploder.

This instrument consists of an electro-magnet and an ordinary Siemens' armature, which, by the turning of a handle, is caused to revolve between the poles of the *electro*-magnet. The coils of the latter are in circuit with the wire of the revolving armature, and during rotation the residual magnetism of the soft iron electro-magnet cores at first excites weak currents, which pass into the coils, increasing the magnetism of the core, thus inducing still stronger currents in the armature-wire. This accumulation by mutual action goes on until the limit of magnetic saturation of the iron cores is reached.

By the automatic action of the machine the powerful current so produced is sent into the leading wire to the fuse. The fuse being practically either an interruption of the circuit, or a great increase in its resistance by the interposition of a badly-conducting substance, the consequent action is that either an electric spark passes between the interrupted portions of the conductor or the piece of bad conductor is highly heated, causing ignition of the explosive substance contained in the fuse. Fig. 3 is a diagram of connections of the apparatus.

A is the revolving armature, on the axle of which is a pinion, driven by a wheel which is turned by the handle at the end of the machine. The axle of the driving wheel is geared into the cam wheel, S, so that the latter makes two revolutions for every revolution of the former. F F are the pole pieces of the electro-magnets. *c* is the commutator, by means of which the currents of alternate direction generated in the armature are caused to flow only in one direction through the coils, E E, of the electro-magnets. After every revolution of S, a tooth of the lever, D, falls into a notch cut in S, and causes the end of the lever to be forced by the spring beneath it into contact with the screw, *d*, thus breaking the short circuit hitherto existing in the instrument, and causing the current to pass to line by the terminals, *e e*, to which the line-wire is connected, and through the fuses, *f f f*.

These dynamo-machines are constructed of two kinds, viz.:—

(1) The dynamo-electric *tension*-exploder, and
(2) The dynamo-electric *quantity*-exploder.

The large tension-exploder, which is the machine just described, has its coils, both of the armature and the electro-magnets, wound with fine wire to a total resistance of 2,000 to 2,500 Siemens' units in about 17,000 windings. Upon causing the armature to revolve, currents of *high electro-motive force* are generated, and an electrical spark passing between the separated conductors in the fuse inflames the explosive priming. *The line wires should be connected to the terminals of the exploder directly after the machine has clicked*, that is, when the tooth of the lever, D, has fallen into the cam, S. Two turns of the handle are then required in order to develop the full power of the machine before the current passes through the fuses. The total weight of the machine is about 59 lbs. Dimensions, 15" × 15" × 7".

The spark given by the large exploder is $\frac{380}{3000}$ of an inch in length, and the apparatus fires simultaneously about 50 Abel's fuses in single circuit.

The small tension-exploder is of the same construction as the large one, but weighs only 35 lbs.; it is placed in a leather knapsack for transport. The spark given by the small exploder is $\frac{180}{3000}$ of an inch in length. This apparatus fires simultaneously

about 30 Abel's fuses in single circuit. Dimensions, 12" × 11" × 6".

The large quantity-exploder is similar in construction to the tension-exploder, except that the cam, S, and short circuiting lever, D, are omitted, and the coils of the armature and electro-magnets are wound with wire of large diameter to a total resistance of 8 to 10 units in about 2,000 windings. The electric current is, after a few turns of the handle, sent into the line wire *by pressing down a firing-key at the top of the instrument.* The current then passes continuously into line until it is sufficiently powerful to heat the bridge-wire in the fuse and cause ignition of the explosive priming. Electric currents possessing *great heating power*, but of *small electro-motive force*, are generated by this machine.

Dynamo-electric quantity-exploders are also made with an automatic firing lever, similar to that in the tension-exploders, in place of the abovementioned firing-key.

The standard of efficiency for these machines is the fusing of a quarter of an inch of iridio-platinum wire of 0·0015 inch diameter, weighing 0·45 grain per yard, through a line resistance of 70 Siemens' units. The weight of the exploder is 71 lbs. Dimensions, 15" × 15" × 7". With short leading-wires this exploder heats 11 inches of iridio-platinum wire of 0·0015 inch diameter, which is equal to about 44 Service Detonators, No. 13.

(*To be continued.*)

20

SOME RECENT ELECTRICAL "NOVELTIES."

Electrician Aug 14/1880

It is always curious and sometimes surprising to find how early the idea of a recent invention has been mooted or its principle propounded by some other mind which lived before the time was ripe for the realisation of its schemes. "Nothing new under the sun" is a proverb to which these inventive times is ever giving proof. Edison's "Ore Separator" is a contrivance which has been again and again shown to be no novelty, but few are aware how old it really is—at least, in idea. It actually belongs to the last century; and, for aught that we know, may have entered into the idle dreams of Tubal Cain. In an English patent of date June 19, 1792, No. 1,891, William Fullarton, of Ayr, in Scotland, describes a new process for "separating iron from iron stones and other ores of that metal, of smelting it into the state of pig or cast iron, and of reducing or refining it into the state of malleable or forged iron." The patent was granted in the old style by King George III. for "His Kingdom of Great Britain, called England, His Dominion of Wales, and Town of Berwick-upon-Tweed, and also His Plantations abroad." That is a long time ago, but not before "telegraphs were thought about," for Charles Marshall, writing from the same district in Scotland, had long before (in 1753) suggested the principle of the electric telegraph; and Lesage, in 1774 had actually operated a frictional telegraph of the kind planned by Marshall.

Fullarton's patent goes on to describe the method of ore separation adopted by him. This consisted in crushing the iron ore by grinders, stamps, or mills worked by hand, horse, steam, water, wind, or other power, and, in the next place, of separating all "earthly, (*sic*) impure, and extraneous matters from the metallic particles by all or any of the following operations, namely, by washing, levigating, buturating, weanowing, and by the application of magnetic attraction, according to the nature and qualities of the different stones and ores." The materials thus purified are put into the furnace and smelted.

The electrical railway of Dr. Werner Siemens finds a forerunner in the "dynamic traveller" of Henry Pinkus, patented on March 1, 1834, No. 6,570, for the propulsion of vessels, carriages, &c., on canals, railways, or common roads. This invention relates to a pneumatic railway in which magnetic attraction may be employed, and which may either form "a complete system of railway in itself," or be applied to common railways or canals.

An extended tunnel, tube, pipe, or conduit is laid down, which contains a piston. On one side of the piston the air is exhausted from the tube by suitable stationary engines and pumps at suitable distances along the line. To the piston is attached "a vehicle or machine," called "the dynamic traveller," which is in connection with a car on the outside of the tube, called "the governor," to which the carriages to be propelled are attached. In the pneumatic railway itself the rails are cast on the sides of the tubes; but in its application to existing railways or canals the tube is laid down between the rails, or at the margin of the canal. The connection between the dynamic traveller and the governor is made either by means of a longitudinal "pneumatic valve," through which a vertical wire rises, or by magnetic attraction. To apply magnetic attraction effectively, the dynamic traveller carries a frame of horseshoe magnets, set transversely, with their poles placed as near to the under surface of the tube as possible. A similar combination of similar magnets inverted is attached or suspended under the body of the governor, and in order to enable the space between the poles of the magnets in the two frames to be as small as possible, the upper part of the tube has a copper plate fitted air-tight into the opening instead of a valve. In the dynamic traveller soft iron may be used instead of magnets, and electro-magnets may be used.

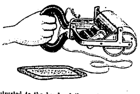
As regards the production of motive power by electricity, we have the patent of Miles Berry, a communication from Edwin Williams on behalf of Thomas Davenport, dated June 6, 1837, No. 7,386. This invention describes a means of obtaining rotary power by "galvanic" magnets alone, or "galvanic" magnets in combination with "permanent" magnets. The device in question consists of a number of electro-magnets fixed radially on a rotating shaft, and segmental permanent magnets, or electro-magnets, fixed to the frame supporting the rotating shaft. The motion of the rotating magnets is made to take place by the attraction of their poles towards the poles of the fixed magnets of opposite name. To effect this the rotating electro-magnets are made to change their polarity at proper times by the motion of plates (connected to the circuit of the electro-magnets) against segmental plates, corresponding in number and position to the number and position of fixed segmental magnets, which segmental plates are connected in a suitable manner with the poles of a galvanic battery.

English Mechanic & World of Science
August 5th 1887.

21

ELECTRO-MASSAGE.

A LARGE portion of electrical treatment that hitherto could only be carried out by specialists by using elaborate apparatus, by the proper use of a new mode of treatment, by employing the apparatus shown in the engraving, can be



intrusted to the hands of those who are not so skilled. By means of this simple machine the manipulator transfers the mechanical motion used in rubbing the patient into an electrical current, and the current as it is generated is transmitted through the part while being rubbed, and it fulfils the requirements of a treatment including rubbing, kneading, pounding, flexing, etc., combined with the application of the electric current. The instrument consists of a metallic roller covered with chamois leather or other suitable material, an electro-magnet, and a permanent magnet set in a strong frame, which holds the instrument together. The roller, besides acting as the driving-wheel of the machine, is so arranged that it also acts as one of the electrodes by which the current is transmitted, and is connected by gearing with the electro-magnet so as to cause the poles of the latter to revolve opposite those of the permanent magnet which forms the handle of the instrument. Each revolution of the roller produces twenty-five revolutions of the electro-magnet, which is magnetised and demagnetised at each revolution, and thus induces a current of electricity which is ample for all purposes for which it is intended. The circuit is completed by connecting any required electrode by the binding-post at the side of the instrument, the roller acting as the other electrode; both are brought into contact with the surface of the body of the patient, and as the roller is moved about over the surface, the current is established and transmitted through the part over which the roller is made to revolve. This machine includes in itself an electric generator, a rubber, kneader, a manipulator, and a set of electrodes, all in one. Any person ordinary intelligence can be taught to use it under the direction of the attending physician. It is portable, being quite capable of being carried in an overcoat pocket. The inventor finds in practice that it has far exceeded his expectations, inasmuch as by its use he gets greater tonic effects than from the employment of both faradism and massage separately. It fulfils most of the requirements of the induction current in general practice and every-day cases. As the current is generated by motion, no acids or liquids of any kind are necessary. The instrument is at all times ready for use, a matter that will be appreciated by all who use electricity. This treatment has been used with great success in cases of nervous exhaustion, debility, neuralgia, rheumatism, paralysis, etc., and we are informed that it is recommended by the medical profession generally. This invention has recently been patented by Dr. John Butler, of New York City.—*Scientific American.*

DE LOCHT'S PANTELEPHONE.

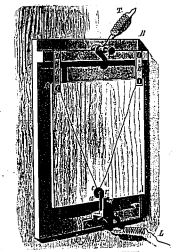
Leon de Locht, Mining Engineer and Professor at the College of Mining, Mont St. Martin 40, Liege, Belgium, after several years' experimenting with a view of overcoming the defects of the best telephones in use, and after the invention of one or two forms of apparatus, which have been the subject of patents in various countries, has finally perfected an instrument which he calls the pantelephone.

This apparatus is a microphonic transmitter which is sensitive to sonorous vibrations emanating at a great distance. It is capable of transmitting words spoken at forty-five feet from the apparatus to a distance of several miles through the medium of receiving telephones. The pantelephone, which is extremely simple, is composed essentially of a movable plate carrying a carbon contact, which presses against a disk of carbon or metal—silver or platinum.

Referring to the accompanying cut, the plate is seen figured at AA. It may be of aluminum, sheet iron, steel, brass, mica, cork, or of any substance whatever that is capable of being formed into plates of large superficial area, while at the same time possessing the requisite amount of lightness. It is preferable that its form should be rectangular, fifteen centimeters square in size, and, when made of metal, two to three tenths of a millimeter in thickness. It should be as inflexible as possible, and not liable to bend out of shape through the influences of temperature and humidity. It is suspended by two small very flexible steel springs, R R, from a support, S, which is perfectly straight and stands out from the fixed plate, B B, forming the framework of the apparatus. To the middle of the lower end of the plate is riveted or soldered a small carbon disk, *c*, which, when the apparatus is in a vertical position, rests against a small piece of silver or platinum fastened to the end of a short and somewhat inflexible spring, *r*, the latter being fixed by means of a screw, *e*, to the copper support, *b b*. By means of a thumb screw, V, passing through the support, the contact of the carbon, *c*, with the piece, *a*, may be regulated at pleasure.

The pantelephone is placed in the circuit of a voltaic pile in such a way, for example, that the current entering at L, proceeds to the support, *b b*, and from thence through the spring, *r*, to the contact, *a*, then to the carbon, *c*, and through the plate, A A, to the springs, R R, and leaves the apparatus at T.

There are other and secondary details of construction, by means of which the inventor is enabled to so regulate the apparatus as to insure of the greatest sensitiveness and of the best possible performance. There are certain arrangements employed, too, to deaden and stop all noises which might arise from tremors of the earth, or from the shaking of the wall to which the apparatus is attached. It is claimed that the pantelephone, when once properly regulated, is not liable to get out of order; and, moreover, that the expense



DE LOCHT'S PANTELEPHONE.

attending the use of the system is insignificant, since the apparatus under pr[illegible]r conditions requires for its making only the electromotive force of a single voltaic couple. The instrument transmits all sounds, articulate or inarticulate, which reach it, through the medium of either solids or the air. It is inclosed in a box (which may be made as ornamental as desired) in such a way that its sensitiveness to sonorous vibrations is in no way impaired.

24

AT A FLASH.

Lighting the Street Lamps of Salem by Electricity.

The Bancroft Lamp-Lighter a Success.

Exhibition of its Working Last Evening.

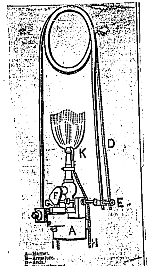
One of the most [illegible] and simple contrivances for lighting and extinguishing street lamps was shown in Salem last evening to a number of gentlemen connected with the Boston and Salem press. It is the invention of Mr. George D. Bancroft, well known to the newspaper fraternity of this section of the state, having been connected with the HERALD and other newspapers for some years. The visitors were met at the depot and conveyed to the Essex House, where refreshments were provided. Then they took a barge and visited the circuits where the apparatus was in operation. There are at [illegible] three circuits attached to the main office, [illegible] 43 lamps in their lines. The first visit was made to the third circuit, which embraces a portion of Bridge, Webb, Marianna and other streets in their vicinity, and at present has [illegible] lamps attached. The second circuit was next visited. This embraces Howard, a portion of Bridge, Winter, Pleasant, Pickman, Milk and Andrew, and has 15 lamps attached. It is intended to extend this circuit east of Andrews street. The first circuit was the last visited. This embraces a portion of Bridge, St. Peter's, Brown, Newbury, Forester and Pleasant streets, and is to be extended around the Common. In these three circuits there are now laid about three miles of wire. When the visitors arrived at the third circuit they halted at the corner of Bridge and Winter streets, and witnessed the lighting of the lamps on the circuit. When the time came to light the third circuit every lamp in the circuit leaped instantly into light, as if by a magic touch. The same operation was witnessed in the other two circuits. There was no hitch, no lighting of this and leaving the other dark, but

ALL BLOOMED OUT TOGETHER,

like flowers of the nether world. The length of wire and the power used in these three circuits were sufficient to light 150 lamps. On Washington street, in Boston, from Haymarket square to Boylston street alone, there are 89 lamps, and this is only about one-fourth of the distance covered by the three circuits in Salem. After viewing the lighting of the lamps, the party went to the main office on Winter street, where Mr. Bancroft showed the party several lights in a circuit, and gave a clear explanation of the operation of his machine. The office, by the way, adjoins the office of the lamp department, to which it will soon be removed. Mr. Bancroft has been at work on his invention some three or four years, and has lately succeeded in so simplifying and perfecting it that it will now, as has been amply shown, bear the test of utility. A company to extend the usefulness of this patent was formed in Boston some six months ago with Mr. George Munroe Endicott as president, and Mr. George Frost Williams as treasurer. The company is chartered by the name of the "Thermo and Electric Gas Lighting Company," and its office is in Boston. The lighting apparatus, as explained by Mr. Bancroft, is a simple affair, of unusually solid construction and great compactness. There are but few moving parts about it; no delicate mechanism to become deranged and no bulky shell or box to intercept the light rays. It is also of

INEXPENSIVE CONSTRUCTION,

being largely made of iron castings. Its composition is mainly the iron cylindrical magnet A, its armature B, the thermal arch D, the stopcock and its lever F. The arrangement of these parts is very clearly shown in the following engraving:



A—Magnet.
B—Armature.
D—Arch.
E—Connecting rod.
F—Stopcock.
H and I—Line wires.
K—Igniting loop.

The arch is composed of a steel rod brazed to a square bar of brass and bent into the form shown above. One end is attached firmly to the arm under the letter G and the other moves loosely over the outer end of the connecting rod E, on which its travel is limited by check-nuts shown on either side. The middle of the bar stands directly over the flame, and when the gas is lighted is, of course, heated to a higher temperature. When this takes place, the brass expanding much faster than the steel, which forms the outer surface of the composite bar, the whole expands as shown by the dotted lines. Now, assuming the lamp to be lighted and everything in the position figured in the cut, it will be seen that the arch immediately expands and, exerting its outward force on the stopcock through the connecting rod, and the lever F, would soon shut off the flow of gas. This, however, it is prevented from doing by the stud, or detent, G, on the top of the armature, which engages in a notch at one side of the lever. Now, as the armature is thrown up by a spring, it will be seen that the lever is firmly locked in the position shown, and there it must remain until released by

A CURRENT OF ELECTRICITY.

All the time the arch is expanding and storing up power, ready to be used in extinguishing. Now it should be understood that within the magnet is a helix of copper wire, one end of which is shown at I, and the other is carried up to the top of the apparatus, where it is affixed to a loop of platinum or other wire of high electrical resistance. The other end of the loop, K, is coupled to the line wire H. Now, when a current of electricity is sent through the apparatus, the armature is drawn down; the stud or detent is disengaged from the lever, and the end of the arch flies out, pulling the lever over, and so, closing the cock, shuts off the gas. Of course, the flame is extinguished, and at once the arch begins to contract, and would, were the current kept on, soon open the cock again; but, to prevent this, the current is soon broken and the armature is thrown up by its spring. This allows the detent to engage in a notch on the opposite side of the lever from that in which it is caught before. This locks the cock in its closed position, where it remains till it is desired to light again. This is accomplished after giving the arch a short time to cool, when its pressure is inward instead of outward. Then, by closing the circuit, the armature is drawn down, the cock flies open and the escaping gas, coming in contact with the heated platinum, is at once ignited. By these means the actual labor of the opening and closing the cocks is accomplished by the heat evolved by the burning gas, and it only remains for the current to release the power stored in the arch and heat the igniting wire.

The plant used by the Thermo and Electric Gas Lighting Company consists of a dynamo-electric machine, a mechanical generator of electricity, wires radiating from the central station at which the dynamo is located, and one of its patent "fixtures" at each lamp post.

THE WIRES ARE INSULATED

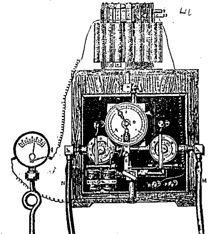
with a compound largely made up of gutta percha, and are buried under the pavements of the streets through which they pass, and each is carried up through the lamp post on its line, and makes in itself a complete circuit. Every lamp-post fixture works in unison with all its fellows on the same circuit, so that each group is lighted or extinguished as a whole. At the central office there is a switch connected with the dynamo machine, and, by means of this, the current is successively applied to each of the circuits. Usually only a fraction of a second is required to light any one circuit, but, as air is liable to escape from the burners before the inflammable gas finds its way out, it is customary to maintain the current for a moment so as to insure ignition. This is, however, a matter entirely within the control of the operator, as was proved by the exhibition of last evening. The invention seems to be in every way a superior one, and cannot failed to commend itself. Indeed, so many features of superiority are apparent in this new lamplighter that there can be no doubt of its desirability wherever gas is used for street-lighting on any considerable scale. To show how wasteful our present system in Boston is, it is only necessary to say that the cost of lamp lighters to the city is $60,000 annually, while it is estimated that the amount of gas unnecessarily consumed in consequence of our present system of lamp-lighting is at least $40,000 more a year, or a total expenditure of $100,000 by the present system.

The affair last evening was wound up by a very finely-catered set-down at the Essex House in Salem, after which the Boston men took the 8 o'clock train to the Hub, with automatic lamp-lighter on the brain, for the time being.

25

ELECTRIC TEMPERATURE REGULATOR.

There are numerous chemical and other processes which require a continued maintenance of an equable temperature. A familiar illustration of this is the equable temperature required by manufacturing dentists in vulcanising the caoutchouc palates for false teeth. For this it is necessary that the pressure, which is proportional to the temperature, should sometimes be the same for several hours, and this cannot be accurately maintained, except by simply watching the pressure gauge attached to the digestor or closed vessel in which the caoutchouc is placed. This watching occupies so much time that, except where assistants can be deputed specially to the work, it is often but indifferently performed, and though the vulcanite is rendered inferior for the purpose if subjected to great range of temperature it is nevertheless used. For this purpose, then, in particular, an automatic temperature regulator is essential, and such an apparatus has been invented and patented in this country by Mr. Joseph Davidson of Berlin, who is represented in this country by Mr. H. Pischon, Metropolitan Chambers, New Broad-street. The principle of the apparatus consists in the control of the gas flame, by which the closed vessel is heated, by means of an electro-magnet, which is put in or out of action by a pressure gauge, when the pressure is above or below the desired limit. For this purpose the gas supply pipe has a valve which is connected to the



armature of an electro-magnet, so that when the latter is in action it holds the valve open against the action of a spring which tends to close the valve. One terminal of the coil of the electro-magnet is connected to the ordinary pointer of a pressure gauge, which communicates with the interior of the vulcanising vessel. The other terminal is connected to a second pointer, which is kept in electrical contact with the first pointer by the action of a spring until this moves beyond the point at which it indicates the maximum pressure, at which point is a stop adjusted by a knob outside the pressure gauge glass, and arranged so that it prevents the second pointer from following the first beyond that point. The two pointers being thus separated, the circuit is interrupted, thereby stopping the action of the magnet, which thus allows the valve to close. When this is effected, a by-pass with regulating cock allows sufficient gas to pass to the burner to prevent it from being entirely extinguished. On the pressure being reduced the first pointer of the gauge in receding comes in contact with the second one again, thus re-establishing the electric circuit, and effecting the opening of the supply valve. Within the range of about one degree the temperature is constantly maintained. The gas supply has a second shut off valve, which is kept open against the action of a spring by a detent connected to a clock, and so arranged that when the clock has been in motion for a determined length of time, the detent is released, and allows the valve to close and cut off the gas supply entirely, thus terminating the vulcanising operation. In order that it should not be even necessary for the operator to wait until the necessary is first attained, an arrangement is made by which the regulator sets itself to work when that pressure is reached, and it then, from that moment, regulates the pressure for any duration of time for which the clock may be set. The armature of the magnet is provided with an arm that withholds the pendulum of the clock until, by the attainment of the full pressure, the action of the electro-magnet is temporarily interrupted for the first time. The armature is then raised by the spring connected to it, the pendulum released, and the clock starts, continuing for the determined duration of the process of vulcanising, at the expiration of which the clock detent allows the other spring to close the valve which it controls, and thus all gas is shut off.

The apparatus is all enclosed in a box, the glass door of which is removed in our sketch, which shows the box in section. The electric current is provided by a Noë thermo-electric battery on the top of the box, with twenty elements, and heated by a Bunsen burner, supplied by the pipe, fitted with gas-cock, H. This battery, which is much used in Germany and Austria, was described in detail in *The Electrician* of the 8th May last. In the illustration B is the clock referred to, C the valve through which gas passes by the pipe N to the vulcanising vessel, M the pipe supplying the gas to the apparatus, KK the magnet, F the armature, and E the arm which holds the clock pendulum until the current is first broken. G is the clock detent which rises into the notch in the disc [illegible] the clock spindle when the determined period has passed [illegible] thus permits the spring to close the valve D and shut off [illegible]. The terminals are connected with the gauge and battery as shown, and to the magnet, by means of the binding screws R and P, connected to wires behind the wood base on which the whole is mounted. The pressure gauge is shown unattached to the vulcanising vessel, and as shown the adjustable stop [illegible] the gauge is set to prevent the rise of pressure above 6½ atmospheres.

Though described as employed for a special purpose the apparatus is obviously applicable as a thermo-regulator for many purposes.

In the new air thermometer of Herr Witz there is another very ingenious electrical arrangement for keeping one of the air bulbs of the apparatus at a constant temperature so as to serve for a standard and make the readings give absolute (not differential) results.

The object was to find a means of keeping the air inside the standard bulb at a practically constant temperature, and Herr Witz achieved it in the following manner. A very fine platinum wire was rolled in a helix, and introduced into the interior. It makes part of an electric circuit, which is closed by a mercurial column, movable in the recurved part of an alcohol thermometer, similar to that of Lix and Bellani. The movement of the alcohol and mercury in this auxiliary thermometer depends on the temperature of the air in the interior of the bulb where the platinum wire is fixed. One end of the mercury column is always in contact with the platinum wire; the other, on the contrary, opens or closes the circuit of a battery in advancing or receding. At the moment when the temperature of the air in the bulb decreases below a determined point the circuit closes, the current passes through the platinum wire, which is heated, then the temperature rises in the bulb, the mercury again opens the circuit, and the current is interrupted. The fixed temperature of the standard bulb is ten degrees C. higher than that of the surrounding air, and there is, therefore, a continual tendency for the hotter bulb to cool down. The result is that there is an oscillation of temperature in the standard bulb, as it is replenished with heat by the current, and parts with some of it again; but the range does not amount to more than $\frac{1}{10}$ degree C. With a steady battery the apparatus works well.

The best battery for the purpose yet tried by Herr Witz is that of Poggendorff, recently described in these columns. It is a bichromate of potash battery, as our readers will, perhaps, remember, and has an electromotive force, quantity and constancy well adapted to the regulating purpose in question. By taking care to renew every day a little of the acidulated water rendered greenish by sulphate of chromium, and to add a crystal of bichromate of potash into the porous vase, two small cells maintain the thermal regulator at 29·5° C. during a long time. Perhaps this device of Herr Witz will prove useful in other ways.

Min. Press. Sept. 11 1880.

26

40 A New, Submarine Torpede

Mining Press Sept 11

The mysterious torpedo, about which so much has been said and written, which is being experimented with at Willett's Point, is entirely different from any other floating torpedo known in this country. The torpedo is the design of a Mr. Sims. It is thus described by the *American Ship:* The torpedo is of the ordinary cylindrical cigar-shaped hull, with fine lines, and is divided into three apartments, the forward one, or magazine, being filled with an explosive compound, which is fired by electricity. The middle compartment contains a roll of fine t[illegible] graphic wire about 1¼ miles long whi[illegible] played out through an aperture in [illegible] while in the after section is located the propelling engine, which drives a screw propeller at a velocity of, so far as tested, 12 miles an hour. The motive power is electricity, conveyed to the torpedo through the roll of wire referred to; and through this wire connection control is exercised over the screw and rudder, as well as the firing of the magazine. From the torpedo rises two stanchions, placed on each outer section, which connect with a light float, V-shaped on the sides and convex on the top. The torpedo proper is raised or lowered by means of the stanchions and float, so th[illegible] class of vessel with an overhang or partly armored can be reached by the impinging end of the torpedo, and the explosive power exerted at any depth of water desired. [illegible] seen in the water, nothing is seen but the c[illegible] of the float with the heads of the stanchions, on which are placed tiny flags, which serve to show [illegible] ator the direction and speed of the torpedo machine, and enable him [illegible] and fire the charge of [illegible] pound. Thus far the [illegible] very successful. The e[illegible]attery for working this torpedo from [illegible] kept within the fort or placed in a [illegible] near the scene of operations. It can also be operated from the deck of a cruising vessel or launch.

Min. Press Sept 11 40

To Remove the Odor [illegible] Benzin[e]. Mr. R. F. Fairthorne suggests, in the *Ameri[can] Journal of Pharmacy,* that if three oun[ces] powdered quicklime be added to a gal[lon] benzine, and the mixture be well shake[n] of the peculiar sulphureted odor of the [illegible] will be removed; and articles that ha[ve] washed in it will have [illegible] disagreeabl[e] [illegible]

Electricity [illegible] War.—Experiment[illegible] stand, being trie[d] [illegible] Plymouth [illegible] trical [illegible] the results [illegible] looked forward [illegible] interest among military circles.

Eng. Mech. & World Science Mch 18 [illegible]

[illegible] be[illegible] by [illegible] same p[illegible] B[illegible] was [illegible] This [illegible] necessary to ex[illegible] delay or to excise [illegible] by inserting a soft iron probe and [illegible] converting it into an electro-magnet, w[illegible] the particle of metal, and saved the eye.

The annual amount paid for gas consumed by the public lamps of the City is about £14,000. The amount agreed upon for the electric lighting, by way of experiment, of three districts for 12 months, from sunset to sunrise, is £8,000. It is roughly estimated that the cost of the experiment, including the plant, machinery, fixing, replacing, and so on, will be about four times the price now paid for gas; but eliminating these expenses, which would not be recurrent, the cost would only be twice that of gas.

Monde de la Nature Août 25 1880

Monde de la Fr[illegible] Août 25 1880

ÉLECTRICITÉ

40

[illegible] électrique.

Une nouvelle [illegible] re de pêcher à la ligne vient d'être imaginée par un [illegible] and. C'est la pêche à l'hameçon électrique. Cette inve[illegible] originale, qui figure à l'Exposition de pêcherie de B[er]lin où elle excite vivement la curiosité consiste, en un petit esquif qui peut être dirigé sans bruit vers n'importe quel point de l'eau au moyen d'un appareil à roue qui met en mouvement une hélice. Une fois arrivé à l'endroit voulu, il s'ancre lui-même contre vent et courant, tandis que la corde et l'hameçon glissent dans l'eau.

Le petit esquif renferme une batterie électrique et un électro-aimant qui sont disposés de telle sorte que la plus légère morsure effectuée par le poisson établit le courant électrique. Aussitôt, avec la rapidité de l'éclair, à l'aide d'un électro-aimant, ligne, corde, hameçon et poisson sont enlevés en l'air ; une petite cloche tinte pour avertir le pêcheur qu'un poisson est pris et qu'il peut être débarqué en tirant le petit esquif qui est relié à la rive par une corde.

Electrotechnische Zeitschrift.

Sept 24 40 ENGINEERING.

TENSILE STRAIN AND ELECTRIC RESISTANCE.

Some interesting results showing the connexion between the electric resistance of iron wires and their state of strain have been communicated by Mr. W. H. Johnson, B. Sc., to the Manchester Literary and Philosophical Society. The wires were tested for their resistance by means of a Wheatstone balance with reflecting galvanometer of low resistance, and for their tensile stress by an apparatus similar in principle to a steelyard weighing machine. A series of measurements were made upon different varieties of iron wire, beginning with pure iron smelted and worked throughout with charcoal, and ending with highly carbonised steel wire. The results show that charcoal iron has the least electrical resistance, or about one-half that of piano steel; and it is noticeable that the resistance regularly increases as the impurities augment. Annealed steel, which comes about midway between pure charcoal iron and piano wire in the amount of carbon it contains, is also intermediate in point of electrical resistance. Annealing considerably diminishes the electrical resistance of puddled iron wire. The breaking strain and the resistance are also found to increase together in [illegible]ly regular manner. Annealing is found to dimin[ish] the resistance of bright steel wire about 1 per cent., while hardening and tempering increase the resistance of annealed steel about 5 per cent. In fact any process, such as wire-drawing and tempering, which makes the particles of steel more rigid, would appear to increase the resistance of the metal to the passage of the electric current. With regard to torsion, the tests show that the electrical resistance is, roughly speaking, inversely proportional to the number of twists in the length of 8 in. The importance of electric conductivity in boiler plates is pointed out by Mr. Johnson in his paper. The heat conductivity of metals is nearly proportionate to their electric conductivity, and, as boiler plates should conduct heat well, they ought also to have a high electric conductivity.

Le Gothe de Nantes

40 Le Gothe de Nantes

Machine électrique à composer

A la dernière exposition des imprimeurs, installée à Islington, près de Londres, se faisait remarquer une nouvelle ma[chine] permettant d'assembler électriquement [les] caractères d'imprimerie, et dans laquelle le travail du compositeur se trouve réduit à sa plus simple expression.

Il suffit, en effet, d'un simple contact pour rendre libres les caractères rangés d'avance dans les casiers, lesquels caractères viennent se rendre d'eux-mêmes, automatiquement, là où ils doivent être assemblés, et le journal anglais l'*Electrician* nous assure, par l'intermédiaire de son collègue français, la *Lumière électrique*, qu'ils sont mis en place avec une rapidité et une précision qui n'avaient pas encore été atteintes.

Après un mois d'exercice, un compositeur ordinaire peut arriver facilement, avec cette machine, à assembler jusqu'à *douze mille* caractères en une heure.

Ce chiffre qui, au premier abord, peut paraître un peu phénoménal, a, nous assure l'*Electrician*, été constaté chez MM. Clowes, imprimeurs à Londres, où plusieurs exemplaires de cette machine sont employés actuellement. Il représente un maximum qui peut bien, en effet, être fourni pendant une heure, mais non, si agile et si infatigable que soit le compositeur, pendant plusieurs heures consécutives.

Lorsque les caractères quittent la machine, ils se disposent sur une ligne continue ; cette ligne est divisée à la main d'après la justification adoptée, pour former ensuite les colonnes et les pages.

En tenant compte du temps employé à la justification et à la mise en pages, on a calculé qu'avec l'aide d'un apprenti, employé pour charger de caractères les casiers, chaque machine pouvait fournir par heure la *composition* définitive et complète de *dix mille* caractères, et que la mise en place ou *distribution* de ceux-ci dans les casiers ne revenait pas à un penny, ou dix centimes par mille.

— L'enlèvement des caractères hors de leurs casiers s'effectue au moyen d'électro-aimants (aimants animés par un courant élétrique), placés derrière chaque casier et correspondant à des plaques métalliques disposées en manière de touches qui, lorsqu'on appuie dessus, déterminent des contacts électriques. Chacune de ces plaques porte l'indication du caractère auquel elle se rapporte.

Le compositeur est placé devant ces plaques comme devant un pupitre et procède comme il a l'habitude de le faire ; seulement, au lieu de prendre les caractères dans les casiers, il touche successivement les plaques qui leur correspondent avec une tige de cuivre qu'il tient dans sa main, comme il tiendrait une plume à écrire.

Par suite de ces contacts, les caractères quittent d'eux-mêmes, les uns a[près] les autres, leurs casiers respectifs pour se rendre à un collecteur où ils viennent s'assembler côte à côte dans l'ordre où l'on a opéré les contacts.

Au bout d'un certain temps de pratique, comme en télégraphie, le compositeur se trouve tellement familiarisé avec les positions relatives des diverses plaques de contact, qu'il n'a plus besoin de les chercher: sa main tombe sur elles d'une façon sûre et pour ainsi dire automati[que].

Les mouvements compliqués qu[e, dans] le mode ordinaire de composition, la main du compositeur doit faire pour placer un caractère, étant réduits à un mouvement unique très simple, et les tâtonnements étant supprimés, il est facile de comprendre que par ce nouveau système, la composition d'un manuscrit puisse se faire, ainsi que l'attestent tout ceux qui ont assisté au fonctionnement, aussi vite que l'épellation même des mots.

Eng. World Science [illegible] Nov. 5

40

Messrs. Siemens and Halske have devised an electric hammer or rock-boring tool. A rod of steel-headed soft iron moves through three coils of insulated wire; the central coil is traversed by a constant current which magnetises the rod, and the other coils are traversed by alternating currents, so they "attract and repel" the rod with rapid [illegible] energy [illegible] removed.

Eng. [illegible]

40 Novel Ind[illegible] of electricity [illegible] Messrs. Siemens [illegible] Berlin, who are [illegible] patented a hammer [illegible] propelled [illegible] city. It consists of a rod or [illegible] steel moving within the axes of three coils. A constant current in the middle magnetises the rod, and alternating currents through the other coils cause it to be forced in and out [illegible]

Engineering Dec 3

40 1705.* Liquid [illegible] Deposition of Aluminium: L[illegible] the Electro-Depo[illegible] [illegible]vis, London. Relates to a bath or liquid compo[illegible] aluminium, the process being [illegible] [illegible] he electro-deposition [illegible] ammonia, the precipitate [illegible] to common alum [illegible] a [illegible] solution of neutral tartr[illegible] evaporated nearly to dryness, w[illegible] acid. The salt is then crystalli[zed] [illegible] crystals dissolved in water. This [illegible] solution [illegible] is then ready to [illegible] the bath [illegible] an anode, either a plat[e] [illegible] of the aluminium [illegible] nium or a bag of alumina may [illegible] is used to co[illegible] (April [illegible] 1880)

Eng. [illegible]

40 Pencil drawings may [illegible] German contemporary, by [illegible] a sheet of ordinary drawing [illegible] surface of a solution of whit[e] [illegible] long enough to become thor[oughly] [illegible] it in a current of warm air. [illegible] very smooth surface. In or[der] [illegible] be simply warmed for a few [illegible] useful for the preservation [illegible] time or any other cause will [illegible] ducing them in ink. A sim[pler] [illegible] over, is to brush over the ba[ck] [illegible] coal or pencil sketch with a [illegible] alcohol.

Taille de la pierre à l'aide de l'électricité

Le *Moniteur des Inventions industrielles* nous fait connaître qu'une nouvelle application de l'électricité vient d'être faite en Amérique. Les journaux américains décrivent longuement une machine dynamo-électrique qui taille la pierre avec une grande perfection. Cette machine sert à dresser les meules et autres pierres, ainsi qu'à forer les rocs, le tout avec précision et une notable économie.

Le ciseau employé à la taille est fixé à un ressort attaché lui-même à un coffre renfermant les aimants et les armatures. Le ressort, au moment où les aimants sont mis en contact avec la machine dynamo-électrique, reçoit de haut en bas un rapide mouvement qui, à chaque descente, fait agir le ciseau sur la pierre. On peut arriver à donner de 1.000 à 2.000 coups par minute.

L'emploi de fils conducteurs au lieu de tuyaux, comme dans les machines à vapeur, permet de déplacer la machine à volonté, de l'établir même à une certaine distance du chantier, sans trop grande déperdition de force, surtout si l'isolement des fils est complet, ce qui est facile à obtenir.

...n des avantages remarquables de cette invention réside dans le bâti portant l'appareil électrique. Ce bâti, étant mobile, peut se fixer où il est nécessaire. Il permet également de régler le mouvement circulaire du ciseau et de le rendre plus ou moins rapide, selon la nature plus ou moins résistante de la pierre ou de roc.

Au moyen de cette machine, on dresse très-rapidement une meule et l'on y trace les rainures voulues, avec cette régularité et ce parallélisme qui sont les qualités distinctives d'une bonne taille.

L'appareil peut marcher soit automatiquement, soit à la main; il est donc applicable à tous les genres de taille, à toutes les natures de pierre, tendre ou dure indistinctement.

Journal of the ... Journal of ... 1881

An Electrical Reporting Machine. 40

A NEWS despatch from Paris of February 21st states that several successful experiments were made on the previous day at the Palais Bourbon with an electric reporting machine, which it is proposed to introduce into the Chambers. The machine has the appearance of a small piano, and is played like that instrument by an operator on a keyboard of ten notes. Three notes are set apart for reporting foreign quotations. As fast as the orator speaks the operator touches the keyboard, on which each sound has a corresponding key. The machine instantly represents the sounds by conventional signs on a strip of paper. The signs have afterward to be translated. About two years are required for learning how to manipulate and make use of the instrument, which is the invention of an Italian named Mitchella.

Aug. 27 1880

ENGINE...

...PHONE AND THE TELEPHONE.

In ... of deafness the auditory nerve itself is def... ut there is a proportion of instances in which ... apparatus of the ear is at fault. For deaf ... ons which belong to the latter category the A... an audiphone is very beneficial since it will enable them to hear music and conversation with very little trouble or expense. All these instruments consist of an artificial diaphragm of some elastic material, capable of vibrating under the impact of the sound waves and of communicating their vibration to the bones of the head and thence to the auditory nerve, when held between the teeth. Mr. Rhodes employed a thin disc of ebonite bent by a cord into a curved form and held before the mouth with the convex side outwards and the edge resting between the ... Professor Colladon substituted Bristol board for ebonite, and Mr. Fletcher, of Warrington, used birch wood veneer in place of Bristol board. The latter gentleman now, however, gets excellent results with a simple sheet of stiff brown paper having its edge placed loosely against the teeth, and its curved increased surface outwards. The audiphonic principle has also been applied quite recently to the speaking telephone by Mr. H. G. Fiske, of Springfield, Massachusetts, in order that persons habitually deaf from mechanical (not nervous) causes may be able to employ that useful apparatus. To the centre of the vibrating plate of the telephone is affixed a short rod of wood, ebonite, or hard elastic substance which can be held between the teeth, and allowed to vibrate there so freely that the vibrations of the telephone diaphragm can communicate themselves to the auditory nerve.

AWARDS TO WORKMEN FOR INVENTIONS.

Messrs. William Denny and Brothers, the well-known shipbuilders, Dumbarton, have notified their intention to establish a system of awards to workmen under the supervision of an Award Committee, under the following general conditions: "1. Any workman in our employ may claim an award from the Committee on the following grounds: (*a*). That he has either invented or introduced a new machine or hand-tool into the yard. (*b*). That he has improved any existing machine or hand-tool. (*c*). That he has applied any existing machine or hand-tool to a new class of work. (*d*). That he has discovered or introduced any new method of carrying on or arranging work. (*e*). Or, generally, that he has made any change by which the work of the yard is rendered either superior in quality or more economical in cost." There are in all eleven rules, any or all of which may be modified, changed, or annulled. The third rule is as follows: "On the establishment of a claim under the conditions above specified [in Rules 1 and 2] the Committee are to make an award, which is not to fall below 2*l*., nor to exceed 10*l*. Between these limits the award will be fixed by the Committee according to the opinion they may form of the value of the improvement or invention for which claim has been made." This arrangement is open to the obvious criticism that the maximum award is entirely inadequate for an... but minor improvements or advantageous modifications, which, we presume, it is only intended to deal with.

WEATHER INFORMATION.

It may not be generally known that descriptions of the actual state of the weather, and forecasts for not more than one day in advance, are prepared at the Meteorological Office for issue to the public. They are posted at the door of the office, 116, Victoria-street, S.W., on week days, for the inspection of the public. Any person can be supplied with ... once on each week day, on ... n of ten shillings per an... t of transmission either by ... y person applying at the off... M. on week days, and be... Sundays, can be supplied in ... ing with the latest information in ... of the office, and with the latest forecast is at ... specified district, on payment of one for each inquiry. Application may be by letter, enclosing thirteen pence in st... if the reply is to be by post, and two shillings ... the reply (not exceeding twenty words) is to be by telegraph. Any person may obtain by telegraph the latest information as to the weather in any district of the United Kingdom by payment of a fee of one shilling in addition to two shillings, the cost of the message and the reply. The telegram containing the inquiry must not contain more than twenty words. Application may also be made for simi... information to be sent either by telegraph ... post on some future specified day.

On the Comparison of Declination Magnetographs at var... Places, by Prof. W. G. Adams.—This paper was accompan... by diagrams of simultaneous magnetic disturbances at St. Petersburg, Kew, and Vienna, showing that many of the sudd... magnetic disturbances occur simultaneously over very great are... but that in some cases the variations were in opposite directio... In the debate which followed Sir Wm. Thomson spoke of th... observations as beginning to open out a glimpse of the true caus... of the magnetic storms. He observed that if similar records ... the other magnetic elements, inclination and intensity, could ... procured, we should know definitely whether these disturbances were due to any changes of the magnetism of the earth itself, or whether they were due to an external magnetic action. Magnetic observations had been going on for forty years, and it was a reproach that more had not hitherto been done. He also referred to the alleged connection between auroræ and magnetic storms. Mr. J. Glaisher and Staff-Commander Creak men...ed cases of sudden magnetic disturbances. Capt. Creak re...lled the observations of the Arctic expeditions of 1875-6, when a deflection of 5° was observed within forty minutes, the Kew records showing synchronously a smaller fluctuation. He argued that an observing station in a more northerly latitude was necessary. Mr. W. H. Preece recounted a magnetic and electrical storm which affected Ireland and the west of England on Aug. 12. Magnetic disturbances always were accompanied by earth currents which affect the telegraph-wires. The same storm affected even the Atlantic cables and the Cape cable. He believed they would be found to have affected the whole earth. The electromotive force on this occasion, through the Atlantic cable, was about as great as that of 300 Daniell's cell, or more exactly one volt per 6·6 miles. Capt. Creak also exhibited the new Admiralty chart of the magnetic variation for 1880.

Prof. G. H. Minchin read a communication *On Photoelectricity*. He had obtained feeble currents from two silver plates coated with sensitive films of iodide, chloride, or bromide of silver, dipping into a common fluid, and then one of them exposed to the light. He had also observed that preparations of fluorescent and phosphorescent bodies upon silver plates acted similarly.

Prof. Silvanus P. Thompson gave a paper *On Electric Convection Currents*, pointing out their analogies with true conduction currents, and of currents of electrolytic conductivity in respect of electro-magnetic phenomena. The application to ring-figures produced by disruptive convection and by electrolytic conduction was considered, and their deformation in the magnetic field. It was pointed out that considerations of a similar nature had been advanced by Prof. Ayrton at an earlier date.

Experiments on Thin Films of Water, with regard to the Absorption of Radiant Heat, by the Hon. F. A. R. Russell.—The experiments, the general results of which are given below, were made with the object of ascertaining the diathermancy of water in very thin films, and these experiments afforded incidentally an opportunity of observing the behaviour of films subject to varying conditions.

The arrangement of instruments was similar to that illustrated at p. 383 of Prof. Tyndall's "Heat as a Mode of Motion." The instruments used were: a dead-beat mirror galvanometer and scale, a thermopile, and a screen. The soap film was carried by a piece of a cork sole perforated by a hole slightly larger than the hole in the screen, about 1¼ inch in diameter. The sources of heat were (1) a copper or iron ball heated from behind by a small gas flame; (2) a gas flame from a Bunsen burner and (3) ...ydrogen flame in air.

...e film was mostly made from a solution of about half a ... of shavings of Castile soap, dissolved five to fifteen ... in about five cubic inches of water, at 60° F.

...lm, soon after being placed perpendicularly at the orifice ... screen, exhibited coloured bands, which descended in ...ar succession until the last band appeared, which contained ...ght blue line. The descent of the bands continued at a ...ened rate till the grey, and finally the black, occupied a po...on of the upper half of the film, which half was alone su...ect to experiment. A condition more or less of equilibrium then prevailed, the tension of the black portion counteracting the force of gravity. A light yellow or bronze was always the last colour to appear, and preceded the white or grey, which again was succeeded by black. When there was any black in the film, the bursting of the film was marked by a slight click or ...ping sound. The best films lasted frequently between ten ... thirty minutes, and sometimes the black portion alone was ... der observation fifteen or twenty minutes.

The following table shows the absorption per cent. for each of the three sources of heat, and the thickness of the film, as derived from a table in Watt's "Dictionary of Chemistry," giving Newton's thicknesses of thin films of air, water, and glass. A ...ble in Cooke's "New Chemistry" gives the thicknesses of ...films as considerably greater than those stated in Newton's ... The "light film" of Cooke corresponds to my "grey," ... "grey" to my "fine grey." Newton's "white" corre... to my "grey." The refractive index of the solution ... by me was 1·34 and 1·35, a little higher than that of pure ...er.

State of Film.	Metal.	Gas.	Hydrogen.	Thickness of Film in millionths of an inch.
Last band alone	9?	8?	—	8·3
bronze	6	5·7	—	5·2
All grey (white)	4·7	—	4·5	3·9
Fine grey	—	3·4	—	1·8
Half grey, half black...	—	2·9	—	2·3
Two-thirds black, one-third grey	—	1·6	1·6	1·8
Half fine grey, half black ...		—	—	
Black and slight fine grey ...		–	1·2	1·34
Fine grey and black ...		—	—	
All black		·5	·6	0·75

SECTION ... SCIENCE

On the Influence of Water on the Union of Carb... with Oxygen at a High Temperature, by Harold B... The author c... the curious re... th... carbonic oxide and oxygen in such proportions as to form carbon dioxide, when ...e, or nearly free, from water, does not explode, either by a direct discharge from a Leyden jar or when sparks are passed through it from a Ruhmkorff coil. By allowing a minute portion of aqueous vapour to mix with the gases, explosion immediately takes place on the passage of the spark. In presence of a very small trace of water, combustion takes place, but slowly, not with explosive energy. The author suggests as an explanation the following equations:—

$$CO + H_2O = CO_2 + H_2$$
$$H_2 + O = H_2O.$$

Prof. Williamson suggested that it would be interesting to determine the inferior limit to the power of water vapour in causing an explosion, and that Mr. Dixon would probably extend his research in this direction.

Prof. Harcourt pointed out that various other similar instances are known, among others the impossibility of causing union of calcium oxide and carbonic anhydride, in absence of water, and the refusal of dry chlorine to act on hot sodium.

Mr. Thomas noticed that in mixtures containing large amounts of marsh-gas the presence of water vapour also influenced the rapidity of explosion.

Eng. Mech & World Science Mar. 25 1881

… ting-iron, … ted by the electric current, and capable of melt… all kinds of solders, such as gold and silver solder (which have hitherto required a blowpipe), has been patented in America by Mr. Ball, of Philadelphia. The electrodes extend through and project beyond the handle, and embrace a piece of platinum or other material offering sufficient resistance to the current to get heated more or less. One of the conductors is interrupted near one end of the handle, and bridged by a button, made partly of conducting and partly of insulating material, so that by turning the button, the circuit may be completed or broken as desired. In another arrangement, the handle is in two halves, pressed apart by a spring, and, in that position, short-circuiting the current. On pressing the halves together the current is sent through the refractory point.

…ro E…IC MINE EXPLODERS.

… SIEMENS' APPARATUS.

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(*Continued from page* 275.)

The small quantity-exploder is of the same construction as the large one, but its weight, including knapsack, is only 39 lbs. It fuses a quarter of an inch of 0·0015 inch iridio-platinum wire through a line resistance of 50 Siemens' units. With short leading-wires this exploder heats 8½ inches of iridio-platinum wire of 0·0015 inch diameter, which is equal to about 35 Service Detonators, No. 13. Dimensions of the exploder, 12" × 11" × 6".

With a given electro-motive force the quantity of current passing through a circuit per unit of time depends upon the resistance of the circuit; hence, if only one quantity-fuse be connected up with the exploder, a stronger current will be generated than when several fuses are joined in series. Thus, with a small exterior resistance, a large quantity of current passes from the armature into the electro-magnets of the machine, whereby a … powerful magnetic field is formed and the revolving armature experiences a resistance to its motion, which may become so great as to render the turning of the handle of the machine difficult. In order to overcome this inconvenience as much as possible, an extra coil of several units resistance is inserted in the base of the instrument. This extra coil may be increased in resistance 10 or 20 units if the machine be required to turn with greater ease. When the firing-key is at rest, the extra coil is in circuit with the electro-magnet coils, but when the key is depressed the extra coil is cut out, and the line and fuses put in circuit.

The only reliable test of the efficiency of tension-exploders is length of spark, as, owing to the great difference in the resistance of tension-fuses, any standard of efficiency based upon the number of such fuses an exploder will fire must be incorrect. The test for the quantity-exploder is the length of iridio-platinum wire of a standard diameter which can be fused.

The nature of electricity of great electro-motive force, by which it overcomes high resistances, requires that the coating of the cable or conducting wire should have high resistance, or, in other words, be well insulated, in order to prevent escape of the electric current. It should be borne in mind that to "insulate a wire" means to surround the wire with a covering which offers sufficient resistance to the escape of the electric current, and, consequently, that the greater the electro-motive force the greater is the resistance required in the insulating covering.

In cases where the conducting wires are for the greater part of their length stationary, high tension electricity is to be preferred, because its greater power of overcoming resistance enables it to fire a larger number of fuses through longer distances. On this account the tension-exploder is better suited to mining purposes, where fuses have to be exploded either in numbers *simultaneously* or through *long* circuits.

But in cases where only short lengths of conducting wires are employed, and these are frequently shifted or subjected to such rough usage as would endanger the insulation of the cable, the use of electricity of *small* electro-motive force is advisable, for this will pass without loss through a cable with faults in the insulation through which currents of greater force would readily escape. On this account the quantity-exploder should be employed.

The mistake of using weak machines has done much to hinder the adoption of electrical firing.

The dynamo-exploders are unquestionably the most suitable for blasting, and of the two kinds of apparatus the tension-exploder is usually preferred in consequence of tension-fuses being cheaper than platinum wire-fuses. When, however, a system of mines has to remain a long time inoperative, and yet in a condition to be fired at a moment's notice, daily electrical tests must be taken, and this can only be done when platinum wire-fuses are used.

There are two kinds of fuses adapted to the two kinds of electric-exploders, viz. :—

(*a*) Tension fuses.
(*b*) Quantity fuses.

Tension-fuses should be made of stable elements, so that no chemical decomposition can take place in the priming, and the fuses must remain unaffected by moisture and heat, even when used in tropical climates. The composition of tension-fuses should likewise keep unchanged during a long sea voyage, as many failures in electric blasting abroad have been due to a chemical change in the fuses or to the mass of the priming having become loosened during transport. It is important, in connecting up the fuses in circuit for firing, that great care should be taken not to put too much strain upon the fuse wires, otherwise these wires are apt to be pulled out of the explosive compound, and the fuse cannot then explode. The data given below respecting the number of fuses fired by Siemens' exploders refer to Abel's fuses only.

When a number of fuses are joined in single circuit the resistance of each fuse is added to that of the entire circuit, but when connected in divided circuit the joint resistance of the fuses is less than that of a single one only. In cases where an unusually large number of *tension-fuses* are required, the *divided circuit* may be used, but the connections are *troublesome* to make, and as a sufficient number of fuses can be fired in *single* circuit, this latter

Eng. Mech

THE SILK INDUSTRY OF THE UNITED STATES.—ITS G… T FUTURE.

THE following very able report by Consul Peixotto, of …ons, will be read with interest not only by our silk manufacturers, bu… every man who has the building up of our industries at heart :

The United States is no less interested in this serious question. We are now annually producing upwards of $30,000,000 worth of silk fabrics, and yet not one single silk filature worthy of the name exists in all our broad dominions. Besides we are wholly dependent upon Europe and Asia for our raw material.

Two questions present themselves at this juncture : the first is, can we raise silk ? The second, can we sell it when we have raised it ? The first has already been solved ; we can raise silk worms because we can grow the mulberry leaf which is its essential food. This question has been conclusively determined. Silk worms have been successfully raised in the United States for more than thirty years. The second remains. The impossibility hitherto of competing with the cheap labor of Europe, where the silk reeler receives but thirty cents a day, and of China and Japan, where but from six to ten cents is paid, has been the principal, in fact the only, cause why we have not and could not sell the silk from the cocoon. Every silk manufacturer will admit the desirability, nay for permanent success, the absolute necessity of having his raw material at hand, even as the cotton manufacturer has his.

To be absolved from the necessity of importing from Europe and Asia the raw material, would be next to constituting the silk industry with us as one of the great sources of our national wealth. It would give employment to hundreds of thousands of hands, women and children, now idle or non-producing ; it would at the same time afford the masses an elegant and durable material at one-third less than the present cost, and it would give to capital a new and lucrative source of investment shared at present but by a few individuals, and restricted to exceedingly limited proportions.

But how can we overcome the competition of Europe and Asia with regard to labor? I am happy to be able to answer this question here and now. In the month of June last, recomended by the Department of State, which under the present administration has done so much to encourage our home manufactures and develop our foreign trade, and provided with letters by the commissioner of agriculture, there came to Europe a young American engineer who, before leaving home had already given much time and study to the subject, and who since has devoted several months to visiting and carefully inspecting the principal filatures of France and Italy. This gentleman, Mr. Edward W. Serrell, Jr., of New York, believed it possible to invent machinery which, by the use and application electricity, would not only overcome existing difficulties, produce a superior quality of thread, but solve at the same time the all important labor question and render silk reeling in the United States as possible and profitable as anywhere else in the world.

It affords me very great satisfaction to say that in my judgment Mr. Serrell h… at length been successful, and that very shortly this fact will be abundantly and incontestably proven, both for the now unhappy and rapidly declining silk reeling industry of Europe as well as for, from one American point of view still more important and valuable interest, the successful planting of silk industry in the United States in all its varied stages and branches from the mulberry tree, the *magnanerie* or hatching house, the reeling mill to a still higher perfection than what we have already attained in the fabrication of tissues. What the cotton gin has done for cotton, which with us ninety years ago hardly had a commercial value, the Serrell invention may yet do for silk, and the United States become pre-eminent for the latter and costlier product as for the former and cheap… culture.

The capital point to be derived from these exhibits is the decline of French filatures, and to note that this decline was produced from (1.) inferior crops (2.) decreased consumption of pure silk goods ; (3.) superiority of Italian filatures (4.) competition of China and Japan labor ; and to add that this deplorable stat… could easily be revived and resuscitated by the introduction of improved a… economical machinery.

Amer. Exporter Jan 1881

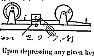
Scientif. Amer 31
40 = Jan. 27 1881

PRINTING M… BY …RICITY. 40

By H. Y. Dickins…, Newbury, Berkshire, England.

PREPARED paper, …, is drawn by wheel, *d*, which rotates by clockwork, from paper wheel, *a*, over printing table, *b*. Within box, *c*, is a set of rulers, which rule on the paper as it runs the treble and bass staff lines. The box, *c*, also contains a number of pins corresponding to the various musical notes, and acted upon by electromagnets in circuits, which are completed by depressing the keys of the instrument

Scientific Am…



Jan 27 1881

played upon. Upon depressing any given key, the movable pin working in connection with this key is also depressed and marks a th… line on the paper, the length of the line corresponding to the time the note is held down. The pins are also so placed, that if a n… … fall inconveniently high or low, the note … an octave lower or higher, as the case may be, and the proper octave indicated by a mark produced in a similar manner.

Eng Mech Jan 7 1881

Dr. Siemens's electric lift, which has been exhibited at the Mannheim Industrial Exhibition, is a useful invention. The cage is carried by wire ropes, having counter weights, so that the cage, when loaded, is practically in in equilibrium. The current-generator at the base is electrically connected to the dynamo-machine in the cage, and the latter actuates two toothed wheels taking into a metal rack running up the centre of the passage-way of the lift.

Herr … … Smith …

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Eng Mech … Jan 7 1881

26 32

Eng Mech & Wld Science March 18, 1881

An apparatus for determining the velocity of a projectile in cannons and rifles, is described in the *Revue d'Artillerie*. It is the invention of MM. Siemens and Halske, and seems in the main a development of previous methods. The projectile passing along the bore brings the bare ends of several insulated wires into contact with the gun, and on each contact, a platinum wire opposite a rotating blackened drum, delivers a spark, marking the surface. This is effected through the agency of an induction apparatus, and a battery of 8 Leyden jars, the former being connected with the outer surface of the jars, and the interior of each of the latter with a gun wire. The highest knob of the batttery is connected with the platinum wire which gives the sparks. As the projectile makes contact, the positive electricity of the wires flows to earth, and the spark passes.

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Two ingenious pieces of electrical apparatus for lighting and extinguishing lamps have recently appeared. In one of them (M. Margret's system) the oil-lamp stands on a base in which is a horizontal electro-magnet. From the armature of this rise two parallel curved rods of copper, joined at the top by a platinum spiral, which is rendered incandescent by a battery current, and brought in that state to the wick, when the armature is attracted. In this movement towards the wick, a small bellows is compressed, giving a puff of air through a tube rebounding on the wick. In the case of lighting the lamp, this puff has no effect, but when the lamp has been burning, and is to be extinguished, the puff produced by a momentary passage of the current blows the flame out, and there is not time for the spiral to relight the lamp. In the other system (that of M. Ranque), a platinum spiral is brought to the wick, much in the same way, but the lamp is put out by an extinguisher at the end of a curved and pivoted wire. The contrivance is such that the extinguisher is brought down to the wick, or raised from it (through attraction of the armature) according as the flame is to be put out or lit. (Both lamps are figured in *La Nature*, No. 401.)

Ironmonger. Apr. 16. 1881.

Electric Apparatus.—There is a pretty good demand for electric apparatus, and the question of electric lighting appears to be disturbing the municipal mind both in Manchester and Salford. Although nothing very definite seems yet to have been done in the matter by either body, the conversation I have had with members indicates that they are looking upon the progress of the electric light as making it a very probable competitor with gas for street-lighting. Amongst other descriptions of electric apparatus, I may record that Messrs. W. H. Bailey, of Manchester, are manufacturing for the lunatic asylums an apparatus for recording the punctuality of the visits of the night nurses and watchmen through the various wards. These have lately been fixed at Hereford and Chester asylums, and orders have recently been received from other establishments.

Amer. Press

W. Science

et des ouvertures ne dépassant pas trois quarts de millimètre de diamètre.

Cette lampe présente cette propriété remarquable que, malgré la température élevée de la combustion, elle s'échauffe peu, consume très-peu de pétrole, et ne charbonne presque pas, si bien qu'elle fonctionne pendant plusieurs journées sans qu'on ait besoin de toucher à la mèche et de renouveler le liquide.

Cela tient à ce que la mèche ne dépasse pas le cylindre qui la contient, que la flamme intense est produite par la combustion de la vapeur du pétrole et au centre du bec, de telle sorte qu'elle est séparée de lui par une couche gazeuse mauvaise conductrice. Il en résulte que même après plusieurs heures de fonctionnement continu, il y n'a de chaud dans la lampe que la partie supérieure du bec.

Le seul inconvénient de la lampe est qu'il se produit de temps à autre, dans l'ouverture donnant accès à l'oxygène, un léger dépôt de matières étrangères carbonisées sous forme d'une sorte de petit cône incandescent; mais on le fait disparaître sans difficulté en soufflant dessus ou à l'aide d'une petite tige, sans éteindre la flamme.

En revanche, la lampe présente, au point de vue spécial qui nous occupe, une propriété particulièrement favorable. Lorsqu'on l'allume sans oxygène, elle donne une flamme fuligineuse qui n'éclaire pas; mais, quand on fait arriver le gaz, elle prend une intensité rapidement croissante et elle atteint son maximum dans un temps très-court; si bien que si l'on met la flamme intense au foyer d'une lentille, de façon à produire un faisceau lumineux parallèle sur un écran éloigné, ce faisceau est très-éclairant, tandis qu'il est à peu près obscur avec la flamme non alimentée de gaz.

Il en résulte la possibilité de faire varier rapidement son intensité d'une quantité considérable et, par suite, de l'utiliser économiquement pour faire des signaux lumineux intermittents.

Il suffit, en effet, pour arriver à ce résultat, de faire dégager l'oxygène brusquement au centre de la flamme et de le supprimer brusquement; on peut y parvenir de plusieurs manières. Celle à laquelle je me suis arrêté est la suivante : l'oxygène, enfermé dans un réservoir sous pression convenable, arrive d'abord à un manipulateur dont la forme est celle d'une clef d'appareil Morse, à travers un tube en caoutchouc, qui, à l'état de repos de la clef, est pressé dans une sorte de guillotine; puis le tube se continue jusqu'à la lampe.

Lorsqu'on abaisse la clef, la pression sur le tube cesse, et l'oxygène se rend dans la flamme; quand la clef se relève, le jet d'oxygène cesse, de telle sorte qu'on *manipule* en quelque sorte l'oxygène, à l'aide d'une manœuvre aussi simple que celle qui constitue la manipulation d'un courant électrique dans le système de Morse.

La rapidité de cette manipulation est plus que suffisante pour les besoins de la télégraphie optique, eu égard au phénomène de la persistance des impressions lumineuses sur la rétine, qui exige une certaine lenteur dans la production des signaux afin d'éviter leur confusion.

Ce système a été adapté à des appareils de télégraphie optique et il donne de bons résultats même dans la télégraphie militaire en campagne. A cet effet, l'oxygène est transporté dans des réservoirs en cuivre dont le poids n'excède pas 8 kilogrammes, et qui en contiennent environ 200 litres à la pression de 20 atmosphères. Dans les conditions habituelles, il y en a assez pour plusieurs jours de travail. Rien n'est plus simple d'ailleurs que de préparer de l'oxygène, de le refouler dans les réservoirs, et de transporter ceux-ci qui constituent un matériel peu encombrant.

Il est à remarquer que cette lampe n'a pas besoin de tirage; elle est donc sans cheminée. Il est vrai qu'il en résulte qu'elle fume quand l'oxygène n'y arrive pas, mais en plein air cela n'a pas d'inconvénient, et dans une station fixe il est toujours facile de se débarrasser de la fumée. Du reste, on peut y adapter, si l'on veut, une cheminée en tôle avec dés ouvertures bouchées par des lames de mica.

Quoi qu'il en soit, on voit que nous avons là une solution économique de la question de la production de signaux intermittents à l'aide d'une source lumineuse intense particulière.

Ces solutions peuvent être d'ailleurs rangées en deux catégories générales : 1° celles dans lesquelles on agit, pour produire l'intermittence, sur l'agent même de la combustion d'où résulte la source lumineuse, 2° celles où l'on agit sur l'agent combustible.

Dans celle qui vient d'être exposée, on agit sur l'agent de la combustion qui est l'oxygène, en rendant intermittent l'écoulement du gaz. Mais on pourrait aussi, si on ne voulait pas économiser l'oxygène, agir sur le combustible, en abaissant et soulevant alternativement la mèche imbibée de pétrole à l'aide d'un pignon à crémaillère, mis en mouvement à l'aide d'une clef Morse. Et, par exemple, on obtient facilement de bons résultats en ce genre en agissant sur une lampe ordinaire à pétrole, à mèche plate, alimentée à la manière ordinaire par un courant d'air, car au-dessous d'un certain niveau, la mèche ne produit qu'une combustion insignifiante, et sa flamme n'est d'ailleurs pas visible extérieurement, enfermée qu'elle est dans le petit dôme fendu en laiton qui existe dans toutes les lampes de ce genre, tandis que si la mèche dépasse tant soit peu ce dôme, la flamme prend immédiatement tout son éclat.

Cette étude avait été écrite (au point de vue particulier de ce Journal) en vue d'un mode d'utilisation économique de la *lumière électrique*.

Effectivement, on conçoit qu'on puisse appliquer les principes précédents à cette lumière, et obtenir deux solutions générales du problème résolu pour la lumière du pétrole oxygéné. Car on peut produire une lumière électrique intermittente; soit en agissant sur le combustible, les charbons, par exemple, entre lesquels se produit l'arc électrique, produisant, maintenant et brisant cet arc à l'aide de mécanismes convenables; soit en fermant, maintenant et rompant le circuit électrique de la pile ou de la machine qui produit le courant.

J'ai pu, en effet, réaliser ces deux solutions, et principalement la première, et c'est celle que je me proposais d'exposer ici, en décrivant les appareils que j'emploie à cet effet; mais,

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DR. SIEMENS' ELECTRICAL FURNACE.

At a meeting of the Society of Telegraphic Engineers, Dr. Siemens gave the following description of his electrical furnace:

Amongst the means at our disposal for effecting the fusion of highly refractory metals, and other substances, none has been more fully recognized than the oxy-hydrogen blast. The ingenious modification of the same by M. H. Ste.-Claire Deville, known as the Deville furnace, has been developed and applied for the fusion of platinum in considerable quantities by Mr. George Matthey, F. R. S.

The Regenerative Gas Furnace furnishes, however, another means of attaining extremely high degrees of heat, and this furnace is now largely used in the arts—among other purposes, for the production of mild steel. By the application of the open hearth process, 10 to 15 tons of malleable iron, containing only traces of carbon or other substances alloyed with it, may be seen in a perfectly fluid condition upon the open hearth of the furnace, at a temperature probably not inferior to the melting-point of platinum. It may be here remarked that the only building material capable of resisting such heats is a brick composed of 98.5 per cent. of silica, and only 1.5 per cent. of alumina, iron, and lime, to bind the silica together.

In the Deville furnace an extreme degree of heat is attained by the union of pure oxygen with a rich gaseous fuel under the influence of a blast, whereas in the Siemens furnace it is due to slow combustion of a poor gas, potentiated, so to speak, by a process of accumulation through heat stores or regenerators.

The temperature attainable in both furnaces is limited by the point of complete dissociation of carbonic acid and aqueous vapor, which, according to Ste.-Claire Deville and Bunsen, may be estimated at from 2500° to 2800° C. But long before this extreme point has been reached, combustion becomes so sluggish that the losses of heat by radiation balance the production by combustion, and thus prevent further increase of temperature.

It is to the electric arc, therefore, that we must look for the attainment of a temperature exceeding the point of dissociation of products of combustion, and indeed evidence is not wanting to prove the early application of the electric arc to produce effects due to extreme elevation of temperature. As early as the year 1807, Sir Humphrey Davy succeeded in decomposing potash by means of an electric current from a Wollaston battery of 400 elements; and in 1810 the same philosopher surprised the members of the Royal Institution by the brilliancy of the electric arc produced between carbon points through the same agency.

Magneto-electric and dynamo-electric currents enable us to produce the electric arc more readily and economically than was the case at the time of Sir Humphrey Davy, and this comparatively new method has been taken advantage of by Messrs. Huggins, Lockyer and other physicists, to advance astronomical and chemical research with the aid of spectrum analysis. Professor Dewar, quite recently, in experimenting with the dynamo-electric current, has shown that in his lime tube or crucible several of the metals assume the gaseous condition, as demonstrated by the reversal of the lines in his spectrum, thus proving that the temperature attained was not much inferior to that of the sun.

My present object is to show that the electric arc is not only capable of producing a very high temperature within a focus or extremely contracted space, but also such large effects, with comparatively moderate expenditure of energy, as will render it useful in the arts for fusing platinum, iridium, steel or iron, or for affecting such reactions or decompositions as require for their accomplishment an intense degree of heat, coupled with freedom from such disturbing influences as are inseparable from a furnace worked by the combustion of carbonaceous material.

The apparatus which I employ consists of an ordinary crucible of plumbago or other highly refractory material, placed in a metallic jacket or outer casing, the intervening space being filled up with pounded charcoal or other bad conductor of heat. A hole is pierced through the bottom of the crucible for the admission of a rod of iron, platinum or dense carbon, such as is used in electric illumination. The cover of the crucible is also pierced for the reception of the negative electrode, by preference a cylinder of compressed carbon of comparatively large dimensions. At one end of a beam supported at its centre is suspended the negative electrode by means of a strip of copper, or other good conductor of electricity, the other end of the beam being attached to a hollow cylinder of soft iron free to move vertically within a solenoid coil of wire, presenting a total resistance of about 50 units or ohms. By means of a sliding weight, the preponderance of the beam in the direction of the solenoid can be varied so as to balance the magnetic force with which the hollow iron cylinder is drawn into the coil. One end of the solenoid coil is connected with the positive, and the other with the negative pole of the electric arc, and, being a coil of high resistance, its attractive force on the iron cylinder is proportional to the electromotive force between the two electrodes, or, in other words, to the electrical resistance of the arc itself.

The resistance of the arc was determined and fixed at will within the limits of the source of power, by sliding the weight upon the beam. If the resistance of the arc should increase from any cause, the current passing through the solenoid would gain in strength, and the magnetic force, overcoming the counteracting weight would cause the negative electrode to descend deeper into the crucible; whereas, if the resistance of the arc should fall below the desired limit, the weight would drive back the iron cylinder within the coils, and the length of the arc would increase, until the balance between the forces engaged had been re-established.

The automatic adjustment of the arc is of great importance to the attainment of advantageous results in the process of electric fusion; without it the resistance of the arc would rapidly diminish with increase of temperature of the heated atmosphere within the crucible, and heat would be developed in the dynamo-electric machine to the prejudice of the electric furnace. The sudden sinking or change in electrical resistance of the material undergoing fusion would, on the other hand, cause sudden increase in the resistance of the arc, with a likelihood of its extinction, if such self-adjusting action did not take place.

Another important element of success in electric fusion consists in constituting the material to be fused the positive pole of the electric arc. It is well known that it is at the positive pole that the heat is principally developed, and fusion of the material constituting the positive pole takes place even before the crucible itself is heated up to the same degree. This principle of action is of course applicable only to the melting of metals and other electrical conductors, such as metallic oxides, which constitute the materials generally operated upon in metallurgical processes. In operating upon non-conductive earth or upon gases, it becomes necessary to provide a non-destructible positive pole, such as platinum or iridium, which may, however, undergo fusion, and form a little pool at the bottom of the crucible.

In this electrical furnace some time, of course, is occupied to bring the temperature of the crucible itself up to a considerable degree, but it is surprising how rapidly an accumulation of heat takes place. In working with

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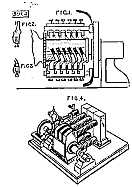
Nature, July 28th 1881.

Prof. Graham Bell has sought to prove whether the diaphragms subjected to intermittent radiation in one of the forms of the radiophone did or did not execute mechanical vibrations. The experiment of Mr. W. H. Preece of attaching a Hughes' microphone to the disk had led to negative results. But Prof. Bell has shown that the central region of the disk (on which the rays fall) is set into mechanical vibration; and he has proved the point by employing a modification of the mechanical microphone of Wheatstone. A stiff metallic wire is fixed to the centre of a thin metallic disk mounted at the extremity of a flexible hearing tube. When the end of the wire is pressed against any vibrating body its sounds are heard, and the vibrations at different points of the disk of a radiophone can be successively explored. The vibrations are found to be almost entirely confined to the illuminated area at the centre of the disk. A Hughes' microphone attached to the edges of the disk would therefore not easily give any indications. With this simple apparatus one very curious effect was obtained. An intermitted beam of rays was focussed upon a brass kilogramme weight, and the surface was explored with the point of the metallic microphone. Over all the illuminated area, and for a very short distance outside it a feeble but distinct sound was detected, but not over other parts.

The Electrician, June 11th 1881

3964. Improvements in Magneto or Dynamo-Electric Machines, P. Jensen.—Dated 30th September, 1880.—(*A communication from T. A. Edison.*) 10d.

The principal improvements described relate to (1) the commutator brushes. Each brush or spring is secured at an angle in a holder, so that the brush bears obliquely upon the commutator. The holder is pivotted on a U-shaped jaw. At the pivotted point of the holder is a chamber, in which is a spring, whose force is exerted to throw the brush upon the commutator. Figs. 1, 2, and 3 show the arrangement. (2) Describes how the prime motor is preferably connected directly to



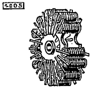
the dynamo machine, and both mounted on one base as on Fig. 4. Another part of the invention describes the means of communicating motion from the rotating armature to the driven mechanism without the use of belts, gear or similar devices. Further, the coil is so made as to be removed or repaired without disturbance of the remainder. This is accomplished by making of wire only that portion of the coil which is upon the operative face, the wires of a coil being connected at the ends by metallic plates, fastened to an insulating base, and insulated from each other.

The Electrician, June 11th 1881

4005. Improvements in Dynamo-Electric or Magneto-Electric Machines, E. G. Brewer.—Dated 2nd October, 1880.—(*A communication from A. J. B. Cance.*) 6d.

This apparatus is essentially composed of one or several induction crowns or rings on a support

4005



in the form of a wheel mounted on the shaft of the machine. The figure shows a double crown of these induction coils.

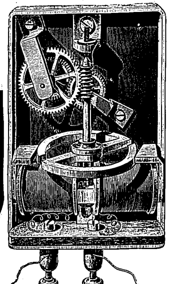
English Mechanic & World of Science August 19, 1881.

[44171.]—Electric Clocks.—Although unable to answer the first part of this query, I may tell "M.M.I.Sc.S." that it is certainly not necessary for the controlled pendulum to swing the opposite way to the standard one. They may just as easily be made to swing in the same direction by properly arranging the currents and magnets; at the same time, it doesn't matter a pin which way they swing. As to the number of cells required, it evidently depends upon what cells are used, and the resistance of the circuit; but I think there are not many electric clocks capable of being driven for any length of time by one cell. I am at present engaged experimenting upon a system in which the controlled pendulum beats half-seconds, and only receives its impulse every second, or every two seconds with a more powerful battery. This bids fair to be successful. I have had one clock going a considerable time all right, and am now making another on the same principle, but simpler in construction, more independent of variations in battery power, more compact, and last, but not least, noiseless. If successful, will report to E.M. —J. E. Floyd.

36 Scientific Am. Nov. 5. 1881.

ELECTRIC CLOCK-DIAL MECHANISM.

The construction of a perfect electric clock involves several difficult problems, and it is this which explains in part the existence of a large number of electric clocks varying in efficiency according to the attention paid to the fundamental principles which should control their construction.



ELECTRIC CLOCK-DIAL MECHANISM.

Electricity actually plays three very distinct characters in the electrical clock, and the Paris Electrical Exposition presents numerous examples of this:

1. Electricity is made use of as a motive power, to swing a pendulum and replace the springs or weights of an ordinary clock.

2. Electricity is employed for transmission. A central clock sends an electric current every second, half minute, or minute, to one or more dials placed at a distance, which causes the hands to advance respectively a second, a half minute, or a minute.

3. Electricity is employed to regulate clocks and dials propelled by ordinary weights and springs, and adjusts the hands every hour, every six hours, or every twenty-four hours. It is this system of synchronism which has been adopted by the city of Paris for the public clocks.

We do not wish to discuss here the respective advantages of the two systems of distribution of time in a city by electric transmission or by electric adjustment effected at fixed intervals. The electric distribution of time has some special advantages which are not possessed by the system of electrical adjustment, and the disadvantages disappear in proportion as the apparatus is perfected and simplified. The pneumatic clock established in Paris two years ago has a transmitter operated by compressed air.

The engraving represents a simple electrical dial mechanism which exactly fulfills the requirements, working surely each minute under the action of the current sent by the central distributing clock.

All of the earlier forms of electrical dial apparatus are operated by an oscillating armature, moved by an electro-magnet and retracted by an antagonistic spring, or two electro-magnets acting upon a polarized armature. The movement of the armature is transmitted to the gearing by the levers and pawls, which must be very perfectly adjusted, as they cease to act if there is a little play, wear, or oxidation. In order to give a slight movement to the armature it is necessary to lengthen the lever immoderately.

All of these inconveniences are avoided in the very simple apparatus of M. Thomas, the mechanism of which is represented in the engraving. It is composed of a horizontal electro-magnet, the poles carrying two armatures, between which is placed a polarized armature in the form of an S, fixed upon a vertical axis. This axis carries an endless screw, which operates the minute hand and gearing. The transmitting clock sends into the electro-magnet alternate positive and negative currents at every half minute. The current sent is such that it develops in the poles of the electro-magnet alternate positive and negative polarity, so that the polarized S-shaped armature is first attracted and then repelled, causing a half revolution of the S-shaped armature for every electrical impulse. The current should continue from two to three seconds, in order that the polarized armature may be maintained in position. The endless screw carries along the gearing and causes the hands to advance each time.

In consequence of its inertia the polarized S shaped armature tends to pass beyond its half revolution, and the speed acquired toward the end of the half revolution is checked by means of a spring against which a pin carried by the vertical spindle strikes at each half revolution.

This simple and ingenious apparatus requires no regulation. The rotation will be produced, whatever may be the distance from the extremities of the polarized armature to the electro magnet, and this distance may vary from one to two millimeters.

The power of the apparatus is determined by the dimensions of the S shaped polarized armature of the electro-magnet, and by the size and length of the wire which surrounds them.

By using a high tension current of electricity a large number of these electrical dial movements may be placed upon the same circuit and made to operate dials of two meters in diameter.

At the Exposition of Brussels, in 1880, where the electric dial mechanism of M. Thomas was in operation for the first time, he had in the same circuit a large dial of 1·80 meters in diameter and eighteen other smaller dials of 0·50 meter and 0·40 meter. They worked perfectly, excepting the five or six interruptions proceeding from the stopping of the transmitting clock caused by the moving of the platform on which the clock was placed.—*La Nature.*

The Iron age
Nov. 27, 1882

Electricity Displacing Watchmen.

Application has been made by Pittsburgh parties for a charter for a corporation whose projectors claim will control a system for the prevention and detection of burglaries and fires, which will not only throw all the private watchmen in the two cities out of employment, but make Pittsburgh and Allegheny an exceedingly unhealthy place for law breakers generally. The corporation is to be known as the Stern Electric Alarm Company. As set forth in its charter, its objects are the prevention and punishment of theft and willful injury to property. The inventor is W. A. Stern, who for many years was associated with Edison. The company was organized several months ago, and by the first of next month expects to be ready for business.

The manner in which the plans of burglars are to be frustrated is thus explained by Mr. Stern: "Central stations will be established in Pittsburgh, Allegheny and the East End, and at each of these a good force of careful and experienced officers will be located night and day. Banks, business houses and private residences will be connected with these stations by wire, and will be so completely protected that even persons who have a right to do so cannot enter without the central station being notified. The plan is very simple. Windows and doors will be supplied with simple electric appliances in such a manner that their presence cannot be detected. The instant an attempt is made to open a door or raise a window a gong in the central office will ring, and an annunciator similar to those used in hotels will indicate the number of the building entered. For bank vaults or other places requiring extra precautions the doors or panels will be lined with electric wires so fine that a coil weighing 1 pound is 3 miles long. These wires will be so close together that, even if their presence or location is known, entrance cannot be effected without breaking or disturbing one or more of the wires, and so sounding the gong in the central office. One or more men will answer each alarm. The stations may be so close to the subscribers that any one can be reached in three minutes. The intruders will not know that an alarm has been sent in, and very few can do much in three minutes."

The electric current is also to be utilized in the detection of fires. Ceilings and other portions of buildings will be studded with thermostats—brass instruments about the length and thickness of a man's finger. These are so susceptible to heat that a match held for a quarter of a second within 6 inches of a thermostat will cause it to ring a gong miles distant. The fire-alarms will be taken on a separate gong from that recording the visits of trespassers. The fire department will be immediately notified, and in addition trained men will be sent to the place.

The company expects to begin business with 200 subscribers. Joseph T. Speer is president and Heber McDowell general inspector. C. F. McKenna, R. P. Duff, D. H. Gilkinson and P. M. King are among the directors. These gentlemen all claim that the Stern system has been thoroughly tested, and that there is no doubt of its practicability. The cost of the apparatus, they say, will average less than is now paid for private watchmen.

Iron - Jan 27, 1882 37

THE TELERADIOPHONE.—M. Mercadier, the eminent French electrician, has ingeniously adapted the photophone of Professor Bell to telegraphy. In the photophone a ray of light is reflected by a mirror, so as to fall upon the sensitive surface of a "selenium cell" joined up in the circuit of a voltaic battery and a speaking telephone. When the light strikes the cell its electric resistance is diminished, and a wave or pulse of current flows through the telephone, causing it to sound. By eclipsing the ray of light a great many times per second, this sound can be exalted into a continuous hum, like that of a tuning fork, and by again occulting the intermittent ray for long and short intervals corresponding to the flashes of a signalling lantern, this hum or drone can be broken up into audible signals. Thus, if the Morse telegraphic code is used a short occultation, producing a short pause in the note of the telephone, will stand for a "dot" and a long occultation, producing a long pause, will stand for a "dash." This photo-electric telegraph is realised by M. Mercadier with the help of a gas flame forming the source of light, a mirror and lenses to direct its rays upon the selenium cell in circuit with a battery and the line wire. The beam is regularly eclipsed by means of a rapidly rotating disc, perforated with a circle of holes, and the telegraphic occultations of the intermittent beam are effected by means of a signalling key, which interposes a dead screen in the track of the light whenever the key is pressed. These apparatus form the transmitter, and the receiver at the other end of the line is of course the telephone, which is fitted with a resonator to reinforce the sound. There is no gain in such an arrangement over the ordinary telegraph now in use; but it has the merit of lending itself to multiple telegraphy. Thus, by multiplying the number of transmitters at one end of the line and the number of telephones at the other, several different messages can be sent along the same wire at once. In order to do this it is only necessary to rotate the eclipsing wheels at different speeds, so as to produce notes of different pitch in the receiving telephones, and to fix each resonator so as to enhance a particular note. Then, although the complex current flows through all the telephones in turn, each telephone will only render to the ear of the clerk the particular note for which he listens, and the makes and breaks of that note will be interpreted as the message. Not only can several messages be sent in one direction along the same wire together, but from opposite ends simultaneously without confusion, and M. Mercadier reckons that with 10 transmitters and 10 receivers at each end of a line he can send 200 despatches of 30 words each per hour, or 100 words per minute, in either direction. The effects of induction, so troublesome in speaking by telephone, are not experienced in this process owing to the employment of musical notes and resonators.

Engineering Aug 84

An Electric Head Light.—An electric head light has been fitted experimentally to one of the engines of the Chicago, Milwaukee, and St. Paul Railroad. This application of the electric light is the invention of Mr. Wooley, of Indianapolis. Some days since his agent sought permission of the superintendent of the Chicago division of the Chicago, Milwaukee, and St. Paul Railroad to place one of his lights, with its engine, on one of the company's locomotives. The apparatus, which consists of a small $1\frac{1}{2}$ horse-power rotary engine, and a box about 2 ft. square by 8 in. in thickness, containing the dynamo, &c., was placed upon the engine, directly in front of the cab on the left-hand side. The focus had been so adjusted as to cast the light a little to the right of the centre of the track. The light was exceedingly brilliant, and its power was estimated to equal 2000 candles.

Engineering Oct. 1884

Position of the Poles of Magnets.

Messrs. W. Hallock and F. Kohlrausch have made a number of experiments on ordinary long bar magnets in order to determine with exactitude the true position of the poles in the length of the bars. Fourteen magnets were used, some of various conditions of hardness, and in general they were in the form of steel cylinders magnetised in the direction of their axes. Their results, taken in connection with those of Schneebeli and Helmholtz, agree in showing that the effective poles of a magnet are about one-twelfth of the distance of the length from the ends. This result is, according to the observers, in all probability correct to within five per cent.

Light and the Electric Resistance of Metals.

Mr. Arthur E. Bostwick has made an elaborate series of experiments on the supposed influence of light in altering the resistance of metals. Since the diminution of resistance of selenium, when a ray of light falls upon it, was discovered by Messrs. May and Willoughby Smith, Dr. Richard Börnstein has attempted to show that not only selenium and tellurium possess the property in question, but other metals such as gold, silver, platinum, also possess it. This effect was not verified by Siemens and Hausemann, of Berlin, and now Mr. Bostwick's researches have not established the fact asserted. His conclusion is that "if light causes any diminution in the electrical resistance of metals, it probably does not exceed a few thousandths of one per cent."

A Tell-Tale Electric Bell.

In order that the person ringing an electric bell may be able to tell whether, on making contact, the bell actually rings, Mr. Douglas Mackenzie has devised the following arrangement. Besides the press-button, and let into the wall, is a simple telephone receiver of the Elisha Gray or Bell model, and consisting of an electro-magnet with a soft iron plate armature free to vibrate over one of its poles. The sounding or "clicking" core of Page may also be employed instead of the diaphragm armature. This electro-magnet is formed up in circuit with the bell and battery, so that when the bell is in action, with its contact interrupting the current, the telephone or electro-magnet will emit a musical note or hum, which, when heard by the person ringing the bell, informs him that the bell is ringing, always supposing that the current is strong enough.

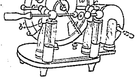
English Mech. & World of Science

July 25, 1884

THE TOEPLER-HOLTZ ELECTRICAL MACHINE.

THE following description of the Toepler-Holtz machine is given by Mr. H. W. Eaton in *Science*:—

Consider the machine before you, the revolving plate in front. Designate the right-hand paper sector by a, the brush connected with it by b, the comb connected with the discharging-rod by c, the comb in metallic connection with a similar comb diagonally opposite by d, and the corresponding parts on the left-hand side by a', b', c', and d'. If the left-hand sector, a', be charged with negative electricity, it draws positive electricity from the comb d' upon the revolving-plate, which is supposed to move in the direction of the hands of a watch. When the positive electricity on the plate reaches the brush b, it draws negative electricity from the brush, and leaves the sector, a, charged with positive. This positive electricity on the sector, and the positive that is left on the plate, both draw negative from the comb c, and leave the discharging-rod connected with it charged with



positive electricity. The plate, now nearly neutral, passes under the diagonal comb, d, and from it receives a charge of negative electricity, drawn out by the positive on the sector, a, which at the same repels positive electricity along the diagonal, and out of d' upon the revolving-plate. The plate, now charged with negative electricity, passes under the brush b', draws positive electricity from it, and thus increases the negative charge on the sector, a'. The residue of negative electricity on the plate, and the negative on the sector, both draw positive from the comb c', and leave the discharging-rod connected with it charged with negative electricity. The plate, now nearly neutral, passes to our starting-point, d', and the process is repeated. If the machine is operated in the dark, the brush, b', and the points on c' and d', will be tipped with the well-known positive brushes, while b, c, and d will show only the negative glowing points. The relative lengths of the brushes on c' and d' will depend on the position of the discharging-rods. If a is negative in the place of a', the position of the brushes will, of course, be reversed. The nature of the electricity on any part of the machine may be tested by bringing the point of a lead pencil near it, and noticing the form of the discharge from the point.

The great use of the knobs on the revolving-plate is to keep the paper sectors charged. Two knobs give better results than the usual six o eight; the reason apparently being, that the larger number of knobs keep the sectors overcharged, and there is a continual loss (by brushes from the sectors) of electricity that would otherwise remain on the revolving-plate, and help to increase the charge on the discharging-rods.

Somewhat longer sparks are also obtained by connecting the sectors and discharging-rods on the same side by conductors; but the machine, thus arranged, reverses more readily, does not give sparks so rapidly when the discharging knobs are near together, and is started by separating the knobs.

In some forms of the machine used in Germany the fixed plate is in two parts, separated by a vertical air-space. This is an improvement, because it prevents the electricities of the two sectors from uniting across the surface of the plate. Machines of this sort sometimes have as many as sixty revolving-plates, all on one axis. Such machines give large quantities of electricity, but not very long sparks.

The following experiments, not generally known, illustrate the power of the single-plate machine. If a strip of vulcanite about two inches wide is moved to and fro in front of the positive pole, the length of the spark will be greatly increased, sometimes reaching five inches and a half on a machine whose revolving-plate is only ten inches and a half in diameter. If a drop of stearine is placed on a thin sheet of glass, which is too large for the spark to pass around the edges, and the glass is held between the discharging-knobs of a good ten and a half inch machine, with the drop toward the positive knob, the spark will pierce the glass when the knobs are about one inch apart.

Competitive Trial of Electric Launches.—A company of seven in the Electricity, including Mr. Courtenay, managing director of the Storage Company, Mr. Simpson, representative of Messrs. Siemens, Mr. Thornton, and others; a company of eight in the Australia with Mr. Stephens, Lieutenant Robinson, R.N., H.M.S. Vernon, Mr. A. Reckenzaun, and others started from Millwall at 1.55 on Saturday last, arriving at Charing Cross at 2.32, the Australia leading. The Reckenzaun motor on board the Australia took a current of 37 ampères with 100 volts. The Siemens O_2 propelling the Electricity consumed 47 ampères with 80 volts, but the accumulators of the Electricity were heavier than those on the Australia. The boats returned from Charing Cross at 2.40, made two stoppages of about ten minutes each, and arrived at Greenwich pier at 4.10 p.m. Both launches cruised about until six o'clock, when they were docked at Millwall on the Storage Company's wharf. The proceedings were very successful, and the whole party, consisting of some twenty-four gentlemen, some of whom were on the steam launch, expressed their admiration and congratulations. The cost of the Australia complete is 200*l*.

Engineering Sept 26/84

starting-point, was not placed high enough. It appeared that the Carrels, neglecting their instructions, had made a push towards the summit, but had reached a height of only about 19,000 feet. As they were quite unencumbered, carrying no instruments, and only enough food for their own use, and had no traveller to look after, and yet came back quite exhausted, it was obvious that we should have to get still higher up before we could make a serious effort to reach the summit. So, as soon as he was well enough, I sent Louis with Perring down to the first camp to fetch up a tent, which had been left there, and when this arrived we were in a position to go forward again.

"On the following morning I went myself up the ridge to look for a higher camping place, and found one on the eastern side on some broken rocks, at a height of 17,400 feet. By this time I was in rather better condition than the Carrels. Feverishness had disappeared, and my blood had resumed its normal temperature. The gaspings had entirely ceased, and headache had gone. You will perhaps inquire how I knew that I was feverish; for in regard to this matter one is often mistaken, and fever is supposed when it does not exist. By the advice of the distinguished physician whose name has been already mentioned, Dr. Marcet, I had provided myself with a registering clinical thermometer for the purpose of taking blood temperature at great elevations. This was duly done, and in respect to this matter nothing more need be said than that at our greatest heights the temperature of the blood was (just as it is at the level of the sea) higher during periods of warmth, and lower when it was unusually cold; but stood at its normal height, when the thermometer was at 60° or thereabouts, and did not appear to be affected by low atmospheric pressure at all. In recommending me to take this little instrument (which I have in my hand), Dr. Marcet rendered me a great service; and amongst all the devices and instruments which have been pressed upon the attention of travellers in general, of late years, I know nothing equal to it in importance. By constant observation, I was able to detect the earliest advances of fever; and by taking proper steps in time, was able to get through the entire journey without having an attack of fever worth mentioning. Its expense is trifling, and it can easily be carried in the waistcoat pocket. When we were first laid on our backs by mountain sickness, it showed that my blood temperature mounted to 100°·4, but by the end of the year it had fallen to its usual height, viz., 98°. Still, although the more disagreeable symptoms had gone, we found ourselves remaining comparatively lifeless and feeble, with a strong disposition to sit down when we ought to have been moving." * *

Mr. Whymper then described his first ascent of Chimborazo, and concluded his account of this mountain by saying, "My residence on Chimborazo thus extended over seventeen days. One night was passed at a height of 14,400 feet, ten at a height of 16,500 feet, and six at 17,300 feet. During this time, besides ascending to the summit, I also went three times as high as 18,500 feet. When we quitted the mountain, *all trace of mountain sickness had disappeared*, nor did it touch us again until we arrived at the summit of Cotopaxi. * * *

"The height of Cotopaxi is 19,600 feet. Our camp was placed about 130 feet below the loftiest point, and it was the most elevated position at which any of us had ever slept. We remained there twenty-six consecutive hours, feeling slightly at first the effects of low pressure, having the same symptoms as we had noticed on Chimborazo; and we used chlorate of potash again with good effect. All signs of mountain sickness had passed away before we commenced the descent, and *they did not recur again during the journey.* * * * * *

"This, ladies and gentlemen, nearly brings my remarks to a close, and, in conclusion, permit me to say a word more in respect to mountain exploration in general. Amongst certain persons it is still fashionable to affect a description of scorn, bordering on contempt, for anything in connection with mountains and mountain work. None of us feel, perhaps, very deeply the criticism of those who are evidently ignorant of the subjects on which they talk; and, in this matter, speaking for myself, I rather look forward to the time, which will surely come, when the study of mountains, the ascent of mountains, and even prolonged residence on mountains, will be found essential for the prosecution of a score of sciences. Before this could be carried out, it was necessary to learn whether life could be made endurable at great heights. We were always haunted by the fear of an invisible enemy who might strike us down at any moment. What we wanted to know was, not whether life could exist at a height of 20,000 feet (that was settled seventy-five years ago, by Lussac), but whether man could become so far habituated to the low pressure which is experienced at that height, as to be able to live without inconvenience, and to do useful work. I went to the Andes in search of an answer to these questions, you have heard the story, and can form an opinion whether it affords encouragement for the prosecution of exploration in other quarters."

ON SOME POINTS RELATING TO THE DYNAMICS OF "RADIANT MATTER"

As the important researches of Mr. Crookes may be said to have made the evidence of the molecular state of matter (grounded on indirect reasoning) almost ocularly visible—the mechanics of gaseous matter therefore acquires a fresh interest. As some years back the present writer devoted much thought to the clear realisation of the nature of the motions of the molecules of gases in connection with a proposed explanation of the mode of propagation of sound on the basis of the kinetic theory (published in the *Philosophical Magazine* for June, 1877), it then appeared to him that the systematic *regularity* of the motions of the molecules of gases was not in practice so generally appreciated as it might be; although of course the mathematical basis of the subject was well established. It has been not unusual to speak of the extreme "irregularity" of the normal motions of gaseous molecules—which is undoubtedly true of any molecule taken individually. The comparison of the molecules of a gas to a "swarm of bees" (sometimes adopted), though no doubt highly convenient and useful to aid the conceptions in some respects, has probably gone to support (rather than not) the idea of a kind of confusion in the motions of the constituent molecules of gases; whereby the systematic *regularity* (or symmetry of the motion) tends to be left out of view. This will perhaps appear more evident if I state the following proposition in regard to a gas, which is only a direct corollary from the established mathematical principles—true in every state of the gas, but emphasised by rarefaction.

The normal motion of the molecules of a gas takes place in such a way, that every point in the gas is a "radiant point," such that matter passes to and from that point (to a certain distance) in the direction of rays: i.e. *as if a luminous point were situated at the point in question.* Or more generally put: If finely subdivided matter be in motion in space according to its own dynamics, every point of space becomes a radiant point; the extent of the radiation of matter depending on its fineness (other things being equal).

It is, I believe, the losing sight of the systematic regularity (or symmetry) of the motion of the molecules of a gas in its normal state, which (as it would seem, at least) has caused the connection of gaseous motion with the conditions for gravity to be overlooked—or the fact to escape realisation that on rarefying the gas, this symmetry of motion (existing in the normal state of the gas) gradu-

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Eng. Mech. & World of Science Jan. 23, 1885

THE LARGEST ELECTRICAL INFLUENCE MACHINE IN THE WORLD.

THERE has just been completed for the physical laboratory at South Kensington, the largest electrical influence machine in the world. It is made on the now well-known pattern of the Wimshurst machine, and was constructed by Mr. Wimshurst himself for the laboratory at cost price. The discs are 7ft. in diameter, of plate-glass, ⅜in. thick, and weigh 280lb. each. They are pierced with a central hole 6in. in diameter, and are firmly attached to gun-metal bosses 15in. long, which run freely on an iron tube 3in. in diameter. This tube is supported by Λ frames of oak, having heavy gun-metal caps so shaped as to afford a support for the iron tube and ebonite rod to which the collecting combs and discharging terminals are attached. The "neutralising" rods of brass, with their fine wire brushes, are attached to the projecting ends of the iron tube, while the pulleys are firmly secured to the outer ends of the gun-metal bosses. The discs, which are varnished with shellac dissolved in alcohol, have each 16 radial sectors of tinfoil 19in. long, with a mean width of 1·65in., thus having an area of 31·35 square inches each, or a total metallic surface on each plate of more than 500 square inches. The collecting combs are connected to the discharging terminals by interchangeable brass rods, bent or straight, so that the position of the combs with respect to the horizontal diameter of the discs can be varied within about a 16in. range, that is 8in. above and below a line representing the horizontal diameter of the plate. The discharging rods are of 1½in. brass tubing, and are fitted with interchangeable brass balls of different diameters. The distance apart of these balls can be varied by turning the glass handles at the other end of the discharging rods, which are made to revolve around a vertical axis, so that the terminals can be separated by any desired distance. At the time of writing, we believe, the machine has not been tried under favourable conditions; but in the workshop, surrounded with a variety of metallic conductors, and in an atmosphere rendered rather damp by the escape of steam from a boiler and engine at work, it started at once, and maintained a constant stream of sparks 14in. in length—a performance which will no doubt be improved when, under the care of Prof. Guthrie, it is fully tested in the laboratory at South Kensington.

Engineering Feb. 13/85

ELECTRICAL SURGERY.

M. Chéroy submitted to the Academie des Sciences during its séance of February 3 a new cauteriser fed by secondary batteries. A great difficulty attending the use of such an instrument, especially in localities where surgeons have not a dynamo at their disposition, lies in the charging of the accumulators. M. Chéroy proposes to effect this either by the use of a hydro-electric battery, or, where lighting gas is available, by means of a thermo-electric pile. In the first case he employs a vert-de-gris battery, without a porous cell with zinc plates. The electromotive force of the accumulators being 2 volts, the battery is so arranged as to have 2½ volts, and to give a flow of six ampère hours. From sixteen to twenty-four hours are required for charging. In the second case the battery is composed of ninety thermo-electric elements working by gas or probably by petroleum. The constants are 4 to 5 volts and 4 to 6 ampères.

Engineering Feb. 13/85

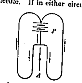
ELECTRIC GAS LIGHTERS.

At the International Society of Electricians, M. Napoli submitted, on behalf of M. Arnaux, a number of electric lighters all based on the same principle. The principal organ is a tube, about the size of an ordinary lamp chimney, in which is placed a stick of carbon of the same length as the tube, a bar of zinc, one-third the length, and an exciting liquid which when the instrument is vertical does not touch the zinc. By reversing the apparatus, a current is generated which is used either to redden a thin platinum wire, or produce a succession of sparks between two terminals. Another instrument by the same maker, is employed to detect gas escapes. It consists of a similar reversing battery, and a supplementary part in which is a platinum wire inclosed within a fine wire gauze envelope, the line being brought to red heat by the current. In the event of a gas escape, the temperature of the wire is increased, and by a somewhat complicated system a signal bell is set ringing.

Engineering - Feb. 13/85

THE INTERNATIONAL SOCIETY OF ELECTRICIANS.

Several interesting papers were read at the recent meeting of the International Society of Electricians, held at Paris on the 4th inst. One referred to a so-called Microhmeter, devised by M. Maiche, for the measurement of small resistances. The accompanying diagram will give a clear idea of the instrument, which was made by M. Carpentier. The circuit of a battery P is divided into two parts as shown. A suspended magnet A is placed between the branches of the circuit, and it is evident that if the current is equal in each, there will be no deviation of the needle. If in either circuit a resistance



of unknown value is introduced, it will produce a deflection which may be counterbalanced by introducing in the other circuit a series of known resistances, until the total equals the unknown resistance. Or the same result can be obtained by gradually removing the wire which affects the needle; indeed the principle of the apparatus is based on this method. The circuits are replaced by coils, and the displacement of one of them gives upon a graduated scale the measure of the resistance sought. This little instrument, which is simple, cheap, and easily used, measures extremely small differences of resistance.

43

JAMIESON'S ELECTRIC GOVERNOR.

Fig. 1.

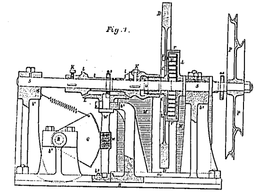
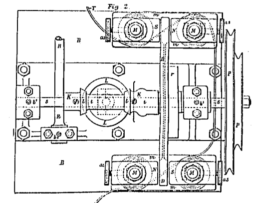


Fig. 2.



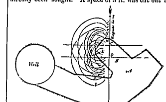
accident. The essential condition is that the pontoon shall rise with its upper surface perfectly horizontal, whether the load be exactly in the centre or not, and shall maintain its position as the car is moved along it, and while the weight is being transferred from the centre to the end, and is finally removed to the shore. In the engraving the pontoon is shown in its highest position, and the dock is represented by a wrought-iron tank partly decked at either side, and thus hiding a part of the pontoon. The deck is cut away in two places to allow the towers to pass through it. These towers are of such a length that the machinery they bear on their summits never descends below the level of the dock wall. They carry a set of hydraulic pumps which are connected by pipes with a system of hydraulic presses mounted on an intermediate deck of the pontoon about 6 ft. below the upper surface. The rams of these presses are visible in the figure, and are seen to be arranged in seven longitudinal rows. They are also disposed in rows crosswise, the central rows comprising seven presses, and those nearer the ends five and three presses respectively, while at the extreme ends there is only one longitudinal row, and consequently the cross rows become single presses. The aggregate area of the rams in each cross row, whether it contain one, three, five, or seven presses, is always the same, and as they are all exposed to the same water pressure per square inch, it follows that the lifting action per unit of length of the ship is equal. Of course a vessel does not weigh an equal amount per foot run from end to end, but her girder-like form is well capable of transmitting a part of the load amidships to the bows and the stern. In lifting the vessel, the pressure of the rams is transmitted through columns fitted with keel and bilge blocks, as will be explained when we come to the car. All the presses are connected to the same pipe, which affords communication with the pump in the tower, and thus the pontoon can rise and fall without in any way interfering with the action of the rams. Provision is made also for arranging the presses in groups if desired, and transmitting a different pressure to each group.

The pontoon is made to rise and fall quite vertically by the four sets of hydraulic rams shown at the corners of the docks. Each set consists of two cylinders and two rams, the cylinders being fixed to the dock wall, and the rams to the pontoon. One cylinder is inverted and projects upwards, working over a ram standing upon the deck of the pontoon, while the other cylinder hangs downwards, and has its ram connected to the pontoon by two side rods. The cylinders at the diagonally opposite corners are connected together in pairs, the inverted cylinder being coupled to the upright cylinder and *vice versâ*. The whole system is filled with water, and a moment's consideration will show that the water forced out of one press must be received in the corresponding one, and that this is only possible when the plungers move at similar rates. Supposing that, as the pontoon stands in the engraving, 100 tons were piled at one end. That end would immediately begin to sink, but in doing so it would force water out of the two upright presses into the two inverted presses at the opposite ends, and the other extremity of the pontoon would be pressed down at exactly the same speed as the loaded part. Such a case assumes the structure to be floating idly with no reserve of buoyancy, a condition in which it would be manifestly impossible to run a heavily laden car upon it. In actual work it is guided in its rise and fall by large pillars acting as anchor rods, and when it has attained the proper level these rods prevent any further rise. The pumping is then continued until the pontoon is sufficiently buoyant to receive its full load without sinking at all, and then the only influence of an unequally distributed weight is to create a hydraulic pressure which holds down the opposite end of the structure and keeps the whole horizontal.

(*To be continued.*)

FINDING A BORE HOLE.

IN sinking a well at the Holyrood Brewery of Messrs. William Younger and Co., Edinburgh, it was considered necessary, after the bore hole had gone down 200 ft., to connect it by a mine with a neighbouring well 18 ft. 3 in. distant, centre to centre. The miner was entrusted with the work, but, owing to one of his plumb-lines not hanging vertically, he cut his gallery in the wrong direction and failed to find the bore hole. A mining engineer was then sent down, and he showed where the hole ought to have been, but as it was not to be found at that spot, it was evident that it had diverged from the vertical. The ground had already been cut away all round the place, and an unsuccessful attempt had been made to locate the hole by the device of listening while the rods were shaken within it. It therefore appeared that large quantities of ground might have to be excavated before the hole could be found. At this point Mr. Andrew Haddow, engineer to Messrs. Younger and Co., took up the question, and located the hole by an extremely ingenious and, we believe, perfectly novel device. Referring to the accompanying engraving, A represents the place where the bore would have been found if it had descended vertically, and where it had already been sought. A space of 3 ft. was cut out all



round this spot, and the mine extended 6 ft. further before Mr. Haddow attempted to indicate the position of the hole by the happy device of passing a magnet down it, and noting its effect on a compass stationed in the mine. He procured four 8 in. bar magnets, which he put end to end and secured between two laths of wood. These were lowered into the bore with the south pole downwards. The north end of the compass needle moved first to the west, then to the east of zero, which showed that the magnets were on the west side of the compass, and led to the mine B being cut. While this was proceeding Mr. Haddow set the compass on a table and passed the magnet round it; finding a number of points on the floor where the deflection of the needle equalled ½ deg., he then drew a line through the points found. He did the same for other deflections and thus produced a series of curves. The compass was then stationed at the points C and D in the mine and the deflections noted. The points C D were marked on the plan and a tracing of the magnetic curves set over each point as shown. The observed deflection at C was 3¾ deg., and at B, 6½ deg. The bore E was found where the curves corresponding to these deflections crossed one another, being about 8 ft. from the expected position.

JAMIESON'S ELECTRICAL GOVERNOR.

IN a paper lately read by Mr. Andrew Jamieson before the Institution of Civil Engineers, he laid it down that a primary requisite in electric lighting was a good electrical governor, which should automatically open and close the throttle valve in synchronism with the load or work to be done, and leave the valve in its last position until there was a change in the load, or in the steam pressure, in order to prevent the breaking of lamps or variations in their light, owing to bad governance or ill-attention to the engine.

Mr. Jamieson exhibited a governor which in conjunction with Mr. Stephen Alley he had devised and tried with good results on board the s.s. Thistle, at Glasgow. It is based on the phenomenon exhibited in Arago's disc, and consists of a copper disc revolving between the poles of an electro-magnet and actuating

Iron June 83

ELECTRICITY APPLIED TO FIREARMS.—A Frenchman, M. Clair, has invented an electric rifle, which is to be exhibited at Amsterdam. It is not the case that an electric shock takes the place of an explosion of powder; only that the electric spark is made to supersede trigger, hammer, and cap, and ignite the powder. The rifle is a breech-loader, and the cartridge is of metal. Instead of the cap, there is a copper wire passing through a metallic eyelet-hole in the wad, which eyelet-hole is put in electrical connection with a small hook by means of an inch or two of platinum wire. On pressing a button, which does not interfere with the aim so much as pulling even a hair trigger, the electric current, derived from a small accumulator in the stock, passes from the metallic eyelet-hole into the platinum wire, which it raises to incandescence, igniting the powder at the front end, and thus giving a great mechanical advantage. This is not all. The same barrel may contain two or more cartridges, which are fired successively in the following manner: the platinum wire of the cartridge nearest the breech is slightly larger in diameter than the next, this one larger than the succeeding, &c. The consequence is that the same current first makes the thinnest wire red hot, then that which is slightly thicker, and so on until all are fired.

Iron June 83.

THE CAPACITY OF ACCUMULATORS.—The Paris correspondent of *Nature* writes:—An interesting experiment took place on June 24, at the early hour of 3.45 in Paris, for the purpose of testing the capacity of accumulators of the French Storage Company to move tramcars. We travelled up to La Muette and back, a distance of 30 kilometres, in about three hours and twenty minutes, including stoppages and loss of time incurred by several incidents. The road has many steep inclines, which were ascended without difficulty. The mean velocity exceeded 10 kilometres per hour. The electricity was supplied by seventy accumulators, weighing 30 kilograms each, which were placed under the seats. At starting the potential was 140 volts, and having completed its task the current was as high as 120, so that at least 10 kilometres more could have been run if deemed necessary. This run is the longest on record made by electricity. M. Philippart was directing the operations.

THE PRACTICAL APPLICATION OF ELECTRICITY.—The National Museum at Washington is one of the best examples in the United States of the practical application of electricity. In so large a building, says *Nature*, it was found advisable to take advantage of the best means of communication, first being its system of telephones and call-bells, by which those in any room can communicate with every room in the building. Twenty-six telephones are connected by a local telephone exchange, which in turn is connected with the main telephone office of the city. The result is that but three messengers are needed in this vast establishment. The photographic laboratory is independent of the sun, owing to the electric light there used. If one of the 850 windows or 230 doors is opened, a bell rings, and an electric annunciator shows to an attendant at the main office which window or door it is. This system is soon to be applied to every case of specimens. The watchmen at night, also, are kept to their posts by hourly releasing an electric current at certain stations, which pierces a dial and records their visit. The sixteen clock dials are likewise run by electric currents.

Iron, June 29th 83.

RAILWAY SIGNALLING.—At the Society of Telegraph Engineers and of Electricians a paper was read on February 22, by Mr. R. von Fischer-Treuenfeld on the Siemens railway gong alarm, which is now adopted in France, Belgium, and other countries, for railway signalling instead of the block system so largely employed in this country. With this apparatus, which is worked by magneto-electric currents generated by the signalman in turning a handle, the signals are given by the strokes of a large bell. It was, however, agreed by Mr. Spagnoletti, Mr. W. H. Preece, and the author, that the gong alarm is not so well adapted for our busy English railways as the continental ones; but it was thought worthy the attention of colonial railway engineers and the managers of local lines on which there was but little traffic. The exigencies of English travelling demanded a system which appealed to the eye as well as to the ear, so that there would be no risk of the signalman forgetting what the signal was, since he could refer to the visual sign. Several speakers insisted strongly on the necessity of a uniform code of signals for railway working throughout this country. At present on some lines the "danger signal" is one stoke of the bell, and on others the "line clear" signal is one stroke of the bell—a state of things which might sooner or later lead to accidents, especially in the case of a signalman who had changed service from one of the former companies to one of the latter. Professor Ayrton also advocated the revival of magneto-electric generators instead of batteries for railway signalling and telegraphic purposes. He had recently found from experiment that a magneto-electric machine turned by hand gave a far stronger current than that used in telegraphing; and he pointed out that ordinarily small dynamo-electric machines could be used in a similar manner.

Electrical Review May 9, 1885

An electric tooth-pulling machine, which is quick and almost painless in its operations, is said to pull seven teeth in five seconds. A pair of forceps protrude from a nickel tube which is connected with a wire. The forceps are applied to the tooth, the operator touches a spring, a spiral arrangement within the tube winds up in a wink, draws down the forceps like a flash, and in an instant the tooth is jerked from the jaw and cast on the floor.

London - Work Law Express April 20/85.

MAKING BUTTER BY ELECTRICITY.—If the announcement made by a French contemporary remains true in practice, butter-churn makers will perhaps have to turn their attention to the construction of other things; perhaps dynamo-electric machines of very low electro-motive force. According to a patent taken out by Mr. A. C. Tichenor, milk is introduced into a vessel of special form, and into it are placed a pair of electrodes, and a current is thus passed through the milk. Butter is formed in little balls on one of the electrodes, and it is said that to extract the butter from forty-five litres of milk the current from a dynamo-electric machine equivalent to that of about forty Daniells for from three to five minutes is all that is required. With such a current the balls of butter are sufficiently voluminous to detach themselves from the electrode and float to the surface of the milk. The butter thus obtained has to be worked in a baratte or something of the kind, so as to work the small pieces into a compact mass. The patent also mentions the electric manufacture of cheese and of removing the bad taste of butter that has turned rancid. We do not know how far the indications of the patent specification have been verified.—

Mail + Express May 18, 1885

ELECTRICAL CURIOSITIES.

Odd Instruments to be Seen Among Dealers in Telegraphic and Electrical Supplies.

"Among the interesting articles that we sell," said a dealer in telegraphic and electrical supplies, "is an improved counting machine. It is a very useful appliance for superintendents, telegraph inspectors and others connected with telegraph construction and repair work. It is a curious instrument and is about the size and shape of a watch. Carried in the hand a single pressure upon a spring that it contains, records one and so on up to 1,000. It is used for keeping tally of any kind, such as counting poles, broken insulation, making inspection tallies of materials, etc.

"A curious name to an important little article is The Anti-Hum. The multiplication of telegraph lines and their connection with buildings of all kind has made a demand for some device for stopping the humming noise. The principle of this instrument is simple. An ordinary shackle of galvanized iron is provided with a washer or cushion of soft rubber, which, when connected, takes the strain off the wire, stopping its vibration, which is the cause of the noise. A loop of wire around the instrument conveys the current. An instrument of peculiar interest is an electro-mechanical tower bell striker. It is adapted to strike by electrical connection large bells of from 500 to 10,000 pounds weight. It will operate with a light battery power, and all that is required in connection with it is a simple key or press-button and battery. It is used for fire alarm purpose in connection with the telephone exchanges. As in many cases the telephone is used for sending fire alarms, the operator can with this apparatus give the public alarm on any near tower bell by the simple use of his press buttons.

"An electric apparatus for blasting is something novel to the general public, although it has been in use some time. It is a magneto-electric instrument of small size and weighs only about sixteen pounds. It occupies considerably less that one-half a cubic foot of space. It has a magnet of the horse-shoe character, of iron, wound about with coils of insulated copper wire; between the poles of the magnet there is fitted to revolve an armature of cylindrical construction, carrying in its body other insulated wire coiled longitudinally as to the cylinder. The rapid revolution of the armature by suitable means generates and sustains in the machine an accumulative current of voltaic electricity of great power, which at the moment of its maximum intensity is practically switched off to the outside circuit in which are the fuses, and in the interior of each fuse the ignition is accomplished instantly. It was a machine of similar description that was used in blasting at Hell Gate when Gen. Newton's little daughter pressed the button that set the apparatus in motion by which thousands of tons of rock were displaced."

Phila. Ledger May 13/85

ELECTRICAL CARTAGE.

In the early days of telegraphy a standard joke repeated in various forms related to the man who expected his messages, or his boots, to be strung upon the telegraph wire and carried bodily to their destination. That joke as such is now out of date, for it is possible, by means of Prof. Jenkin's system of "Telpherage," to actually send a pair of boots by wire from one place to another. The system has been in experimental use in England for a year or more, and the "Telpherage" Company recently equipped a line which is to be put in practical use at a South America mine. "Telpherage" is a manufactured word intended to designate all modes of transport effected automatically with the aid of electricity. But as limited to Mr. Jenkin's invention it means a system of electrical *cartage*, at a slow pace, of minerals and similar materials that can be divided into packages of two or three hundred weight. The conducting line is a single suspended wire or rod, but as it also sustains the weight of the train, it has to be strong enough to carry the traffic. There is also a return line, and the two are so arranged in cross-over sections that whenever a train bridges the sections the current from the dynamo at the end of the line passes through and sets in action the motor of the train, which is one of the ordinary forms of electric motor. The "trains," of sufficient length to bridge over the gap between sections, are made up of buckets or other suitable receptacles for coal, grain or minerals, these buckets being suspended on wheel trucks running on the line wire. When the train is made up and the current is passed through the motor the latter drags the train along the line. As Professor Jenkin designed the system to be a substitute for cartage, the speed is only four or five miles an hour. The problems involved are chiefly mechanical, most of the electrical difficulties having been already overcome in apparatus used for other purposes.

At first sight it would seem to be a very wasteful way of using power, but the losses by conversion are made up in other ways and on its limited field telpherage appears to be of economical value. In a line five miles long with twenty-five trains, each conveying a useful load of fifteen hundred-weight, the estimated cost of cartage is about five cents per ton per mile. In a shorter line with fewer trains the cost is somewhat increased, reaching perhaps six cents per ton per mile. At such rates it cannot compete with railroad transportation, nor is it expected to do so. Its rival is cartage, and the estimated cost of cartage (leaving the roads out of consideration) is twenty-five cents per ton per mile. In these calculations it is assumed that the useful power exerted at the locomotive is only one-third that of the stationary engine, the loss of two-thirds of the power arising in the conversion of mechanical power into electricity in its reconversion and in electrical resistances. Better results than this can no doubt be reached, but telpherage appears to already offer a cheap means of cartage in some situations, notwithstanding this great waste of energy.

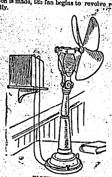
The uses of such a system of conveying goods are various, especially in localities without roads. The lines can be cheaply constructed to mines, and may be tapped wherever desired to obtain sources of power for operating circular saws or electric light plants. Or, in the mines themselves, the telpherage lines could be employed to carry the coal or minerals to the mouth at small cost, while at the same time furnishing electricity for lighting the mine. This is a field of work entirely distinct from that of the ordinary electric railway, which is almost as costly in construction as a steam railroad, and is designed to carry both goods and passengers at a high speed. The telpherage lines designed by Professor Jenkin may become feeders to, but not the rivals of, railroads. They can compete with mules and horses at points where steam railroads cannot be used.

46

Character of article Edl.
From the Palladium
Published at Chicago Ill.
Date Aug 1 85

Good for Hot Weather.

An electric lamp manufacturing firm have recently invented something quite new. It is an electric fan. The illustration shows it. Given any sort of standard, plain or ornamental, like an ordinary lamp pedestal and about a foot high. Upon the top is mounted a screw propeller fan. One who looks at this fan will see a small model of the screws which move steamers. The standard is of wood or other non-conducting material, with wires running up through the center. Wires from a small battery are connected with these near the bottom. When the connection is made, the fan begins to revolve rapidly.



ELECTRIC FAN.

The battery is contained in a little box four to five inches square. It holds material to generate electricity enough to turn the fan several hours. The fan is fixed upon a hinge, so that it can be set at any desired angle, thus changing its direction. Clock-work fans are not uncommon. In large factories, where numbers of men are crowded together in hot rooms, large revolving wooden fans are attached to the machinery and worked by steam. But this neat little electric arrangement seems an improvement on any other plan that has yet been tried.

N.Y. Times. 7-30-86.

FINISHING A TORPEDO.

At the Edison machine shops, No. 104 Goerck-street, the third of the electrical torpedoes in process of manufacture for the Government was finished yesterday. The torpedo is 45 feet long and 30 inches in diameter, and is made of polished copper. Its motive power is a small dynamo, which is inclosed in an iron case in the centre of the torpedo, and which operates a propeller. The torpedo will run 10 minutes at the rate of 10½ miles an hour, and is controlled by two wires connected with the shore. These are rolled up in an apartment in the torpedo and uncoil as it goes along. The contrivance is shaped like a cigar, pointed at both ends, and is suspended from a float. The float moves on the surface of the water and the torpedo is 4 feet below. The charge is 350 pounds of dynamite. The torpedo will cost $5,000 and will demolish a million-dollar man-of-war. The Government will have eight of them.

N.Y. Tribune 7-31-86.

HIGHLY DESTRUCTIVE TORPEDOES.

THE THIRD MADE BY EDISON TO BE SHIPPED TO-DAY—HOW THE THING WORKS.

The third of the five electrical torpedoes which are being built for the Government at the Edison Machine Works, No. 104 Goerck-st., has been finished and will be shipped to-day. These torpedoes, which are all made alike, are submarine vessels, consisting of a cigar-shaped copper hull—the torpedo proper—forty-five feet long and about two feet in diameter at the widest part, attached by upright steel stanchions to a copper float, which rises some six inches above the surface of the water. Placed fore and aft on the float are two rods for showing signal flags, balls or lights. These rods are hinged at the base with a spring-hinge so as to assume an oblique or horizontal position when meeting and moving under an obstruction and to recover their position automatically when it is passed. Both hull and float are protected from cables, ropes and other obstructions by a sharp steel blade, which runs from the bow of the hull to the top of the float and from the stern of the float to the stern of the hull and is set at such an angle as to make the torpedo dive under or cut through any obstacle. The hull of torpedo itself is made up in four parts or sections united by lock joints. The bow section contains the explosive charge, from 250 to 400 pounds of dynamite; the second compartment is filled with cable, which connects the torpedo with the shore and is paid out as the vessel proceeds on its errand; the third part contains the dynamo which supplies the power for propelling, guiding and exploding the torpedo; in the stern section are placed the steering apparatus and the shaft of the screw propeller.

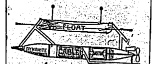
The operator from his station on shore or on shipboard can at will start, stop or steer the dangerous craft and explode the charge, which can also be arranged to explode by contact if desired; and he receives notice when the hull meets with any obstruction, thus making sure of the proper moment for explosion. The torpedo weighs all told from 3,000 to 5,000 pounds according to the distance to be overcome, but no single part or section weighs more than 800 pounds. Fifteen minutes is all the time required to take it apart or put it together again. It will run ten minutes at the rate of ten and one-half miles an hour and it is claimed that it can demolish any man-of-war afloat. The torpedoes cost the Government, it is said, $5,000 apiece. Representatives of the English, French, Turkish and Japanese Governments have been inspecting them within the last few weeks with a view to ordering some made for themselves.

N.Y. Sun. 8-8-86.

TORPEDOES FOR UNCLE SAM.

Built by Edison at a Cost of Five Thousand Dollars Each.

Although Congress did little toward preparing the country to defend itself against an enemy in case of war, the Navy Department has not been wholly idle, even outside of the preparing of plans for new war ships and completing the ships already begun when the present Administration came into power. Some time ago a contract was made with the Edison Machine Works in Goerck street to build eight torpedoes which should be propelled by an electrical apparatus and steered through wires from the shore or the ship from which they were launched. Three of these torpedoes have been completed and delivered. The picture gives a very excellent idea of what they are like.



The torpedo proper is 45 feet long over all. As shown in the cut, it is purposely made to appear thicker than it really is. It is cylindrical in the centre, tapering to sharp points at each end. It is thirty inches in diameter.

The explosive is put forward, the coil of wire through which the electrical current passes is in the middle, and the dynamo that turns the propeller and operates the rudder is aft. It is manifest that this device would not displace enough water to float itself, and a boat is therefore provided to float it. This boat is sharp at both ends and is decked over. Its model is like a Yankee whaleboat's. It is made of copper, as is the torpedo. Stiff but thin bars of iron connect and brace it firmly to the torpedo. These braces are put at an angle, so that if any obstructions, such as booms about a ship, are met the whole apparatus will dive under and continue on its course. A long slender guard projects aft under the propeller to protect it under like circumstances. The two balls that rest on top of slender rods above the float are to enable the launching party to keep track of and steer the craft. They are hinged to substantial springs, so that when diving under a log or other obstruction they will bend down into slots prepared for them and then rise up in place again.

The contract provides that these torpedoes shall run not less than ten miles an hour. They carry 300 pounds of dynamite or any other high-power explosive. This quantity exploded against the side of a war ship is believed to be sufficient to agitate somewhat those on board of her. The range of these torpedoes is limited to the length of wire they can carry. Those built so far carry enough to enable them to travel one mile and two-fifths away. The most astonishing curves and spirals can be made by them under the direction of the operator sitting at a table at the place of launching. They cost $5,000 each.

N.Y. Sun. 8-5-86.

ELECTRICAL FLYING MACHINES.

Attempts in Germany and Russia to Make Balloons for Use in War.

BERLIN, July 27.—The success of the aeronaut L'Hoste and his companion in making in a balloon the journey across the Channel from Cherbourg to London has caused no little excitement here. It is the first successful attempt to reach a point determined on beforehand, and indicates a decided advance in aeronautics, which will be put to good use in a coming war. Germany and Russia have both for some time been pushing forward experiments in flying machines for use in war or otherwise. The direction in which they have been working was the one which, previous to the experiment just made by L'Hoste in the balloon Torpilleur, was most likely to be successful. It ignored the idea of the inflated gas-bag, which is enormous in size, difficult and costly to fill in war, and floats—a gigantic derelict—at the mercy of every current of air, a huge mark for the first gunner who can hit and bring it to the ground.

Baumgarten in Germany and Baranovski in Russia have adopted the principle of the inclined plane pressed against the air, and thus capable of making some attempt, at least, to regulate its own course. In the kite the force that presses the inclined plane is the hand of the boy acting through the string. In the sail of the boat the resistance of the water to sidelong motion keeps the sail pressed against the wind. In the flying machines of Baumgarten and Baranovski the pressure is given by an engine carried by the machine and acting by means of fans. The difficulty was the weight of the engine and the fuel; but with the development of practical knowledge of electricity accumulators have been built which supply the maximum of motive power with the minimum of weight. If the attempts should prove successful, the problem of flying in still air would be solved. But whether men shall ever be able to ride the storm is another matter.

Rochester Herald. 9-17-86.

AN ELECTRIC BOAT.

The Volta is the name of a little electric boat which on Monday last crossed the English channel from Dover to Calais and back, a distance of twenty-four miles each way. She is thirty-seven feet long, seven feet beam and three and a half feet deep. Her propelling power consists of sixty-one electric accumulators, each eight inches square which were placed under the floor of the launch with a pair of Reckenzaun's electro-motors. The accumulators were charged two days before the electricity stored in them was used.

This little craft will carry forty passengers, but only seven, including a correspondent of the New York *Herald*, crossed the channel in her. She can travel at the rate of twelve miles an hour, though, of course, she is not driven constantly at that rate. The party left Dover at 10:40 A. M., reached Calais at 2:30 P. M. and arrived in Dover on the return a little after six o'clock in the evening, an average of about seven miles an hour, including the stop at Calais. The entire cost of the electricity stored in the accumulators was eight shillings, or two dollars, and that was sufficient to take the party across the channel and back. She ran easily, swiftly and silently, without smoke, noise or jar. The astonishment of those who saw the original steamboat, pushing her way through the water without sails, could not have been much greater than that of the persons who discovered the little Volta skimming over the channel without the sign of sails, smoke-stack, engine or boiler. Unquestionably electricity is the coming power for small boats, though until dynamos become more numerous and generally distributed these electric boats will have to confine their trips within the limits of stations where the batteries can be recharged.

It would appear from the success of the Volta and the statements of its owner regarding her speed and the cost of the electricity that great improvements have recently been made in storage batteries. As originally constructed they were not of much account except for laboratory illustration and experiment, but inventors have been at work on them right along with results that seem to be highly encouraging.

Brooklyn. Eagle. 9-14-86.

The Voyage of the Volta.

In the race between aerostation and the development of electricity as a motor, the former had a start of nearly a century. Its progress has been slow, and it is doubtful whether it has even yet reached a stage of practical usefulness, although within the past year or two it has received an impetus in the land of its birth, which holds out a promise of better things to come. The success of two

47

aeronauts recently in directing their air ship from a point in France to another in London has given rise to the belief that with improved methods of applying electrical energy the balloon or aerostat of the not remote future will find its place among the established services of man, and that before the century closes the age of iron and steam will have given place to that of steel and electricity, while the upward progress of the race will be typified by the ascent of man into the air as a medium of transportation. It will be observed that electricity is actually the means by which this result is to be obtained, so far as we can see ahead, and yet, while steam will not be immediately connected with the enterprise, it will merely have been deposed one step as the servant of the electrician. The more ethereal energy will owe its life to the coarser, then as now, and will represent a refinement of power as much better adapted to the rarer wastes of the atmosphere as the bird with his hollow bones and spread of wing is a sublimation of the reptile from which he sprang.

Already the secondary battery, which is the electrical storehouse of energy, has been put to use in the aerostat; recently it was applied to the more material and onerous work of propeling a boat. In a sea so calm that sleeping gulls were not apprised of its noiseless approach, the cable tells us, the Volta was driven from Dover to Calais in 3 hours and 51 minutes and back again in 4 hours and 15 minutes, making the round trip of about 44 miles in a trifle over 8 hours, or at the not very startling rate of speed of about 5 1-4 miles an hour. Whether the inventors were pleased or disappointed with this experiment we are not told, but to persons who have seen the famous Herreschoff steam launch, Henrietta, dart like a dolphin through a lively seaway at the rate of 24 miles an hour, the result is not exactly startling. It is in the fact of electric propulsion, not in the measure of its achievement that success, if there was any in it, must be looked for. The one note of triumph to be detected in the account is the assurance that the secondary batteries were recharged but once during the entire trip. That is to say, with these batteries stored to their full capacity energy enough was developed to carry the Volta—dimensions not given—so many miles at such a rate of speed.

The Volta's is not by any means the first demonstration given of ability to propel small vessels by means of electricity, although it may be the first application of the mysterious and omnipresent force in an indirect way. Indeed, in a variety of ways, locomotion dependent upon a continuous current has been effected for some years past. Upon surface roads, for example, the supply of energy has been conveyed from the dynamo to the engine of a motor by means of the rails upon which it ran or by a wire in air. The Daft and Siemens systems represent these two methods, which have been differentiated in a number of ways. The secondary battery, however, for reasons that are easy to understand, has not yet been developed to yield a sufficient current for such ponderous purposes. The reader is probably familiar with the general principles of this discovery. A battery consisting of plates of metal, with the largest available area according to weight, is subjected, under chem-

ical treatment, to an electrical current, the effect of which is to produce rapid superficial decomposition. This decomposition represents the work of so much energy. When by reverse chemical treatment recomposition is effected, then the same energy, minus a little loss, is released in the form of electricity which is applicable to machinery. So far the current thus obtainable is bounded by the bulk of the metal treated. The secondary battery hitherto has been so heavy in proportion to the energy it stored that the force of gravity forbade its application, generally speaking, to other than static enterprizes. The value of the Volta's experiment lies, then, in developing a battery which could, without recharging, propel itself a given distance.

The demonstration at present is scientific, not practical. The economic side of the question is far more important than any that has yet been studied. The cost of generating an equal energy of electricity is so much greater than that of the steam which develops it as to forbid a substitution of one for the other for general purposes as yet. For particular purposes, such as submarine lighting, where gas would not serve; for submarine propulsion, where steam or other expansive gas would be out of the question, and for aerostation, where the maximum of energy and the minimum of weight are indispensable, electricity from a storage battery may have a practical value. It has none yet.

New Orleans. Picayune. 4-1-86.

THE ELECTRO-CHRONOGRAPH.

An Automatic Detective to Watch the Electric Lights—The Important Discovery of a New Orleans Mechanic Now Ready for Practical Demonstration.

Up to the present time the city has been compelled to depend upon the reports of the police force as to the number of electric lights which have been burning dimly, or left unlit during the entire night, or any portion thereof. Taking into consideration the extent of territory allotted to each man on the force, more especially in localities other than the more central portions of the city, these reports were necessarily incomplete, and it is presumed many lights, which were not burning at all, or only dimly so, escaped the notice of the police, and the city paid for lights that had not been furnished.

No device by which the length of time an electric light has been burning, or in other words no electro-chronograph has been heretofore known that could be practically applied to electric lamps in order to ascertain how long they may have been burning; but it remained for an ingenious New Orleans electrician and mechanic to solve the problem; and the result is that he has perfected an instrument which will not only answer the purposes for which it is intended, but he has also invented an automatic electric clock that will show the hours of the night from any street electric lamp in the city, and record the hour while the current is projected along each and every circuit of the different electric light plants in the city.

The first of these inventions, which was exhibited to the reporter last evening, was the meter. This is in reality an adaptation of the patent fire indicator to the purposes of measuring and indicating the time during which the electric lamp may be burning or not. The fire indicator is really a thermometer connected by wires with a battery, and alarm bell. When the mercury rises to a certain height the metal comes in contact with brass, platinum or other conductive metal and completes the circuit, which sets in motion a vibrating electric gong and gives the alarm. This principle is reversed in the meter, and it is when the mercury in the thermometer falls that the circuit is closed and a small piece of machinery, devised somewhat after the plan of a watch, is set in motion and the time during which the light is very low, and consequently emits but little heat, or when out and emits no heat at all, is indicated on the machinery. These indicators or meters, which can be constructed very cheaply, after the style of the Waterbury watch, are examined each morning by the police and can be then wound up, ready for service the next night. The thermometer is small, neat and compact and is to be so placed as not to interfere with the illuminating power of the light, or to cast a shadow.

A very small battery is all that is required, as sufficient electricity can be procured from a single Leclanche cell without deflecting more than an infinitesimally small quantity of the main current. The indicator or meter can be placed inside of buildings if required, connected as they will be by small wires.

The electric clock which this ingenious mechanic has invented, although involving no new principle, will without doubt prove of the greatest benefit to the citizens at large as well as remunerative to the inventor.

The hours of the day or night will be painted on the outside of the glass globes of the various electric lamps throughout the city, as on the dial of a clock. A small hole is drilled through the glass at the centre, through which will project the rod which will revolve the hands, which will be made of exceedingly light metal or wood. The rod forms the axis of a cogwheel which is geared by a series of wheels to the armature of a magnet. This magnet will move to and fro by a constant electrical current, automatically made and broke, as is the case in a vibrating gong such as are in general use on burglar alarms, hotel annunciators, etc. The rapidity with which this armature is to be moved can be adjusted by means of set screws, which can be moved wider apart to lessen the number of strokes per second, or closer together to increase the number, as may be required in regulating the time-piece. The current which is to operate the clock is to be derived from the Electric Light Company's wire, as in the case of the electro-chronograph before described, and as but very little is required the loss to the company will be small indeed from connecting with the small wires of the clock, the electro-chronograph being independent.

The motor of the clock is the electrical current applied to the armature, the motion of which revolves a cog wheel. Every time the armature is attracted to the magnet the wheel is moved forward one cog, and when the armature is drawn back by means of a small spring it is reset automatically and catches under the next cog, which is forced forward when the armature is again attracted to the magnet.

Both these instruments are supplied with their fusible wire automatic cut outs so that the delicate magnets and machinery cannot be injured by an excess of current, the thin wire fusing when the current becomes too strong.

Another advantage promised by the electric clock is in indicating the hour at which the current is projected over the wires. Thus, the company contract to light their lamps at 6 o'clock in the evening. The clocks are all set at that hour and the instant the dynamos commence to revolve the clock is started and continues as long as there is a medium of current on the wires. At 6 o'clock the lights are extinguished and the clocks cease working. When the hours for lighting and extinguishment are as above the clocks need not be reset in the morning, but should the hours of lighting be later the hands can be moved to the proper time each day by hand.

The clocks will not cost more than about $10 apiece, and at that rate, should the inventor's system be generally adopted—which it no doubt will be in every city where electric lights are in use—the fortune of the man is certainly made. The clock, he claims, is no infringement on the electric clocks recently introduced in this city, as they are operated from one central timepiece, which transmits a current each minute, while his clock runs automatically and by a constant current. The advantages of this electric clock are at once apparent, and will be highly appreciated by those whose duty or pleasure causes them to remain outdoors late at night.

Yesterday the inventor received information from the Patent Office at Washington, D. C., that his application and the patent accompanying it had been examined and approved, and that a patent would be issued forthwith.

The inventor is in reduced circumstances, and for a number of years past has been devoting himself and his means to the perfection of a machine which proved to be a failure, and of which he would enter into no explanation. The name of the inventor, Prof. Edmunds, is well known in this city as a man of great talent and ingenuity. A working model of both the electro-chronograph and the clock were exhibited at his rooms at No. 138 Camp street, on the third floor, last evening, and both apparatus put to work by means of a battery composed of two Daniels cells.

To demonstrate the practical workings of the electro-chronograph he used a candle and moved it gradually away from the minute thermometer after having connected the battery. By degrees the mercury fell, and as soon as the light had been moved sufficiently far away the little watch commenced ticking, and continued to do so until the light was again moved close to the thermometer, when it suddenly ceased.

He has obtained one of the globes in use on the electric lamps in the city, and has had painted thereon the twelve hours of the day. He has attached his clock to this, and to-day proposes to apply to the Louisiana Electric Light and Brush Electric Light companies for permission to place this globe on one of their lamps.

He proposes to place his clock on the Louisiana electric lamp at the corner of Lafayette and Carondelet streets at 8 o'clock and allow it to remain until 9 o'clock this evening. He will then remove it to the Poydras Market and demonstrate its great utility on a Brush electric lamp. He will also attach the electro-chronograph and explain its use to any who may apply to him. There is not the least doubt of the success of these two valuable and ingenious inventions, and a man more deserving of a recognition of his attainments and merits could not be found anywhere.

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26

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A SELECTIVE MICROFILM EDITION

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(1850-1878)

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